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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 07/06/2023

Roark IP
1438 Dahlia Loop
San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	

ART UNIT	PAPER NUMBER
2441	

MAIL DATE	DELIVERY MODE
07/06/2023	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
001

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	ISSUE DATE	PATENT NO.
17/142,983	04-Jul-2023	11695823

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1438 Dahlia Loop
San Jose, CA 95126

EGRANT NOTIFICATION

Your electronic patent grant (eGrant) is now available, which can be accessed via Patent Center at https://patentcenter.uspto.gov

The electronic patent grant is the official patent grant under 35 U.S.C. 153. For more information, please visit https://www.uspto.gov/electronicgrants

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	07/04/2023	11695823	TAAG001CONT3	2943

112449 7590 06/14/2023

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1438 Dahlia Loop
San Jose, CA 95126

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at https://certifiedcopycenter.uspto.gov/index.html. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
003

INVENTOR(s) (Please see PAIR WEB site http://pair.uspto.gov for additional inventors):

Pouya Taaghol, San Jose, CA;
Vivek Ramanna, San Jose, CA;

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Big Data Federation, Inc., Santa Clara, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

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112449 7590 05/09/2023
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San Jose, CA 95126

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

TITLE OF INVENTION: Distributed Software Defined Networking

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	08/09/2023

EXAMINER	ART UNIT	CLASS-SUBCLASS
HIGA, BRENDAN Y	2441	709-201000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ROARK IP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Edge Networking Systems, LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Austin, TX

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ☒ Issue Fee ❑ Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via Patent Center or EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Christopher J. Horgan/ Date May 16, 2023

Typed or printed name Christopher J. Horgan Registration No. 40,394

PTOL-85 Part B (08-18) Approved for use through 01/31/2020 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
005

Electronic Patent Application Fee Transmittal

Application Number:	17142983
Filing Date:	06-Jan-2021
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Filer:	Christopher James Horgan
Attorney Docket Number:	TAAG001CONT3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	480	480

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**480**

Electronic Acknowledgement Receipt	
EFS ID:	48012898
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	16-MAY-2023
Filing Date:	06-JAN-2021
Time Stamp:	17:53:50
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$480
RAM confirmation Number	E20235FH56108255
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	TAAG001CONT3_ISSUE_FEE_PAYMENT.pdf	142279 7ba6ff05aae0bdfbe20b01bdd2f5b38c8d974f36	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	38134 182e5c8e3bf71cc381646e6e9a192f7c932df9a5	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	180413		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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NOTICE OF ALLOWANCE AND FEE(S) DUE

112449 7590 05/09/2023

Roark IP
1438 Dahlia Loop
San Jose, CA 95126

EXAMINER
HIGA, BRENDAN Y

ART UNIT	PAPER NUMBER
2441	

DATE MAILED: 05/09/2023

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

TITLE OF INVENTION: Distributed Software Defined Networking

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	08/09/2023

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

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San Jose, CA 95126

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

TITLE OF INVENTION: Distributed Software Defined Networking

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	08/09/2023

EXAMINER	ART UNIT	CLASS-SUBCLASS
HIGA, BRENDAN Y	2441	709-201000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

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(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via Patent Center or EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
011

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 05/09/2023

Roark IP
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San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	
ART UNIT	PAPER NUMBER
2441	

DATE MAILED: 05/09/2023

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
012

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 17/142,983	Applicant(s) Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to Applicant's 04/17/2023 Request for Continued Examination (RCE).
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 19-36 and 39 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/BRENDAN Y HIGA/
Primary Examiner, Art Unit 2441

Exhibit 1007
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014

Notice of References Cited	Application/Control No. 17/142,983	Applicant(s)/Patent Under Reexamination Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20140351428-A1	11-2014	Madani; Habib	H04L47/76	709/224
*	B	US-20140082156-A1	03-2014	Jagtap; Sameer S.	G06F9/5027	709/220
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	Art Unit
	BRENDAN HIGA	2441

CPC - Searched*		
Symbol	Date	Examiner
H04L41/08,0895; 45/563; 67/10, 34	05/04/2023	BH

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see SEARCH history	05/04/2023	BH
IP.com (NPL+Patents)	05/04/2023	BH
Google Scholar (see search history and results)	05/04/2023	BH
Reviewed prosecution history of US application 14/295331, particularly final rejection mailed on 12/28/2016	09/02/2022	BH
PALM inventor search	12/14/2022	BH

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H04L	41/08,0895; 45/563; 67/10, 34	05/04/2023	BH

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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

CPC						
Symbol					**Type**	**Version**
H04L	/	67	/	10	F	2013-01-01
G06F	/	21	/	57	I	2013-01-01
G06F	/	21	/	44	I	2013-01-01
H04L	/	67	/	34	I	2013-01-01
H04L	/	41	/	0803	I	2013-01-01
H04L	/	63	/	0227	I	2013-01-01
G06F	/	21	/	53	I	2013-01-01
H04L	/	9	/	0822	I	2013-01-01
H04L	/	41	/	0893	I	2013-01-01
H04L	/	45	/	563	I	2013-01-01
H04L	/	45	/	64	I	2013-01-01
H04L	/	67	/	1076	I	2013-01-01
H04L	/	41	/	0895	I	2022-05-01
H04W	/	4	/	00	A	2013-01-01
H04L	/	63	/	0218	A	2013-01-01
G06F	/	8	/	60	A	2013-01-01
H04L	/	41	/	082	A	2013-01-01
H04L	/	41	/	5019	A	2013-01-01
G06F	/	8	/	70	A	2013-01-01
G06F	/	2009	/	45587	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/BRENDAN Y HIGA/ Primary Examiner, Art Unit 2441	04 May 2023	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	3

U.S. Patent and Trademark Office — Part of Paper No.: 20230426-A

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	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04L67/10	/	67	/	10
H04L67/00	/	67	/	00
H04L41/0803	/	41	/	0803
H04L9/40	/	9	/	40
H04L9/08	/	9	/	08
H04L41/0893	/	41	/	0893
H04L45/00	/	45	/	00
H04L45/64	/	45	/	64
H04L67/1074	/	67	/	1074
H04L41/0895	/	41	/	0895
H04W4/00	/	4	/	00
H04L41/082	/	41	/	082

NON-CLAIMED				
G06F21/57	/	21	/	57
G06F21/44	/	21	/	44
G06F21/53	/	21	/	53
G06F8/60	/	8	/	60
G06F8/70	/	8	/	70

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/BRENDAN Y HIGA/ Primary Examiner, Art Unit 2441	04 May 2023	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	3

U.S. Patent and Trademark Office — Part of Paper No.: 20230426-A

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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☑ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	19	5	28	19	39										
2	20	6	29												
3	21	14	30												
4	22	15	31												
9	23	8	32												
10	24	7	33												
11	25	16	34												
12	26	17	35												
13	27	18	36												

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 19	
/BRENDAN Y HIGA/ Primary Examiner, Art Unit 2441 (Primary Examiner)	04 May 2023 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 3

U.S. Patent and Trademark Office Part of Paper No.: 20230426-A

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☑ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/01/2022	04/07/2022	09/04/2022	12/14/2022	05/04/2023				
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	4	✓	✓	-	-	-				
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18	36			✓	✓	=				
	37			✓	-	-				
	38			✓	-	-				
19	39			✓	✓	=				

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Web Search History

date, time	web site	search string
5/4/2023 1:43:55 PM	Google Scholar	"distributed" "SDN" "app"
5/4/2023 1:44:03 PM	Google Scholar	"distributed" "SDN" "app" [before:2013]
5/4/2023 1:44:40 PM	Google Scholar	[before:2013] "distributed" "SDN" "app" "API"
5/4/2023 1:45:33 PM	Google Scholar	[before:2013] "distributed" "SDN" "app" "API" "programmable"
5/4/2023 1:46:44 PM	Google Scholar	[before:2013] "dSDN" "app" "API" "programmable" "flow"
5/4/2023 1:47:24 PM	Google Scholar	[before:2013] "SDN" "distributed applications" "API" "programmable" "flow"

Google Scholar "SDN" "distributed applications" "API" "programmable" "flow" SIGN IN

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An opennaas based sdn framework for dynamic qos control
I Bueno, JI Aznar, E Escalona, J Ferrer ... - 2013 IEEE SDN for ..., 2013 - ieeexplore.ieee.org
... of the inter-**SDN** routing information and the coordination of the **flow** setup across multiple ... The switch resource maps the OpenFlow rules into the controller through the REST **API** ...
Save Cite Cited by 83 Related articles All 2 versions

Software-Defined Networking and OpenFlow
S Das, D Talayco, R Sherwood - Handbook of Fiber Optic Data ..., 2013 - Elsevier
... that is above them that makes use of the network **API**. In ... **SDN** architecture decouples the control of data plane forwarding from the decision processes related to **distributed applications** ...
Save Cite Cited by 3 Related articles All 2 versions

[BOOK] Handbook of Fiber Optic Data Communication: Chapter 17. Software-Defined Networking and OpenFlow
S Das, D Talayco, R Sherwood - 2013 - books.google.com
... that is above them that makes use of the network **API**. In ... **SDN** architecture decouples the control of data plane forwarding from the decision processes related to **distributed applications** ...
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Is SDN the de-constraining constraint of the future internet? [PDF] acm.org Full Text @ USPTO-STIC
J Crowcroft, M Fidler, K Nahrstedt ... - ACM SIGCOMM Computer ..., 2013 - dl.acm.org
... **SDN** again would be the tool to replace the adhoc functionality with a clean slate **programmable** system with a public, open standard **API**... -scale, **SDN**, virtualization, and Open**Flow** seem ...
Save Cite Cited by 9 Related articles All 14 versions

[PDF] A compass through SDN networks [PDF] tum.de
T Zinner, M Jarschel, T Hossfeld, P Tran-Gia ... - 2013 - mediatum.ub.tum.de
... via the Northbound-**API** between the **SDN** controller and what we ... technologies as well as **distributed applications**. This has led to ... , **SDN** allows load balancing to operate on any **flow** ...
Save Cite Cited by 5 Related articles All 3 versions

Design of a H. 261 video codec with 12 Xilinx LCAs
AM Praden, E Jouve, F Albert, M Dumas ... - Proceedings Euro ASIC ..., 1992 - computer.org
... readily available,to the **SDN** controller in achieving effective ... In-Memory Data Grid **distributed applications**,,in addition to ... - through its southbound OpenFlow **API**,to network view, and ...
Save Cite Related articles All 3 versions

Controller load balancing schemes in software defined networks [PDF] yok.gov.tr
H Selvi - 2010 - acikbilim.yok.gov.tr
... on SimPy for **SDN** systems: We develop a **SDN** simulation ... It provides a standard OF **API** to the controller for control ... wide-area storage for **distributed applications**. HyperFlow is resilient ...
Save Cite

Towards Migrating Security Policies along with Virtual Machines in Cloud [PDF] concordia.ca
S Sadri - 2013 - spectrum.library.concordia.ca
... of all **flow** entries contradicts an important **SDN** concept, ... In fact, as **distributed applications**, they are scattered around ... any **SDN** controller that offers a firewall module and a REST **API**, ...
Save Cite Cited by 2 Related articles All 2 versions

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022

Cooperative routing between traffic control device and multi-server application [PDF] googleapis.com

L Deganaro, A Rodriguez - US Patent App. 11/224,691, 2007 - Google Patents

... routing requests through networks to **distributed applications**. ... TCP controls the **flow** of information on an end-to-end basis, ... **programmable** router is capable of accepting though its **API**. ...

Save Cite Cited by 6 Related articles All 2 versions

Open platform architecture for integrating multiple heterogeneous network functions [PDF] googleapis.com

K Fendick, L Kalampoukas, T Woo - US Patent 8,000,329, 2011 - Google Patents

... 3 , 4 and 5, it should be apparent to those skilled in the art that the logical path (ie, a **programmable** service path structure) that each packet **flow** takes when traversing through platform ...

Save Cite Cited by 123 Related articles All 4 versions

IQSearchText-202305041742

Main Concept Document
==========
US10893095
Title: Distributed software defined networking

(No Concept Modifiers)
==========

Filters (1)
==========
Publication Date: To 2013-12-31

Options
==========
De-dup: Extended Family Numbers (PAT only)
Relevance Cut-off: None
Sort: Relevance

Content: Patents + NPL (192)
==========
US Patents
US Designs
US Applications
EPO Patents
EPO Applications
China Patents
China Applications
Japan Patents
Japan Applications
Korea Patents
Korea Applications
WIPO Applications
Argentina Patents
Argentina Applications
Brazil Patents
Brazil Applications
Canada Patents
Canada Applications
Chile Patents
Chile Applications
Colombia Applications
Costa Rica Applications
Cuba Patents

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Cuba Applications
Dominican Republic Applications
Ecuador Patents
Ecuador Applications
El Salvador Applications
Guatemala Applications
Honduras Applications
Mexico Patents
Mexico Applications
Nicaragua Patents
Panama Applications
Peru Applications
Trinidad & Tobago Patents
Uruguay Applications
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Austria Applications
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Belgium Patents
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Iceland Applications

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Montenegro Applications
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Slovakia Applications
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Spain Patents
Spain Applications
Sweden Patents
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Switzerland Patents
Switzerland Applications
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Yugoslavia/Serbia and Montenegro Applications
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India Applications
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Indonesia Applications
Israel Patents
Israel Applications
Jordan Patents
Jordan Applications
Kyrgyzstan Patents
Macao Applications
Malaysia Patents
Mongolia Patents
New Zealand Patents
Philippines Patents
Philippines Applications
Saudi Arabia Patents
Saudi Arabia Applications
Singapore Patents
Singapore Applications
Taiwan Patents
Taiwan Applications
Tajikistan Patents
Tajikistan Applications
Thailand Patents
Thailand Applications
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ARIPO Patents
ARIPO Applications
Egypt Patents
Kenya Patents
Malawi Patents
Morocco Patents
Morocco Applications
OAPI Patents
South Africa Patents
Tunisia Applications
Zambia Patents
Zimbabwe Patents
EAPO Patents
EAPO Applications
Georgia Patents
Georgia Applications
Kazakhstan Patents
Kazakhstan Applications
Russia Patents
Russia Applications

Turkey Patents
Turkey Applications
IEEE Xplore Publications: IEEE Periodicals
IEEE Xplore Publications: IEEE Conferences
IEEE Xplore Publications: IEEE Standards
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IP.com Prior Art Database: The IP.com Journal
IP.com Prior Art Database: Internet Society RFC
IP.com Prior Art Database: IBM TDB Archive
IP.com Prior Art Database: Legacy Journals
IP.com Prior Art Database: Software Patent Institute
OnePetro.org: Periodicals at OnePetro.org
OnePetro.org: Conferences at OnePetro.org
Other Literature: IBM Redbooks
Other Literature: PubMed Central
Other Literature: arXiv.org

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	30892	(H04L41/08,0895).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 11:17 AM
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L4	500	1 AND 2 AND 3	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2023/05/04 11:17 AM

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029

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L5	39	4 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 11:17 AM
L6	7	(docker kubernetes SDN NFV Open$1flow open$1stack) AND 5	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 11:19 AM
L9	613956	(docker kubernetes $1SDN NFV Open$1flow open$1stack)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2023/05/04 11:41 AM

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
030

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L10	22	1 AND 2 AND 9 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 11:42 AM
L11	172741	($2SDN NFV VNF $3app$1 $3appliance$2 VM cloud) adj10 (flow$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 11:57 AM
L12	2	1 AND 3 AND 11 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 11:58 AM
L13	11	1 AND 2 AND 11 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2023/05/04 12:04 PM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L14	723847	($2SDN NFV VNF $3app$1 $3appliance$2 VM cloud) adj10 (pair$3 sister two couple match$3 team group$3)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 12:59 PM
L15	422	1 AND 14 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 01:00 PM
L16	27	15 AND (2 3)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2023/05/04 01:00 PM

			IBM_TDB)				
L17	322584	($2SDN NFV VNF $3app$1 $3appliance$2 VM cloud) adj10 (pair$3 sister coupl$3 match$3)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 01:01 PM
L18	335	1 AND 17 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/05/04 01:01 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	9932	(H04L41/08,0895).cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2023/05/04 01:02 PM
N2	45245	(H04L67/10).cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2023/05/04 01:02 PM
N3	21637	(H04L45/563 H04L67/34).cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2023/05/04 01:02 PM
N4	297	1 AND 2 AND 3	(US-PGPUB; USPAT)	OR	ON	ON	2023/05/04 01:02 PM
N5	15	N4 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT)	OR	ON	ON	2023/05/04 01:02 PM

PTO/SB/30 (11-17)
Approved for use through 05/31/2024. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	17/142,983
Filing Date	1/6/2021
First Named Inventor	Taaghol
Art Unit	2441
Examiner Name	Higa
Attorney Docket Number	TAAG001CONT3

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. ☐ Other _____

   b. ☑ Enclosed

      i. ☑ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☐ Information Disclosure Statement (IDS)

      iv. ☐ Other _____

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☐ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. _____.

      i. ☐ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other _____

   b. ☐ Check in the amount of $ _____ enclosed

   c. ☐ Payment by credit card (Form PTO-2038 enclosed)

   d. ☐ Payment by EFS-Web

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Christopher J. Horgan/	Date	April 9, 2023
Name (Print/Type)	Christopher J. Horgan	Registration No.	40,394

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being EFS-Web transmitted to the United States Patent and Trademark Office (USPTO), deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the USPTO on the date shown below.

Signature			
Name (Print/Type)		Date	

A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with an information collection subject to the requirements of the Paperwork Reduction Act of 1995, unless the information collection has a currently valid OMB Control Number. The OMB Control Number for this information collection is 0651-0031. Public burden for this form is estimated to average 12 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden to the Chief Administrative Officer, United States Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450 or email InformationCollection@uspto.gov. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **If filing this completed form by mail, send to:**

Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal

Application Number:	17142983
Filing Date:	06-Jan-2021
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Filer:	Christopher James Horgan
Attorney Docket Number:	TAAG001CONT3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
RCE- 2ND AND SUBSEQUENT REQUEST	2820	1	800	800
		Total in USD ($)		**800**

Electronic Acknowledgement Receipt

EFS ID:	47855141
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	17-APR-2023
Filing Date:	06-JAN-2021
Time Stamp:	17:21:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$800
RAM confirmation Number	E20234GH24068212
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	TAAG001CONT3_RCE.pdf	265768 5fd6e0eceec57770f6bd3cd897dcebd46b517ca9	no	1
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
2	Amendment Submitted/Entered with Filing of Continued Prosecution Application (CPA)/Request for Continued Examination(RCE)	TAAG001CONT3_RESPONSE_APR2023.pdf	66637 75b110945cbd66334153cea12e0c34dc484b514f	no	10
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	38177 570fa0d3be697be1b417e68eea38f3916a80464b	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	370582		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Taaghol
Serial No.: 17/142,983
Filed: 1/6/2021
Attorney Docket No.: TAAG001CONT3

Examiner: Higa
Art Unit: 2441

For: DISTRIBUTED SOFTWARE DEFINED NETWORKING

Mail Stop Amendment
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE

Applicants offer the following election in response to the Office Action (hereinafter "Office Action") mailed on December 16, 2022.

Amendments to the Claims begin on page 2 of this paper.
Applicant's Statement of Substance of Interview begins on page 8 of this paper.
Remarks begin on page 9 of this paper.

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039

In The Claims:

1. (Canceled)
2. (Canceled)
3. (Canceled)
4. (Canceled)
5. (Canceled)
6. (Canceled)
7. (Canceled)
8. (Canceled)
9. (Canceled)
10. (Canceled)
11. (Canceled)
12. (Canceled)
13. (Canceled)
14. (Canceled)
15. (Canceled)
16. (Canceled)
17. (Canceled)
18. (Canceled)

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19. (Currently Amended) A system comprising:

a programmable network device adapted to host a plurality of network device applications;

a programmable cloud device adapted to host a plurality of cloud applications, wherein the plurality of network device applications and the plurality of cloud applications are in secure communication with each other to form distributed applications; and

wherein the plurality of network device applications and plurality of cloud applications device form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) to ~~simultaneously~~ program the plurality of network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware.

20. (Previously Presented) The system of claim 19, wherein the programmable network device and the programmable cloud device each include an access network interface unit configured to send and receive communications and a processor with a memory associated with the access network interface unit.

21. (Previously Presented) The system of claim 19 further comprising:

an application management portal capable of managing life cycles of the distributed applications; and

an infrastructure application marketplace in communication with the application management portal, said infrastructure marketplace capable of providing tested and certified distributed applications to the application management portal.

22. (Currently Amended) The system of claim 21, wherein the application management portal is capable of at least one of the group consisting of: receiving new applications from the infrastructure application marketplace; testing said distributed applications prior to deployment; ~~provision~~ provisioning said distributed applications; and ~~deprovision~~ deprovisioning said distributed applications.

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23. (Currently Amended) The system of claim 19, wherein at least one of the plurality of network device applications is responsible for a plurality of functional capabilities of the programmable network device and is capable of at least one of the group consisting of: updating firmware of the programmable network device; updating default communication protocols of the programmable network device; initializing programmable network device settings; boot loading the programmable network device; providing security digital certificates; providing operating system (OS) and kernel upgrades; and upgrading and commissioning agents for upgrading at least one of the plurality of network device applications ~~application upgrades~~ and related procedures.

24. (Currently Amended) The system of claim 19, wherein at least one of the plurality of cloud applications is responsible for a plurality of functional capabilities of the programmable cloud device and is capable of at least one of the group consisting of: upgrading and commissioning agents for updating at least one of the plurality of cloud applications ~~application updates~~; hypervisor upgrades; virtual machine and isolated execution environment lifecycle management; security digital certificate management; operating system (OS) and kernel upgrades; and default communication protocols.

25. (Previously Presented) The system of claim 19, wherein the programmable network device is an LTE eNB and the programmable cloud device hosts LTE core network functions in separate virtual machines from the group consisting of: MME, S-GW, and P-GW.

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26. (Previously Presented) The system of claim 19, further comprising:

a virtual fabric which provides a secure communication layer for said at least one of the plurality of network device applications and said at least one of the plurality of cloud applications.

27. (Previously Presented) The system of claim 19, further comprising:

a second programmable network device which includes at least one of the plurality of network device applications which is the same as at least one of the plurality of network device applications in the programmable network device and where each of the network device applications can communicate directly.

28. (Previously Presented) The system of claim 21, further comprising:

a distributed resource service (DRS) which controls access to a plurality of resources upon receiving instructions from the application management portal.

29. (Previously Presented) The system of claim 28, wherein the plurality of resources include at least one of a group consisting of: a firewall; data and statistics; storage; a load evaluator; general settings; a routing engine; a virtual machine master controller; a power controller; and a wireless engine.

30. (Currently Amended) The system of claim 19, further comprising:

a distributed resource service which is capable of providing at least one service from a group consisting of: exposing application programming interfaces (APIs) to other applications; configuring and managing platform resources; policy enforcement and authorization of the plurality of network device applications and the plurality of cloud applications to access [to] platform resources; and policy conflict resolution.

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31. (Previously Presented) The system of claim 19 further comprising:

a distributed content service wherein contents generated by the at least one of the plurality of network device applications are shared with at least one of the plurality of cloud applications.

32. (Previously Presented) The system of claim 21 further comprising:

a distributed notification service wherein notice of a predetermined event is sent from at least one of the plurality of network device applications to at least one of the plurality of cloud applications.

33. (Previously Presented) The system of claim 28, wherein the DRS further includes a load controller adapted to monitor loads on at least one of the plurality of network device applications and at least one of the plurality of cloud applications and effect change in accordance with thresholds received from the application management portal.

34. (Previously Presented) The system of claim 19, wherein the programmable network device, at least one of the plurality of network device applications, the programmable cloud device, and the at least one of the plurality of cloud applications each have unique identities.

35. (Previously Presented) The system of claim 19, wherein at least one of the plurality of network device applications and at least one of the plurality of cloud applications are given an access level to determine which APIs can be accessed.

36. (Previously Presented) The system of claim 19, wherein the at least one programmable network device and the programmable cloud device are adapted to verify the authenticity and integrity of updates to the plurality of network device applications and the plurality of cloud applications.

37. (Canceled)

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38. (Canceled)

39. (Currently Amended) A system comprising:

a programmable network device adapted to host a plurality of network device applications;

a programmable cloud device adapted to host a plurality of cloud applications, wherein the plurality of network device applications and the plurality of cloud applications are in secure communication with each other to form distributed applications;

wherein the plurality of network device applications and plurality of cloud applications form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) to ~~simultaneously~~ program the plurality of network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware;

an application management portal capable of managing life cycles of the plurality of network device applications and plurality of cloud applications; and

an infrastructure application marketplace in communication with the application management portal, said infrastructure marketplace capable of providing tested distributed applications to the application management portal.

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Applicant's Statement of Substance of Interview

Applicant thanks the Examiner for the courtesy of the telephone interview on March 16, 2023. No specific agreement was reached on overcoming the outstanding rejection.

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REMARKS

Claims 1-18 and 37-38 are canceled. Claims 19-36 and 39 are pending.

CLAIM OBJECTIONS

Claims 30 and 39 have been objected to. Accordingly, Applicant has amended claims 30 and 39.

REJECTIONS UNDER 35 USC §112(a)

Claims 19-36 and 39 are rejected under 35 USC §112(a). Accordingly, Applicant has amended the independent claims 19 and 39.

REJECTIONS UNDER 35 USC §112(b)

Claims 23 and 24 are rejected under 35 USC §112(b). Accordingly, Applicant has amended claims 23 and 24.

ALLOWABLE SUBJECT MATTER

Applicant appreciates the indication of allowable subject matter in claims 19-36 and 39.

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CONCLUSION

It is respectfully submitted that claims 19-36 and 39 are allowable over the prior art of record. No new matter has been added in the new claims and/or limitations presented in this Amendment.

Respectfully submitted,
ROARK IP
By: /Christopher J. Horgan/

Christopher J. Horgan
Registration No. 40,394
1438 Dahlia Loop
San Jose, CA 95126
Telephone: (408) 687-8306

Date: April 9, 2023

Exhibit 1007
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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/142,983	Filing Date 01/06/2021	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	04/17/2023	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0		x $40 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $192 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/TAMMY D MCBETH/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal

Application Number:	17142983
Filing Date:	06-Jan-2021
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Filer:	Christopher James Horgan
Attorney Docket Number:	TAAG001CONT3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 1 month with $0 paid	2251	1	88	88
Miscellaneous:				
		Total in USD ($)		**88**

Electronic Acknowledgement Receipt

EFS ID:	47847083
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	14-APR-2023
Filing Date:	06-JAN-2021
Time Stamp:	17:04:18
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$88
RAM confirmation Number	E20234DH06386861
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (SB06)	fee-info.pdf	38108 10c02639a5bb4fca24514e74c8ed3390822fc202	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	38108		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 03/20/2023

Roark IP
1438 Dahlia Loop
San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	

ART UNIT	PAPER NUMBER
2441	

MAIL DATE	DELIVERY MODE
03/20/2023	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Applicant-Initiated Interview Summary	**Application No.** 17/142,983	**Applicant(s)** Taaghol et al.		
	Examiner BRENDAN HIGA	**Art Unit** 2441	**AIA (First Inventor to File) Status** Yes	**Page** 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
BRENDAN HIGA	Primary Examiner	Telephonic
Christopher Hogan (Reg. No. 40,394)	Attorney	

Date of Interview: 16 March 2023

Issues Discussed:

35 U.S.C. 112

Discussed the filing of a continuation and whether removing "simultaneously" from the limitation "wherein the plurality of network device applications and plurality of cloud applications form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) to simultaneously program the plurality of network device applications and plurality of cloud applications", would be sufficient to overcome the 112(a) rejection. The Examiner indicated that further consideration would be required in determining whether the specification recites a sufficient algorithm (e.g., the necessary steps and/or flowcharts, see MPEP 2161.01) for meeting the written description requirement for the computer-implemented "enabling" function to be performed.

/BRENDAN Y HIGA/ Primary Examiner, Art Unit 2441	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

UNITED STATES PATENT AND TRADEMARK OFFICE

USPTO Automated Interview Request (AIR)

Mar 14 2023

This paper requesting to schedule and/or conduct an interview is appropriate because:

I have previously submitted an authorization for internet communications in a patent application. See form SB/0439.

Name(s):
Christopher Horgan

S-signature:
/Christopher Horgan/

Registration Number:
40394

U.S. Application Number:
17142983

Confirmation Number:
2943

E-mail Address:
chris.horgan@roarkip.com

Phone Number:
+1 4086878306

Proposed Time of Interview:
3-21-2023 10:30 AM ET

Alternative Proposed Time(s) of Interview:
3-23-2023 10:30 AM ET

Alternative Proposed Time(s) of Interview:
3-24-2023 10:30 AM ET

Prefered Interview Type:
Telephonic

I am the applicant or applicant's representative for this application.

Topic for Discussion:
35 USC 112 rejections

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
056

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 12/16/2022

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1438 Dahlia Loop
San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	

ART UNIT	PAPER NUMBER
2441	

MAIL DATE	DELIVERY MODE
12/16/2022	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 17/142,983	Applicant(s) Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 09/19/2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 19-36 and 39 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 19-36 and 39 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

This Office action is in response to Applicant's amendment and request for reconsideration filed on 09/19/2022.

Claims 19-36 and 39 are pending.

Claim Objections

Claims 30 and 39 are objected to because there is a typographical error in the claim. For the purpose of this office action the Examiner is interpreting the claim to read:

as per claim 30, "… and authorization of the plurality of network device applications and the plurality of cloud applications ***to*** *access* ***[[to]]*** *platform resources…"; and*

*as per claim 39, "…enabling a plurality of upper layer application programming interfaces (APIs) to simultaneously program the network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware****;***

an application management portal…".

Response to Arguments

Applicant's arguments filed September 19, 2022, with respect to the rejection under 35 U.S.C. 112(a) as being supported by ¶0030 of Applicant's specification, have been fully considered but they are not persuasive.

First, Applicant's specification does not appear to describe specific steps for programming the network device applications and plurality of cloud applications by the

plurality of upper layer application programming interfaces (API). Thus, mentioning that steps of the invention can broadly be performed *"simultaneously"*, as in ¶0030, is insufficient to support the specific limitations of:

"enabling a plurality of upper layer application programming interfaces (APIs) to simultaneously program the network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware".

Secondly, as noted in MPEP §2161.01: *"original claims may lack written description when the claims define the invention in functional language specifying a desired result but the specification does not sufficiently describe how the function is performed or the result is achieved. For software, this can occur when the algorithm or steps/procedure for performing the computer function are not explained at all or are not explained in sufficient detail (simply restating the function recited in the claim is not necessarily sufficient). In other words, the algorithm or steps/procedure taken to perform the function must be described with sufficient detail so that one of ordinary skill in the art would understand how the inventor intended the function to be performed."*

Thus, simply stating that steps can be performed *"simultaneously"* as in Applicant's ¶0030, without describing how the result is achieved - i.e., an algorithm or steps/procedure taken to perform the function - amounts to no more than restating the function recited in the claim, which is insufficient to satisfy the written description requirement of 35 U.S.C. §112(a).

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112(a):

> (a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.

The following is a quotation of the first paragraph of pre-AIA 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 19-36 and 39 are rejected under 35 U.S.C. 112(a) or 35 U.S.C. 112 (pre-AIA), first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for applications subject to pre-AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.

As per claims 19-36 and 39 the limitation "…wherein the programmable network device and programmable cloud device *form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) to simultaneously program the network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware*", does not appear to be described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for applications subject to pre-AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.

Particularly Applicant's specification is completely silent as to the steps or processes to "*simultaneously program the network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware".*

> The following is a quotation of 35 U.S.C. 112(b):
> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.
>
> The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:
> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claim 23 is rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor (or for applications subject to pre-AIA 35 U.S.C. 112, the applicant), regards as the invention.

As per claim 23, the limitation *"the plurality of network device application upgrades"* (i.e., *"…upgrading and commissioning agents for at least one of the plurality of network device application upgrades and related procedures"*) lacks antecedent basis in the claim. For the purpose of this office action the Examiner is interpreting the claim to read:

"…upgrading and commissioning agents for ***upgrading*** *at least one of the plurality of network device applications* ~~***upgrades***~~ *and related procedures"*

As per claim 24, the limitation *"the plurality of cloud application updates"* (i.e., *"…upgrading and commissioning agents for at least one the plurality of cloud*

application updates") lacks antecedent basis in the claim. For the purpose of this office action the Examiner is interpreting the claim to read:

"…upgrading and commissioning agents for ***updating*** *at least one the plurality of cloud application****s*** ~~***updates***~~*"*.

Allowable Subject Matter

Claims 19-36 and 39, though rejected under 35 U.S.C. 112(a), for purposes of 35 U.S.C. 102 and 103, are allowed over the prior art.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRENDAN HIGA whose telephone number is (571)272-5823. The examiner can normally be reached on Monday - Friday 8:30 AM - 5:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wing Chan can be reached on (571) 272-7493. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/BRENDAN Y HIGA/
Primary Examiner, Art Unit 2441

Notice of References Cited	Application/Control No. 17/142,983	Applicant(s)/Patent Under Reexamination Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20170257432-A1	09-2017	FU; TIANYING	H04L67/1014	1/1
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	Art Unit
	BRENDAN HIGA	2441

CPC - Searched*		
Symbol	Date	Examiner
H04L41/08,0895,12-122,22; 45/00,036,56-563,586,64,645,655,76; 67/34	12/14/2022	BH

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see SEARCH history	12/14/2022	BH
IP.com (NPL+Patents)	12/14/2022	BH
Google Scholar (see search history and results)	12/14/2022	BH
Reviewed prosecution history of US application 14/295331, particularly final rejection mailed on 12/28/2016	09/02/2022	BH
PALM inventor search	12/14/2022	BH

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H04L	41/08,0895,12-122,22; 45/00,036,56-563,586,64,645,655,76; 67/34	12/14/2022	BH

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
066

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	Art Unit
	BRENDAN HIGA	2441

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
067

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/01/2022	04/07/2022	09/04/2022	12/14/2022					
	1	✓	✓	-	-					
	2	✓	✓	-	-					
	3	✓	✓	-	-					
	4	✓	✓	-	-					
	5	✓	✓	-	-					
	6	✓	✓	-	-					
	7	✓	✓	-	-					
	8	✓	✓	-	-					
	9	✓	✓	-	-					
	10	✓	✓	-	-					
	11	✓	✓	-	-					
	12	✓	✓	-	-					
	13	✓	✓	-	-					
	14	✓	✓	-	-					
	15	✓	✓	-	-					
	16	✓	✓	-	-					
	17	✓	✓	-	-					
	18	✓	✓	-	-					
	19			✓	✓					
	20			✓	✓					
	21			✓	✓					
	22			✓	✓					
	23			✓	✓					
	24			✓	✓					
	25			✓	✓					
	26			✓	✓					
	27			✓	✓					
	28			✓	✓					
	29			✓	✓					
	30			✓	✓					
	31			✓	✓					
	32			✓	✓					
	33			✓	✓					
	34			✓	✓					
	35			✓	✓					
	36			✓	✓					
	37			✓	-					
	38			✓	-					
	39			✓	✓					

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IQSearchText-202212142148

Main Concept Document
==========
US10893095
Title: Distributed software defined networking

(No Concept Modifiers)
==========

Filters (1)
==========
Publication Date: To 2013-12-31

Options
==========
De-dup: Extended Family Numbers (PAT only)
Relevance Cut-off: None
Sort: Relevance

Content: Patents + NPL (192)
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Ireland Patents
Ireland Applications
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Kazakhstan Applications
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Russia Applications

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Turkey Patents
Turkey Applications
IEEE Xplore Publications: IEEE Periodicals
IEEE Xplore Publications: IEEE Conferences
IEEE Xplore Publications: IEEE Standards
IEEE Xplore Publications: IEEE Early Access
IEEE Xplore Publications: SMPTE Periodicals
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[BOOK] **Distributed** and **cloud computing**: from parallel processing to the internet of things [PDF] pace.edu
K Hwang, J Dongarra, GC Fox - 2013 - books.google.com
... cover **programming**, and the use of **distributed** or **cloud** systems in innovative Internet **applications**... A typical P2P network may involve millions of client machines working ...
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Cloudanalyst: A cloudsim-based visual modeller for analysing **cloud computing** environments and **applications** [PDF] ieee.org Full Text @ USPTO-STIC
B Wickremasinghe, RN Calheiros... - ... and applications, 2010 - ieeexplore.ieee.org
... to **distribute applications** among **Cloud infrastructures** and value added services such as optimization of **applications** ... Quantifying impact of number of **simultaneous** users, geographic ...
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[BOOK] Mastering **cloud computing**: foundations and **applications programming**
R Buyya, C Vecchiola, ST Selvi - 2013 - books.google.com
... **applications** for PCs to **cloud** datacenters that enable millions of users to use software **simultaneously**... to the concepts of parallel and **distributed computing**, Chapter 2 can be skipped. ...
Save Cite Cited by 491 Related articles All 5 versions

Load balancing in **cloud computing** using stochastic hill climbing-a soft **computing** approach [PDF] sciencedirect.com Full Text @ USPTO-STIC
B Mondal, K Dasgupta, P Dutta - Procedia Technology, 2012 - Elsevier
... in **cloud computing** provides an organization with the ability to **distribute application** requests **across** ... Quantifying impact of number of **simultaneous** users, geographic location of relevant ...
Save Cite Cited by 277 Related articles All 6 versions

[PDF] Availability and load balancing in **cloud computing** [PDF] academia.edu
Z Chaczko, V Mahadevan, S Aslanzadeh... - ... on Computer and ..., 2011 - academia.edu
... , **across** multiple availability zones, reduces the chance of outages that could **simultaneously** affect the services in **cloud** ... to use **distributed applications through** different computers on ...
Save Cite Cited by 271 Related articles All 5 versions

Multimedia **cloud computing** [PDF] ieee.org Full Text @ USPTO-STIC
W Zhu, C Luo, J Wang, S Li - IEEE Signal Processing ... , 2011 - ieeexplore.ieee.org
... users' **simultaneous** accesses at the Internet scale. In today's **cloud computing**, the **cloud** uses a ... P2P multimedia computing refers to a **distributed application** architecture that partitions ...
Save Cite Cited by 564 Related articles All 3 versions

[PDF] Above the **clouds**: A berkeley view of **cloud computing** [PDF] ust.hk
M Armbrust, A Fox, R Griffith, AD Joseph, RH Katz... - 2009 - cse.ust.hk
... Hours purchased via **Cloud Computing** can be **distributed** ... **computing programmers** to rewrite their **programs** using more ... be for the **Cloud Computing** provider to offer **simultaneous** gang ...
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Modeling and simulation of scalable **Cloud computing** environments and the CloudSim toolkit: Challenges and opportunities [PDF] ieee.org Full Text @ USPTO-STIC

R Buyya, R Ranjan... - ... performance computing & ..., 2009 - ieeexplore.ieee.org
... SimGrid is a generic framework for simulation of **distributed applications** on Grid platforms. ... As discussed earlier, a host can **simultaneously** instantiate multiple VMs and allocate cores ...
Save Cite Cited by 1525 Related articles All 16 versions

A survey of mobile **cloud computing**: architecture, **applications**, and approaches [PDF] wiley.com Full View
HT Dinh, C Lee, D Niyato... - ... and mobile computing, 2013 - Wiley Online Library
... sharing files and folders **across** multiple devices **simultaneously**. ... **distributed** partitioning system called Coign, which automatically transforms a **program** into the **distributed applications** ...
Save Cite Cited by 3012 Related articles All 11 versions

[PDF] Above the **clouds**: A berkeley view of **cloud computing** [PDF] academia.edu
A Fox, R Griffith, A Joseph, R Katz... - Dept. Electrical Eng ..., 2009 - academia.edu
... Hours purchased via **Cloud Computing** can be **distributed** ... **computing programmers** to rewrite their **programs** using more ... be for the **Cloud Computing** provider to offer **simultaneous** gang ...
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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	0	17/142983.app.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 02:45 PM
L2	282077	(H04L41/08,0895,12-122,22 H04L45/00,036,56-563,586,64,645,655,76 H04L67/34).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:28 PM
L3	329726	(cloud docker kubernetes SDN NFV Open$1flow open$1stack VM virtual$4) adj15 (install$6 deploy$5 orchestrat$6)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:29 PM
L4	486189	(Program$6 API) adj10 (cloud docker kubernetes SDN NFV Open$1flow	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2022/12/14 04:31 PM

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		open$1stack VM virtual$4)	CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L5	17715	(simultaneous$2 concurrent$3 synchronous$3) SAME 4	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:33 PM
L6	291	2 AND 3 AND 5	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:33 PM
L7	40	6 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2022/12/14 04:33 PM

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			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L8	185398	(cloud docker kubernetes SDN NFV Open$1flow open$1stack VM virtual$4) adj15 (deploy$5 orchestrat$6)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:35 PM
L9	6273	2 AND 4 AND 8	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:35 PM
L10	3037	2 AND 4 SAME2 8	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:35 PM
L11	39257	(Program$6 API) adj15 (distribut$4 ADJ5 (service application app))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2022/12/14 04:37 PM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L12	121	11 AND 10	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:37 PM
L13	34	12 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/12/14 04:44 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	692	(simultaneous$2 concurrent$3 synchronous$3).CLM. SAME (Program$6 API) adj10 (cloud docker kubernetes SDN NFV Open$1flow open$1stack VM virtual$4).CLM.	(US-PGPUB; USPAT)	OR	ON	ON	2022/12/14 04:30 PM

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N2	72329	(H04L41/08,0895,12-122,22 H04L45/00,036,56-563,586,64,645,655,76 H04L67/34).cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2022/12/14 04:30 PM
N3	21	N1 AND N2	(US-PGPUB; USPAT)	OR	ON	ON	2022/12/14 04:30 PM
N4	7	N3 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT)	OR	ON	ON	2022/12/14 04:30 PM
N5	183382	(Program$6 API) adj10 (cloud docker kubernetes SDN NFV Open$1flow open$1stack VM virtual$4)	(US-PGPUB; USPAT)	OR	ON	ON	2022/12/14 04:31 PM

Web Search History

date, time	web site	search string
12/14/2022 4:17:46 PM	Google Scholar	programmable cloud infrastructure for wireless or mobile or cellular network
12/14/2022 4:17:53 PM	Google Scholar	programmable cloud infrastructure for wireless or mobile or cellular network [before:2013]
12/14/2022 4:18:09 PM	Google Scholar	[before:2013] programmable cloud infrastructure for wireless or mobile or cellular network and "API"
12/14/2022 4:51:53 PM	Google Scholar	[before:2013] simultaneous programmable cloud infrastructure for wireless or mobile or cellular network and "API"
12/14/2022 4:52:59 PM	Google Scholar	[before:2013] APIs for programming distributed applications in a cloud infrastructure
12/14/2022 4:53:41 PM	Google Scholar	[before:2013] simultaneous programming of distributed applications across a cloud infrastructure

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Electronic Acknowledgement Receipt

EFS ID:	46648801
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	19-SEP-2022
Filing Date:	06-JAN-2021
Time Stamp:	22:41:39
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Request for Reconsideration-After Non-Final Rejection	TAAG001CONT3_RESPONSE_____.pdf	92731 58c844be5813c5097b0f89b7f0ac13ccdd52db22	no	9

Warnings:

Information:	
Total Files Size (in bytes):	92731

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Taaghol
Serial No.: 17/142,983
Filed: 1/6/2021
Attorney Docket No.: TAAG001CONT3

Examiner: Higa
Art Unit: 2441

For: DISTRIBUTED SOFTWARE DEFINED NETWORKING

Mail Stop Amendment
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE

Applicants offer the following election in response to the Office Action (hereinafter "Office Action") mailed on September 13, 2022.

Amendments to the Claims begin on page 2 of this paper.
Remarks begin on page 8 of this paper.

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In The Claims:

1. (Canceled)
2. (Canceled)
3. (Canceled)
4. (Canceled)
5. (Canceled)
6. (Canceled)
7. (Canceled)
8. (Canceled)
9. (Canceled)
10. (Canceled)
11. (Canceled)
12. (Canceled)
13. (Canceled)
14. (Canceled)
15. (Canceled)
16. (Canceled)
17. (Canceled)
18. (Canceled)

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19. (Currently Amended) A system comprising ~~a plurality of network elements, said network elements comprising~~:

a programmable network device adapted to host a plurality of [first] network device applications;

a programmable cloud device adapted to host a plurality of [second network] cloud applications, wherein the plurality of [first] network device applications ~~in the programmable network device~~ and the plurality of [second network] cloud applications ~~in the programmable cloud device~~ are in secure communication with each other to form distributed applications; and

wherein the ~~programmable~~ plurality of network device applications and ~~programmable~~ plurality of cloud applications ~~device~~ form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) [that] to ~~allow for simultaneous programming of~~ simultaneously program the [programmable] plurality of network device applications and [programmable] plurality of cloud applications [device] independent of network device hardware and cloud device hardware.

20. (Currently Amended) The system of claim 19, wherein ~~each of~~ the programmable network device and the programmable cloud device each include an access network interface unit configured to send and receive communications and a processor with a memory associated with the access network interface unit.

21. (Currently Amended) The system of claim 19 further comprising:

an application management portal capable of managing life cycles of the distributed applications; and

an infrastructure application ~~market place~~ marketplace in communication with the applicationmanagement portal, said infrastructure ~~market place~~ marketplace capable of providing tested ~~and certified~~ distributed applications to the application management portal.

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22. (Currently Amended) The system of claim 21, wherein the application management portal is capable of at least one of the group consisting of: receiving new applications from the infrastructure application marketplace ~~market place~~; testing said distributed applications prior to deployment; provision said distributed applications; and deprovision said distributed applications.

23. (Currently Amended) The system of claim 19, wherein [the] at least one of the ~~first~~ plurality of network device applications is responsible for a plurality of functional capabilities of the programmable network device and is capable of at least one of the group consisting of: updating firmware of the programmable network device; updating default communication protocols of the programmable network device; initializing programmable network device settings; boot loading the programmable network device; providing security digital certificates; providing operating system (OS) and kernel upgrades; and upgrading and commissioning agents for [the first] at least one of the plurality of network device ~~application~~ applications upgrades and related procedures.

24. (Currently Amended) The system of claim 19, wherein [the] at least one of the ~~second network~~ plurality of cloud applications is responsible for a plurality of functional capabilities of the programmable cloud device and is capable of at least one of the group consisting of: upgrading and commissioning agents for the [second network] plurality of cloud application updates ~~and related procedures~~; hypervisor upgrades; virtual machine and isolated execution environment lifecycle management; security digital certificate management; operating system (OS) and kernel upgrades; and default communication protocols.

25. (Currently Amended) The system of claim 19, wherein the ~~progrmmable~~ programmable network device is an LTE eNB and the programmable cloud device hosts [an] LTE core network functions in separate virtual machines from the group consisting of: MME, S-GW, and P-GW.

26. (Currently Amended) The system of claim 19, ~~wherein the programmable network device and programmable cloud device further comprise~~ further comprising:

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a virtual fabric which provides a secure communication layer for said at least one of the [first] plurality of network device applications and said at least one of the [second network] plurality of cloud applications.

27. (Currently Amended) The system of claim 19, further comprising:

a second programmable network device which includes at least one of the [first] plurality of network device applications which is the same as [the] at least one of the [first] plurality of network device applications in the [first] programmable network device and where each of the [first] network device applications can communicate directly.

28. (Currently Amended) The system of claim 21~~, wherein the programmable network device and the programmable cloud device further comprise~~ further comprising:

a distributed resource service (DRS) which controls access to a plurality of resources upon receiving instructions from the application management portal.

29. (Currently Amended) The system of claim 28, wherein the plurality of resources include at least one of a group consisting of: a firewall; data and statistics; storage; ~~compute;~~ a load evaluator; general settings; a routing engine; a virtual machine master controller; a power controller; and a wireless engine.

30. (Currently Amended) The system of claim 19~~, wherein the programmable network device and programmable cloud device further comprise~~ further comprising:

a distributed resource service which is capable of providing at least one service from a group consisting of: exposing application programming interfaces (APIs) to other applications; configuring and managing platform resources; policy enforcement and authorization of the plurality of network device applications and the plurality of cloud applications access to platform resources ~~resource and other application's APIs~~; and policy conflict resolution.

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31. (Currently Amended) The system of claim 19~~, wherein the programmable network device and the programmable cloud device further comprise~~ further comprising:

a distributed content service wherein contents generated by the at least one of the plurality of [first] network device applications are shared with [the] at least one of the plurality of ~~second network~~ cloud applications.

32. (Currently Amended) The system of claim 21~~, wherein the flexible network device and flexible cloud platform further comprise~~ further comprising:

a distributed notification service wherein notice of a predetermined event is sent from [the] at least one ~~fxDeviceApp~~ of the plurality of network device applications to [the] at least one of the plurality of cloud applications ~~fxCloudApp~~.

33. (Currently Amended) The system of claim 28, wherein the DRS further includes a load controller~~; and wherein the load controller is~~ adapted to monitor loads on [the] at least one of the plurality of [first] network device applications and at least one of the plurality of ~~second network~~ cloud applications and effect change in accordance with thresholds received from the application management portal.

34. (Currently Amended) The system of claim 19, wherein the programmable network device, at least one of the plurality of [first] network device applications, the programmable cloud device, and the at least one of the plurality of ~~second network~~ cloud applications each have unique identities.

35. (Currently Amended) The system of claim 19, wherein [the] at least one of the plurality of [first] network device applications and at least one of the plurality of ~~second network~~ cloud applications are given an access level to determine which APIs can be accessed.

36. (Currently Amended) The system of claim 19, wherein the ~~at least one~~ programmable network device and the programmable cloud device are adapted to verify the authenticity and integrity of updates to the plurality of network device

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applications and the plurality of cloud applications.

37. (Canceled)

38. (Canceled)

Please add the following new claim:

39. (New) A system comprising:

a programmable network device adapted to host a plurality of network device applications;

a programmable cloud device adapted to host a plurality of cloud applications, wherein the plurality of network device applications and the plurality of cloud applications are in secure communication with each other to form distributed applications;

wherein the plurality of network device applications and plurality of cloud applications form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) to simultaneously program the plurality of network device applications and plurality of cloud applications independent of network device hardware and cloud device hardware

an application management portal capable of managing life cycles of the plurality of network device applications and plurality of cloud applications; and

an infrastructure application marketplace in communication with the application management portal, said infrastructure marketplace capable of providing tested distributed applications to the application management portal.

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REMARKS

Claims 1-18 and 37-38 are canceled. Claim 39 has been added. Claims 19-36 and 39 are pending.

REJECTIONS UNDER 35 USC §112(a)

Claims 19-36 are rejected under 35 USC §112(a). Page 3 of the Office Action states:

> **As per claims 19-36 the limitation "...wherein the programmable network device and programmable cloud device *form unified capabilities enabling a plurality of upper layer application programming interfaces (AP/s) that allow for simultaneous programming of the programmable network device and programmable cloud device independent of network device hardware and cloud device hardware",* does not appearto be described in the specification in such a way as to reasonably convey to one skilledin the relevant art that the inventor or a joint inventor, or for applications subject to pre- AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.**
>
> **Particularly Applicant's specification is completely silent as to the steps or processes for the *"simultaneous programming of the programmable network device and programmable cloud device independent of network device hardware and cloud device hardware".***

The Examiner's attention is pointed to paragraph [0030] of the specification which states (underling added):

> **[0030] Although process (or method) steps may be described or claimed in a particular sequential order, such processes may be configured to work in different orders. Further, some steps may be performed simultaneously despite being described or implied as occurring non-simultaneously (e.g., because one step is described after the other step) unless specifically indicated.**

It is respectfully submitted that the use of "simultaneously" in independent claim 19 (as well as new independent claim 39) is in accordance with paragraph [0030].

REJECTIONS UNDER 35 USC §102(a)(2)

Claims 37-38 are rejected under 35 USC §102(a)(2) as being anticipated by U.S. Patent Publication No. 2013/0054763 to Van der Merwe (hereinafter, "Van der Merwe").

Accordingly, Applicant has canceled claims 37 and 38.

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REMARKS

It is respectfully submitted that claims 19-36 and 39 are allowable over the prior art of record. No new matter has been added in the new claims and/or limitations presented in this Amendment.

Respectfully submitted,
ROARK IP
By: /Christopher J. Horgan/

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Registration No. 40,394
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Telephone: (408) 687-8306

Date: September 19, 2022

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/142,983	Filing Date 01/06/2021	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	09/19/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $240 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/SHERRY A DAVIS/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 09/13/2022

Roark IP
1438 Dahlia Loop
San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	

ART UNIT	PAPER NUMBER
2441	

MAIL DATE	DELIVERY MODE
09/13/2022	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 17/142,983	Applicant(s) Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 07/25/2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 19-38 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 19-38 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 01/06/2021 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on July 25, 2022 has been entered.

Claims 19-38 are pending.

Response to Arguments

Applicant's new claims 19-38 overcome the previous statutory Double Patenting rejection.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112(a):

> (a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.

The following is a quotation of the first paragraph of pre-AIA 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 19-36 are rejected under 35 U.S.C. 112(a) or 35 U.S.C. 112 (pre-AIA), first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for applications subject to pre-AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.

As per claims 19-36 the limitation "…wherein the programmable network device and programmable cloud device *form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) that allow for simultaneous programming of the programmable network device and programmable cloud device independent of network device hardware and cloud device hardware*", does not appear to be described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for applications subject to pre-AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.

Particularly Applicant's specification is completely silent as to the steps or processes for the "*simultaneous programming of the programmable network device and programmable cloud device independent of network device hardware and cloud device hardware".*

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale or otherwise available to the public before the effective filing date of the claimed invention.
>
> (a)(2) the claimed invention was described in a patent issued under section 151, or in an application for patent published or deemed published under section 122(b), in which the patent or application, as the case may be, names another inventor and was effectively filed before the effective filing date of the claimed invention.

Claims 37-38 are rejected under 35 U.S.C. 102(a)(2) as being anticipated by Van Der Merwe et al. (US 2013/0054763) ("Van der Merwe").

As per claim 37, Van Der Merwe, teaches a system comprising a plurality of network elements (*see Fig. 1-2*), said network elements comprising:

a programmable cloud device having a plurality of virtual machines (*i.e., a cloud computing data center comprising virtual machines, see ¶0025, and ¶0083, i.e., "virtualized content server 510 includes the virtual machines VM X3 and VM X4 provisioned for the Client X"*), wherein each of the virtual machines has at least one of a plurality of first network applications (*hosting enterprise applications, see ¶0083*); and

a programmable network device (*i.e., edge router, see abstract and Fig. 2, ref. 232*) adapted to process data flows (*i.e., network traffic, including filtering and/or firewall functioning, read as "processing" data flows, see ¶0063*) having at least one of a plurality of second network applications (*i.e., operating as a logical router, see ¶0062, read as a second network application*), wherein the first and second network

applications are in secure communication to form a distributed application (*i.e., "virtualized platform", see ¶0002, and/or "an overlay network", see ¶0019, read as a distributed application, also see ¶0019, "an overlay network to provide secure connection(s)", also see ¶0105, "The updating of the VRF tables causes the routers 204-208 and 232 to transmit securely communications received from the interface 114 of a VPMN with a destination address of a virtual machine through the IP network 102 along the virtual route 326")*.

As per claim 38, Van der Merwe teaches a system comprising a plurality of network elements (*see Fig. 1-2*), said network elements comprising:

a programmable cloud device having a plurality of zones (*i.e., a cloud computing data center comprising virtual machines, see ¶0025, read as isolated "zones")*, wherein each of the plurality of zones has at least one of a plurality of first network applications (*hosting enterprise applications, see ¶0083)*; and

a programmable network device adapted to process data flows (*i.e., network traffic, including filtering and/or firewall functioning, read as "processing" data flows, see ¶0063*) having at least one of a plurality of second network applications, wherein the first and second network applications are in secure communication to form a distributed application (*i.e., "virtualized platform", see ¶0002, and/or "an overlay network", see ¶0019, read as a distributed application, also see ¶0019, "an overlay network to provide secure connection(s)", also see ¶0105, "The updating of the VRF tables causes the routers 204-208 and 232 to transmit securely communications received from the*

interface 114 of a VPMN with a destination address of a virtual machine through the IP network 102 along the virtual route 326").

Allowable Subject Matter

Claims 19-36 are allowed over the prior art.

The following is an examiner's statement of reasons for allowance:

The prior art does not teach or render obvious to one of ordinary skill in the art, before the earliest effective filing date of the claimed invention, in the specific combinations and manner recited within the claims, the features of:

"…wherein the programmable network device and programmable cloud device *form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) that allow for simultaneous programming of the programmable network device and programmable cloud device independent of network device hardware and cloud device hardware*."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRENDAN HIGA whose telephone number is (571)272-5823. The examiner can normally be reached on Monday - Friday 8:30 AM - 5:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an

interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wing Chan can be reached on (571) 272-7493. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/BRENDAN Y HIGA/
Primary Examiner, Art Unit 2441

Notice of References Cited	Application/Control No. 17/142,983	Applicant(s)/Patent Under Reexamination Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8762501-B2	06-2014	Kempf; James	H04L47/825	709/228
*	B	US-20150071053-A1	03-2015	Kempf; James	H04W24/02	370/216
*	C	US-20130054763-A1	02-2013	Van der Merwe; Jacobus	H04W8/12	709/220
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	Art Unit
	BRENDAN HIGA	2441

CPC - Searched*		
Symbol	Date	Examiner
H04L41/08,0895,22; 45/00,56-563,586,64,645,655,76; 67/34	09/05/2022	BH

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see SEARCH history	09/05/2022	BH
IP.com (NPL+Patents)	09/05/2022	BH
Google Scholar (see search history and results)	09/05/2022	BH
Reviewed prosecution history of US application 14/295331, particularly final rejection mailed on 12/28/2016	09/02/2022	BH

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H04L	41/08,0895,22; 45/00,56-563,586,64,645,655,76; 67/34	09/05/2022	BH

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/01/2022	04/07/2022	09/04/2022						
	1	✓	✓	-						
	2	✓	✓	-						
	3	✓	✓	-						
	4	✓	✓	-						
	5	✓	✓	-						
	6	✓	✓	-						
	7	✓	✓	-						
	8	✓	✓	-						
	9	✓	✓	-						
	10	✓	✓	-						
	11	✓	✓	-						
	12	✓	✓	-						
	13	✓	✓	-						
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	36			✓						
	37			✓						
	38			✓						

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IQSearchText-202209051736

Main Concept Document
==========
US9843624
Title: Distributed software defined networking
Abstract: The Distributed Software Defined Network (dSDN) disclosed herein is an end-to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

(No Concept Modifiers)
==========

Filters (1)
==========
Publication Date: To 2013-12-31

Options
=======
De-dup: Extended Family Numbers (PAT only)
Cut-off: None
Sort: Relevance

Content: Patents + NPL (190)
==========
US Patents
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US Applications
EPO Patents
EPO Applications
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Japan Patents
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OnePetro.org: Conferences at OnePetro.org
Other Literature: IBM Redbooks
Other Literature: PubMed Central
Other Literature: arXiv.org

Mobile **fog**: A **programming** model for large-scale applications on the **internet** of things

K Hong, D Lillethun, U Ramachandran... - ... on Mobile **cloud** ..., 2013 - dl.acm.org

... On the other hand, we provide the point-to-point **API** to support communication with mobile ... events stored at each Mobile **Fog** process running on **edge fog** nodes in the MCEP scenario. ...

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Methods, devices, and media for securely utilizing a non-secured, **distributed**, virtualized **network** resource with applications to **cloud**-computing security and ...

G Parann-Nissany - US Patent App. 12/887,547, 2011 - Google Patents

... this **API** appears similar to the **API** of the **cloud** resource (eg HTTP-based REST **API**), differing from the **cloud**-resource **API** only ... of URLs and addresses by the **cloud** interface proxy. The ...

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Clouds of virtual machines in **edge networks**

A Manzalini, R Minerva, F Callegati... - IEEE ..., 2013 - ieeexplore.ieee.org

... This floating "**fog**" of ICT resources at the **edge** will give rise to new business models based on ... an open application **programming** interface (**API**) for **programming** the **network** at various ...

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Cloud computing gateway, **cloud** computing hypervisor, and methods for implementing same

DC Hilt - US Patent 8,514,868, 2013 - Google Patents

... account 960, and the Sungard **cloud** provider **network** account 965) has a unique **API** and a corresponding back-end plug-in 915. It will be appreciated that, in other embodiments, each ...

☆ Save 99 Cite Cited by 425 Related articles All 4 versions »

Bridging enterprise **networks** into **cloud**

P Lahiri, PK Patel, DA Maltz, A Greenberg... - US Patent App. 12 ..., 2010 - Google Patents

... In another implementation, management service 120 may provide an application **programming** interface (**API**) of management functions to users. Management service 120 may be ...

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Application Aware **Networking**

WC Stillwell III, PE Harris - US Patent App. 11/971,355, 2009 - Google Patents

... , that cutting **edge** content always exceeds the capacity of the **network** to deliver it. For ... **programming** interface (**API**), for use by a developer or tester, and/or included within the **network** ...

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Java application framework for use in a content delivery **network** (CDN)

AT Davis, J Parikh, S Pichai, E Ruvinsky ... - US Patent ..., 2006 - Google Patents

... a globally **distributed** computing platform, such as an **Internet** content delivery **network** (CDN). ... **distributed edge** layer and a centralized origin layer. In a representative embodiment, the ...

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Applying policies to **schedule network** bandwidth among virtual machines

Y Zuo, HY Chau, HH Vo, SN Arafeh... - US Patent ..., 2013 - Google Patents

... In one instance, updates to the client contracts may be made via a user-mode **API** that ... absolute bandwidth may be entered at the user-mode **API**. The "relative weighting" and the "...

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Application Resource Manager over a **Cloud**

MV Devarakonda, NA Joukov, B Pfitzmann... - US Patent App. 13 ..., 2013 - Google Patents

... a communications **network**. In a **distributed cloud** computing environment, **program** modules ... here that either this also contains an **API** (application **programming** interface), web service ...

☆ Save 99 Cite Cited by 122 Related articles All 2 versions »

System and method for grid and **cloud** computing

R Buyya, S Venugopal, X Chu, K Nadiminti - US Patent 8,230,070, 2012 - Google Patents

... **Network** 10 allows a user to implement various parallel and **distributed programming** models, as is ... In addition, the threading **programming** model, and core MPI **APIs** or the Map Reduce ...

☆ Save 99 Cite Cited by 178 Related articles All 4 versions »

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	3	("20140241158" "20120300615" "20090276771").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/02 10:48 AM
L2	1	14/295331.app.	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/02 12:10 PM
L3	92	("7114021" | "7630706" | "8132166" | "8528108" | "8650299" | "8756595" | "8843933" | "9226333" | "20020016954" | "20040107417" | "20040237081" | "20050246703" | "20070078988" | "20080209491" | "20090007091" | "20090113327" | "20090276771" | "20090300057" | "20110075611" | "20120300615" | "20130007254" | "20130160147" | "20130263104" | "20140052976" | "20140241158" | "20140254373" | "20140259012" | "20140317293" | "20150173121").pn. OR ("9843624").urpn. AND (PGPB | USPT | USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/02 12:43 PM
L4	3	("20150071053" "8762501" "20130054763").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/02 04:02 PM
L5	78988	(H04L45/00,586,64,645,655,76).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/04 01:05 PM

L6	6574	(docker kubernetes SDN NFV Open$1flow open$1stack VM virtual$4) SAME (simultaneous$2 concurrent$3 synchronous$3) adj5 (program$5 install$6 deploy$5 orchestrat$4)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/04 01:06 PM
L7	14	5 AND 6 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/04 01:07 PM
L8	65635	(H04L41/08,0895,22).CPC.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/04 03:34 PM
L11	11	6 AND 8 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2022/09/04 03:34 PM

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
113

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L12	1678	(cloud) SAME (simultaneous$2 concurrent$3 synchronous$3) adj5 (program$5 install$6 deploy$5 orchestrat$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/04 03:36 PM
L13	0	12 AND (5 8) AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/04 03:36 PM
L14	1	("10893095").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/05 12:48 PM
L15	39	(Artificial Intelligence) More like doc: US-10893095-B1 Text: (US-9843624-B1 OR US-10686871-B1 OR US-20180139109-A1 OR US-20220038530-A1 OR US-10904108-B2 OR US-20200244552-A1 OR US-20200067797-A1 OR US-11153367-B2 OR US-10523531-B2 OR CN-114095196-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/05 12:48 PM

		OR US-10911558-B1 OR US-10887130-B2 OR CN-113039768-A OR US-10904107-B2 OR WO-2021080800-A1 OR US-10819650-B2 OR US-20210119971-A1 OR CN-114365454-A OR US-11019035-B2 OR US-20200412823-A1).did.					
L16	40	("7114021" | "7630706" | "8132166" | "8495611" | "8528108" | "8650299" | "8756595" | "8843933" | "9226333" | "20020016954" | "20040107417" | "20040237081" | "20050246703" | "20060271341" | "20070078988" | "20080209491" | "20090007091" | "20090113327" | "20090276771" | "20090300057" | "20110075611" | "20110265077" | "20120066665" | "20120096071" | "20120266156" | "20120300615" | "20130007254" | "20130160147" | "20130223442" | "20130263104" | "20140052976" | "20140241158" | "20140254373" | "20140259012" | "20140317293" | "20150160877" | "20150173121" | "20150242237" | "20160224460" | "20190165997").pn. OR ("10893095").urpn. AND (PGPB | USPT | USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/05 12:49 PM
L17	0	(6 12) AND (15 16)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/05 12:49 PM
L18	2	5 AND 8 AND (15 16)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/05 12:50 PM
L19	0	17/142983.app.	(US-PGPUB; USPAT;	OR	ON	ON	2022/09/05

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				02:35 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	175	(cloud docker kubernetes SDN NFV Open$1flow open$1stack VM virtual$4) SAME (simultaneous$2 concurrent$3 synchronous$3) adj5 (program$5 install$6 deploy$5 orchestrat$4).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/04 03:37 PM
N2	126	N1 AND (@pd @ptad @prad @ad @rlad)<"20130613"	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/04 03:37 PM

Web Search History

date, time	web site	search string
9/5/2022 1:30:47 PM	Google Scholar	[before:2013] programmable cloud or fog or edge for wireless network
9/5/2022 1:31:00 PM	Google Scholar	[before:2013] programmable cloud or fog or edge for wireless network and "simulatneous"
9/5/2022 1:31:03 PM	Google Scholar	[before:2013] programmable cloud or fog or edge for wireless network and "simultaneous"
9/5/2022 1:31:49 PM	Google Scholar	programmable cloud or fog or edge for wireless network and "simultaneous" [before:2013]
9/5/2022 1:55:27 PM	Google Scholar	[before:2013] API for programming "distributed" cloud or fog or edge network
9/5/2022 1:55:36 PM	Google Scholar	API for programming "distributed" cloud or fog or edge network [before:2013]
9/5/2022 2:00:41 PM	Google Scholar	[before:2013] API for programming "distributed" "OpenFlow" applications
9/5/2022 2:01:35 PM	Google Scholar	[before:2013] API for "simultaneous" programming "distributed" cloud or SDN network
9/5/2022 2:02:00 PM	Google Scholar	[before:2013] API for programming "distributed" cloud or SDN network

PTO/SB/30 (11-17)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	17/142,983
Filing Date	1/6/2021
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. ☐ Other _____

   b. ☑ Enclosed

      i. ☑ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☐ Information Disclosure Statement (IDS)

      iv. ☐ Other _____

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☐ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. _____.

      i. ☐ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other _____

   b. ☐ Check in the amount of $ _____ enclosed

   c. ☐ Payment by credit card (Form PTO-2038 enclosed)

   d. ■ Payment by EFS-Web

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Christopher J. Horgan/	Date	July 19, 2022
Name (Print/Type)	Christopher J. Horgan	Registration No.	40,394

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being EFS-Web transmitted to the United States Patent and Trademark Office (USPTO), deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the USPTO on the date shown below.

Signature			
Name (Print/Type)		Date	

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal

Application Number:	17142983
Filing Date:	06-Jan-2021
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Filer:	Christopher James Horgan
Attorney Docket Number:	TAAG001CONT3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 1 month with $0 paid	2251	1	110	110
Miscellaneous:				
RCE- 1ST REQUEST	2801	1	680	680
		Total in USD ($)		**790**

Electronic Acknowledgement Receipt	
EFS ID:	46267413
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	25-JUL-2022
Filing Date:	06-JAN-2021
Time Stamp:	20:00:34
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$790
RAM confirmation Number	E20227OK02063353
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	TAAG001CONT3_RCE_____.pdf	169822 0e57507d70ae53e8d9a774d271e872aaeecc3ef4	no	1
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
2	Amendment Submitted/Entered with Filing of Continued Prosecution Application (CPA)/Request for Continued Examination(RCE)	TAAG001CONT3_RESPONSE_____.pdf	62108 c0bb4d78245da630d85881d156093b747af798cb	no	8
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Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	40603 3f3a1bf6758b310896762661d51e0f0a1583e658	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	272533		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Taaghol
Serial No.: 17/142,983
Filed: 1/6/2021
Attorney Docket No.: TAAG001CONT3

Examiner: Higa
Art Unit: 2441

For: DISTRIBUTED SOFTWARE DEFINED NETWORKING

Mail Stop Amendment
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE

Applicants offer the following election in response to the Office Action (hereinafter "Office Action") mailed on April 8, 2022.

Amendments to the Claims begin on page 2 of this paper.
Remarks begin on page 7 of this paper.

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In The Claims:

1. (Canceled)
2. (Canceled)
3. (Canceled)
4. (Canceled)
5. (Canceled)
6. (Canceled)
7. (Canceled)
8. (Canceled)
9. (Canceled)
10. (Canceled)
11. (Canceled)
12. (Canceled)
13. (Canceled)
14. (Canceled)
15. (Canceled)
16. (Canceled)
17. (Canceled)
18. (Canceled)

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Please add the following new claims:

19. (New) A system comprising a plurality of network elements, said network elements comprising:

a programmable network device adapted to host a plurality of first network applications;

a programmable cloud device adapted to host a plurality of second network applications, wherein the plurality of first network applications in the programmable network device and the plurality of second network applications in the programmable cloud device are in secure communication with each other to form distributed applications; and

wherein the programmable network device and programmable cloud device form unified capabilities enabling a plurality of upper layer application programming interfaces (APIs) that allow for simultaneous programming of the programmable network device and programmable cloud device independent of network device hardware and cloud device hardware.

20. (New) The system of claim 19, wherein each of the programmable network device and programmable cloud device include an access network interface unit configured to send and receive communications and a processor with a memory associated with the access network interface unit.

21. (New) The system of claim 19 further comprising:

an application management portal capable of managing life cycles of the distributed applications; and

an infrastructure application market place in communication with the application management portal, said infrastructure market place capable of providing tested and certified distributed applications to the application management portal.

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22. (New) The system of claim 21, wherein the application management portal is capable of at least one of the group consisting of: receiving new applications from the infrastructure application market place; test said distributed applications prior to deployment; provision said distributed applications; and deprovision said distributed applications.

23. (New) The system of claim 19, wherein the at least one of the first network applications is responsible for a plurality of functional capabilities of the programmable network device and is capable of at least one of the group consisting of: updating firmware of the programmable network device; updating default communication protocols of the programmable network device; initializing programmable network device settings; boot loading the programmable network device; providing security digital certificates; providing operating system (OS) and kernel upgrades; and upgrading and commissioning agents for the first network application upgrades and related procedures.

24. (New) The system of claim 19, wherein the at least one of the second network applications is responsible for a plurality of functional capabilities of the programmable cloud device and is capable of at least one of the group consisting of: upgrading and commissioning agents for the second network application updates and related procedures; hypervisor upgrades; virtual machine and isolated execution environment lifecycle management; security digital certificate management; OS and kernel upgrades; and default communication protocols.

25. (New) The system of claim 19, wherein the progrmmable network device is an LTE eNB and the programmable cloud device hosts an LTE core network functions in separate virtual machines from the group consisting of: MME, S-GW, and P-GW.

26. (New) The system of claim 19, wherein the programmable network device and programmable cloud device further comprise:

a virtual fabric which provides a secure communication layer for said at least one of the first network applications and said at least one of the second network

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applications.

27. (New) The system of claim 19, further comprising:

a second programmable network device which includes at least one of the first network applications whichis the same as the at least one of the first network applications in the first programmable network device and where each of the first network applications can communicate directly.

28. (New) The system of claim 21, wherein the programmable network device and the programmable cloud device further comprise:

a distributed resource service (DRS) which controls access to a plurality of resources upon receiving instructions from the application management portal.

29. (New) The system of claim 28, wherein the resources include at least one of a group consisting of: firewall; data and statistics; storage; compute; load evaluator; general settings; routing engine; virtual machine master controller; power controller; and wireless engine.

30. (New) The system of claim 19, wherein the programmable network device and programmable cloud device further comprise:

a distributed resource service which is capable of providing at least one service from a group consisting of: exposing application programming interfaces (APIs) to other applications; configuring and managing platform resources; policy enforcement and authorization of applications access to platform resource and other application's APIs; and policy conflict resolution.

31. (New) The system of claim 19, wherein the programmable network device and the programmable cloud device further comprise:

a distributed content service wherein contents generated by the at least one of the plurality of first network applications are shared with the at least one of the plurality of second network applications.

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32. (New) The system of claim 21, wherein the flexible network device and flexible cloudplatform further comprise:

a distributed notification service wherein notice of a predetermined event is sent from the at least one fxDeviceApp to the at least one fxCloudApp.

33. (New) The system of claim 28, wherein the DRS further includes a load controller; and wherein the load controller is adapted to monitor loads on the at least one of the plurality of first network applications and at least one of the plurality of second network applications and effect change in accordance with thresholds received from the application management portal.

34. (New) The system of claim 19, wherein the programmable network device, at least one of the plurality of first network applications, the programmable cloud device, and the at least one of the plurality of second network applications each have unique identities.

35. (New) The system of claim 19, wherein the at least one of the plurality of first network applications and at least one of the plurality of second network applications are given an access level to determine which APIs can be accessed.

36. (New) The system of claim 19, wherein the at least one programmable network device and programmable cloud device are adapted to verify the authenticity and integrity of updates.

37. (New) A system comprising a plurality of network elements, said network elements comprising:

a programmable cloud device having a plurality of virtual machines, wherein of the virtual machines has at least one of a plurality of first network applications; and

a programmable network device adapted to process data flows having at least one of a plurality of second network applications, wherein the first and second network applications are in secure communication to form a distributed application.

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38. (New) A system comprising a plurality of network elements, said network elements comprising:

a programmable cloud device having a plurality of zones, wherein of the plurality of zones has at least one of a plurality of first network applications; and

a programmable network device adapted to process data flows having at least one of a plurality of second network applications, wherein the first and second network applications are in secure communication to form a distributed application.

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REMARKS

Claims 1-18 are canceled. Claims 19-38 have been added.

DOUBLE PATENTING REJECTIONS

Claims 1-18 are rejected on the ground of statutory double patenting as being unpatentable over U.S. Patent No. 10,893,095.

Applicant has canceled claims 1-18 and added new claims 19-38 which are not coextensive in scope with the prior applications of this family. No new matter has been added in the new claims and/or limitations presented in this Amendment.

Respectfully submitted,
ROARK IP
By: /Christopher J. Horgan/

Christopher J. Horgan
Registration No. 40,394
1438 Dahlia Loop
San Jose, CA 95126
Telephone: (408) 687-8306

Date: July 19, 2022

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/142,983	Filing Date 01/06/2021	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	07/25/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $240 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/DORIS M KING/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/142,983	Filing Date 01/06/2021	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	07/25/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $240 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/DORIS M KING/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 04/08/2022

Roark IP
1438 Dahlia Loop
San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	

ART UNIT	PAPER NUMBER
2441	

MAIL DATE	DELIVERY MODE
04/08/2022	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 17/142,983	Applicant(s) Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 02/13/2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-18 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-18 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

This Office action is in response to Applicant's request for reconsideration filed on February 13, 2022.

Claims 1-18 are pending.

Response to Arguments

Applicant's arguments filed February 13, 2022 have been fully considered but they are not persuasive.

Applicant is reminded that the filing of a terminal disclaimer **cannot** overcome a statutory double patenting rejection based upon 35 U.S.C. 101.

With that said, upon further consideration, the Examiner has withdrawn the statutory double patenting rejection of claim 6 in view of claim 1 of prior U.S. Patent No. 10,686,871.

Statutory Double Patenting

A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or discovers any new and useful process... may obtain a patent therefor..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the claims that are directed to the same invention so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

Claims 1-18 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1-18 of prior **U.S. Patent No. 10,893,095**. This is a statutory double patenting rejection.

Allowable Subject Matter

Claims 1-18 are allowed over the prior art.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRENDAN HIGA whose telephone number is (571)272-5823. The examiner can normally be reached on Monday - Friday 8:30 AM - 5:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wing Chan can be reached on (571) 272-7493. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/BRENDAN Y HIGA/
Primary Examiner, Art Unit 2441

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/01/2022	04/07/2022							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
	8	✓	✓							
	9	✓	✓							
	10	✓	✓							
	11	✓	✓							
	12	✓	✓							
	13	✓	✓							
	14	✓	✓							
	15	✓	✓							
	16	✓	✓							
	17	✓	✓							
	18	✓	✓							

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	Art Unit
	BRENDAN HIGA	2441

CPC - Searched*		
Symbol	Date	Examiner
H04L 29/08135, 08981; 41/08-082, 0866-0876; 45/563; 63/0218; 67/10, 34	04/07/2022	BH

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see SEARCH history	04/07/2022	BH
IP.com (NPL+Patents)	04/07/2022	BH
Google Scholar (see search history and results)	04/07/2022	BH

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H04L	H04L 29/08135, 08981; 41/08-082, 0866-0876; 45/563; 63/0218; 67/10, 34	04/07/2022	BH

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
139

Main Concept Document
==========
US10893095
Title: Distributed software defined networking

Concept Modifiers (3)
==========
3. More Like Text: key or token

2. More Like Text: upgrade

1. More Like Text: orchestrate

Filters (1)
==========
Publication Date: To 2013-12-31

Options
=======
De-dup: Extended Family Numbers (PAT only)
Cut-off: None
Sort: Relevance

Content: Patents + NPL (187)
==========
US Patents
US Designs
US Applications
EPO Patents
EPO Applications
China Patents
China Applications
Japan Patents
Japan Applications
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Argentina Applications
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Brazil Applications
Canada Patents

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Cuba Patents
Cuba Applications
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Ecuador Patents
Ecuador Applications
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Uruguay Applications
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Switzerland Applications
Ukraine Patents
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Armenia Patents

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Other Literature: IBM Redbooks
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Other Literature: arXiv.org

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	187807	(H04L29/08981 H04L67/34 H04L41/08-082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:49 PM
L2	2173	distribut$3 adj2 (Software adj2 defin$3 adj2 Network (SDN)) d$1sdn	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:49 PM
L3	290	1 AND 2	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:49 PM
L4	16	3 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2022/04/07 12:49 PM

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			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L5	2003388	(file application image container app) adj5 (portal merchant market$1place hub registry register$3 repository database DB directory)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:57 PM
L6	1517498	SDN VNF VNFCI Kubernetes Docker openflow openstack (MEC (Fog distributed mobile edge) adj5 (cloud computing))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:58 PM
L7	78183	6 same2 5	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA,	OR	ON	ON	2022/04/07 12:58 PM

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			VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L8	3182	1 AND 7	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:58 PM
L9	962	8 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:58 PM
L10	726	8 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 12:59 PM
L18	3634458	SDN VNF VNFCI Kubernetes Docker openflow openstack MEC Fog cloud	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:04 PM
L19	86301	5 SAME 18	(US-PGPUB; USPAT;	OR	ON	ON	2022/04/07

			USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				01:05 PM
L20	3697	1 AND 19	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:05 PM
L21	687	20 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:05 PM
L22	492	20 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:06 PM
L23	161042	SDN VNF VNFCI Kubernetes Docker openflow openstack	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2022/04/07 01:11 PM

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			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L24	88	21 AND 23	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:11 PM
L25	28912	23 SAME (version$3 updat$3 recent$3 up$1grad$3)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:16 PM
L27	4310	25 SAME (delay$3 paus$3 latency down$1time "without" interrupt$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2022/04/07 01:18 PM

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			IBM_TDB)				
L28	32	27 AND 1 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:18 PM
L29	940497	(version$3 updat$3 recent$3 up$1grad$3) adj20(delay$3 paus$3 latency down$1time "without" interrupt$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:27 PM
L30	172	21 AND 29	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:27 PM
L32	1	12/908606.app.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 01:32 PM
L33	2	("10893095").pn.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2022/04/07 05:35 PM

			CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L34	464641	(version$3 updat$3 recent$3 up$1grad$3) adj20(orchestrat$3 deploy$6 install$3 installation)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 05:42 PM
L35	740713	(version$3 updat$3 recent$3 up$1grad$3) adj10(hot delay$3 paus$3 latency down$1time "without" interrupt$4)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 05:43 PM
L36	20652	35 SAME 34	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	ON	ON	2022/04/07 05:43 PM

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			TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L38	2754564	SDN VNF VNFCI Kubernetes Docker openflow openstack cloud tenant multi$1tenant	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 05:44 PM
L39	16451	34 SAME 38	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 05:44 PM
L40	1327	36 AND 39	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/04/07 05:44 PM
L41	26	1 AND 40 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2022/04/07 05:45 PM

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	43002	SDN VNF VNFCI Kubernetes Docker openflow openstack.clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/04/07 01:14 PM
N2	1426678	(delay$3 paus$3 latency down$1time "without" interrupt$4).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/04/07 01:19 PM
N3	645378	(version$3 updat$3 up$1grad$3).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/04/07 01:19 PM
N4	35	N1 SAME N2 SAME N3	(US-PGPUB; USPAT)	OR	ON	ON	2022/04/07 01:19 PM
N6	3	N4 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT)	OR	ON	ON	2022/04/07 01:19 PM

Web Search History

date, time	web site	search string
4/7/2022 1:41:22 PM	Google Scholar	"distributed SDN"
4/7/2022 1:42:07 PM	Google Scholar	updating distributed SDN application without substantial interruption
4/7/2022 1:42:23 PM	Google Scholar	updating distributed SDN application without substantial interruption [before:2013]
4/7/2022 1:43:40 PM	Google Scholar	[before:2013] updating distributed application in a cloud environment without substantial interruption
4/7/2022 1:45:04 PM	Google Scholar	[before:2013] updating multitenant software without substantial interruption
4/7/2022 1:45:11 PM	Google Scholar	[before:2013] updating multi tenant software without substantial interruption
4/7/2022 1:45:16 PM	Google Scholar	[before:2013] updating "multi tenant" software without substantial interruption

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M Reitblatt, N Foster, J Rexford, D Walker - Proceedings of the 10th ACM ..., 2011 - dl.acm.org
... term, is unlikely to lead to **significant** long-term progress. ... We believe **SDN** desperately needs such abstractions to make ... of adjusting link metrics to minimize **disruptions** [2, 3, 5]. The ...
Save Cite Cited by 266 Related articles All 18 versions

[PDF] **Walk the line: Consistent network updates with bandwidth guarantees** [PDF] acm.org
S Ghorbani, M Caesar - ... of the first workshop on Hot topics in software ..., 2012 - dl.acm.org
... Our algorithm runs in the **SDN** controller to orchestrate these ... The time interval [t1, t2) could be **significant** considering that ... to shield **applications** from **disruption** while migrating. ...
Save Cite Cited by 142 Related articles All 8 versions

B4: Experience with a globally-deployed software defined WAN [PDF] acm.org Full View
S Jain, A Kumar, S Mandal, J Ong ... - ACM SIGCOMM ..., 2013 - dl.acm.org
... scale B **outage**, pointing to challenges in both **SDN** and large... , and we can **upgrade** servers independently from the switch ... However, it has experienced one **substantial outage** that has ...
Save Cite Cited by 2661 Related articles All 60 versions

[PDF] **Onix: A distributed control platform for large-scale production networks** [PDF] usenix.org
T Koponen, M Casado, N Gude, J Stribling ... - ... USENIX Symposium on ..., 2010 - usenix.org
... network control as **Software**-Defined Networking (**SDN**). This is ... **disruption** to network traffic, the **application** may require the ... **distributed** coordination, race-conditions in state **updates** will ...
Save Cite Cited by 1932 Related articles All 64 versions

The road to SDN: An intellectual history of programmable networks [PDF] acm.org Full View
N Feamster, J Rexford, E Zegura - Queue, 2013 - dl.acm.org
... evolution of **SDN**, **substantially** predating **SDN** yet taking root ... load, minimizing transient **disruptions** during planned routing ... a firmware **upgrade**---vendors did **not** need to **upgrade** the ...
Save Cite Cited by 458 Related articles All 16 versions

OpenSession: SDN-based cross-layer multi-stream management protocol for 3D teleimmersion [PDF] ieee.org Full Text @ USPTO-STIC
A Arefin, R Rivas, R Tabassum... - 2013 21st IEEE ..., 2013 - ieeexplore.ieee.org
... Through **extensive** evaluation with multi-stream 3D ... : 1) modification of flow table does **not interrupt** on-going forwarding ... Below we formally present the **distributed** route **update** algorithm ...
Save Cite Cited by 19 Related articles All 10 versions

Abstractions for network update [PDF] acm.org

M Reitblatt, N Foster, J Rexford, C Schlesinger... - ACM SIGCOMM ..., 2012 - dl.acm.org

Full View

... correctly, and can result in **disruptions** such as transient outages, lost ... The emergence of **Software** Defined Networks (**SDN**) ... In this section, we describe optimizations that **substantially** ...

Save Cite Cited by 787 Related articles All 38 versions

[BOOK] **SDN: Software** Defined Networks: an authoritative review of network programmability technologies

TD Nadeau, K Gray - 2013 - books.google.com

... **updates** to this text going forward, given how young **SDN** still ... highly **distributed** world we live in today, in which **applications**... Incorporating a **significant** amount of example code from this ...

Save Cite Cited by 454 Related articles All 2 versions

Live migration of an entire network (and its hosts)

[PDF] acm.org

Full Text @ USPTO-STIC

E Keller, S Ghorbani, M Caesar, J Rexford - Proceedings of the 11th ..., 2012 - dl.acm.org

... After a brief overview of **SDN** and the state in the switches, ... with the switches to **update** the rules and handle events: ... **substantially** reduced **outage** time (measured by packet loss), ...

Save Cite Cited by 142 Related articles All 27 versions

Electronic Acknowledgement Receipt

EFS ID:	44983238
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	13-FEB-2022
Filing Date:	06-JAN-2021
Time Stamp:	21:56:10
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Req. Reconsideration-After Non-Final Reject	TAAG001CONT3_RESPONSE____.pdf	30123 554ff256c63997a5b42be3d6d8fa643668c3b5fc	no	2
Warnings:					

Information:	
Total Files Size (in bytes):	30123

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Taaghol
Serial No.: 17/142,983
Filed: 1/6/2021
Attorney Docket No.: TAAG001CONT3

Examiner:
Art Unit:

For: DISTRIBUTED SOFTWARE DEFINED NETWORKING

Mail Stop Amendment
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE

Applicants offer the following election in response to the Office Action (hereinafter "Office Action") mailed on January 5, 2022.

Remarks begin on page 2 of this paper.

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
159

REMARKS

Claims 1-18 are currently pending.

DOUBLE PATENTING REJECTIONS

Claims 1-18 are rejected on the ground of nonstatutory double patenting as being unpatentable over U.S. Patent No. 9,843,624. Claims 1-18 are rejected on the ground of statutory double patenting as being unpatentable over U.S. Patent No. 10,686,871 and 10,893,095.

Accordingly, Applicant has filed a Terminal Disclaimer with this response.

CONCLUSION

Therefore it is respectfully submitted that claims 1-18 are allowable over the prior art. No new matter has been added in the new claims and/or limitations presented in this Amendment.

Respectfully submitted,

ROARK IP

By: /Christopher J. Horgan/

Christopher J. Horgan
Registration No. 40,394
1438 Dahlia Loop
San Jose, CA 95126
Telephone: (408) 687-8306

Date: February 13, 2022

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
160

Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	17142983
Filing Date	06-Jan-2021
First Named Inventor	Pouya Taaghol
Attorney Docket Number	TAAG001CONT3
Title of Invention	Distributed Software Defined Networking

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
Big Data Federation, Inc.	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

9843624

10686871

10893095

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request. ○ I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.	
Applicant claims the following fee status: ◉ Small Entity ○ Micro Entity ○ Regular Undiscounted I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.	
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application Registration Number 40394 ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this request	
Signature	/Christopher J. Horgan/
Name	Christopher J. Horgan

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	17142983
Filing Date:	06-Jan-2021
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Filer:	Christopher James Horgan
Attorney Docket Number:	TAAG001CONT3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	2814	1	170	170
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**170**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 17142983

Filing Date: 06-Jan-2021

Applicant/Patent under Reexamination: Taaghol

Electronic Terminal Disclaimer filed on February 13, 2022

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt	
EFS ID:	44983208
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	13-FEB-2022
Filing Date:	06-JAN-2021
Time Stamp:	21:37:35
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$170
RAM confirmation Number	E20222CL37281015
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	41535 091953ae367ee5a6819fb0debd3e4e2ee95b2f2d	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	38107 723903ecfb649c580f89cab899ab5f814a639be4	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	79642		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3	2943

112449 7590 01/05/2022

Roark IP
1438 Dahlia Loop
San Jose, CA 95126

EXAMINER	
HIGA, BRENDAN Y	

ART UNIT	PAPER NUMBER
2441	

MAIL DATE	DELIVERY MODE
01/05/2022	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 17/142,983	Applicant(s) Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 01/06/2021.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-18 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-18 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 01/06/2021 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date 01/06/2021.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Statutory Double Patenting

A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or discovers any new and useful process... may obtain a patent therefor..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the claims that are directed to the same invention so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

Claims 1-18 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1-18 of prior **U.S. Patent No. 10,893,095**. This is a statutory double patenting rejection.

In addition claim 6 is rejected under 35 U.S.C. 101 as claiming the same invention as that of claim 1 of prior **U.S. Patent No. 10,686,871**. This is a statutory double patenting rejection.

Non-Statutory Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); In re Vogel, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/forms/. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to http://www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 1-18 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-21 of **US Patent No. 9,843,624** (*' Patent). Although the claims at issue are not identical to that of the 624' Patent, for example the current application does not require the limitations of *"processing data packets in a mobile data wireless network"* and "*wherein the programmable network device and the programmable cloud device form unified capabilities using a plurality of application programming interfaces (APIs) wherein the APIs accessible to each of the plurality of the first network applications and the plurality of second network applications are determined based on a respective access level associated with each of the plurality of first and second network applications"* (see claim 1 of the 624' Patent), the claims are not patentably distinct as the broader claim scope of the current Application is anticipated by the narrower claim scope of the 624' Patent.

Claims 1-18 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-12 of US Patent No. **10,686,871** (871' Patent). Although the claims at issue are not identical to that of the 871' Patent, for

example the current application does not require *"wherein at least one of the plurality of first network applications in the programmable network device and at least one of the plurality of second network applications in the programmable cloud device are in secure communication with each other through a virtual fabric to form a distributed application"* (see claim 1 of the 871' Patent), the claims are not patentably distinct as the broader claim scope of the current Application is anticipated by the narrower claim scope of the 871' Patent.

Allowable Subject Matter

Claims 1-18 are allowed.

The following is an examiner's statement of reasons for allowance:

For similar reasons noted in parent application 16/900963 (US Patent No. 10,893,095), the prior art does not teach or render obvious, before the earliest effective filing date of Applicant's claimed invention, in the specific combinations and manner recited within the claims, the features of:

"…a programmable network device hosting a plurality of first network applications;

a programmable cloud device hosting a plurality of second network applications;

wherein at least one of the plurality of first network applications in the programmable network device and at least one of the plurality of second network applications in the programmable cloud device are in secure communication with each other to form a distributed application;

the programmable network device and programmable cloud device are each powered by a sandboxing operating system which facilitates deployment of the plurality of first and second network applications and facilitates upgrades of the first and second network applications with substantially no interruption to operation of the programmable network device and programmable cloud device; wherein the programmable network device verifies authenticity of the upgrades to the plurality of first network applications and the programmable cloud device verifies authenticity of the upgrades to the plurality of second network applications and wherein the verification is based on unique security keys associated with each of the plurality of first and second network applications;

an application repository storing distributed applications which have been tested for installation in the programmable network device and programmable cloud device; and

an application management portal coupled to the programmable network device, programmable cloud device and the application repository, wherein the application management portal manages usage of the distributed applications on the programmable network device and programmable cloud device."

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure (see PTO 892).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRENDAN HIGA whose telephone number is (571)272-5823. The examiner can normally be reached on Monday - Friday 8:30 AM - 5:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wing Chan can be reached on (571) 272-7493. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/BRENDAN Y HIGA/
Primary Examiner, Art Unit 2441

Notice of References Cited	Application/Control No. 17/142,983	Applicant(s)/Patent Under Reexamination Taaghol et al.	
	Examiner BRENDAN HIGA	Art Unit 2441	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20180309747-A1	10-2018	Sweet; Carson	H04L63/20	1/1
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	Art Unit
	BRENDAN HIGA	2441

CPC - Searched*		
Symbol	Date	Examiner
H04L 9/08-0838; 29/08135, 08981; 41/08-082, 0866-0876; 45/563; 63/0218; 67/10	01/01/2022	BH

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
see SEARCH history	01/01/2022	BH
IP.com (NPL+Patents)	01/01/2022	BH
Google Scholar (see search history and results)	01/01/2022	BH

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H04L	9/08-0838; 29/08135, 08981; 41/08-082, 0866-0876; 45/563; 63/0218; 67/10	01/01/2022	BH

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/142,983	Taaghol et al.
	Examiner	**Art Unit**
	BRENDAN HIGA	2441

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/01/2022								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
	13	✓								
	14	✓								
	15	✓								
	16	✓								
	17	✓								
	18	✓								

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	92	((("TAAGHOL") near3 ("Pouya")) OR (("RAMANNA") near3 ("Vivek"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/12/31 03:08 PM
L2	792	distribut$3 adj2 (Software adj2 defin$3 adj2 Network (SDN)) d$1sdn	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/12/31 03:09 PM
L3	3	1 AND 2	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/12/31 03:09 PM
L4	40	("20020016954" OR "20040107417" OR "20040237081" OR "20050246703" OR "20060271341" OR "20070078988" OR "20080209491" OR "20090007091" OR "20090113327" OR "20090276771" OR "20090300057" OR "20110075611" OR "20110265077" OR "20120066665" OR "20120096071" OR "20120266156" OR "20120300615" OR "20130007254" OR "20130160147" OR "20130223442" OR "20130263104" OR "20140052976" OR "20140241158" OR "20140254373" OR "20140259012" OR "20140317293" OR "20150160877" OR "20150173121" OR "20150242237" OR "20160224460" OR "20190165997" OR "7114021" OR "7630706" OR "8132166" OR "8495611" OR "8528108" OR "8650299" OR "8756595" OR "8843933" OR "9226333").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:00 PM
L5	66354	(H04L29/08135,08981	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01

		H04L41/08-082 H04L45/563 H04L67/10).cpc.					05:02 PM
L6	4224	H04L41/0866-0876.CPC.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:02 PM
L7	18633	H04L9/08-0838.cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:03 PM
L8	2	5 AND 6 AND 7	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:03 PM
L9	8	5 AND 4	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:04 PM
L10	647791	SDN VNF VNFCI Kubernetes Docker openflow openstack MEC (Fog distributed mobile edge) adj5 (cloud computing)	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:05 PM
L11	26802	5 AND 10	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:05 PM
L12	174	2 AND 11	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:06 PM
L13	13	12 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:06 PM
L14	45947	(file application image container app) adj5 (portal merchant market$1place hub registry register$3 repository database DB) SAME (push$3 pull$3 download$3)	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:07 PM
L15	504	14 AND 11 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:08 PM
L16	17	15 AND (6 7)	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:08 PM
L18	140896	(file application image container app) adj5 (portal merchant market$1place hub registry register$3 repository database DB directory) SAME (push$3 pull$3 download$3)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/01/01 05:16 PM
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		tenant mult$1tenant sandbox$4 virtual adj2 machine docker)	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				05:17 PM
L20	1377	19 AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:18 PM
L21	7	20 AND (6 7)	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:18 PM
L22	351	10 AND 20	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:20 PM
L23	81577	SDN VNF VNFCI Kubernetes Docker openflow openstack MEC (Fog edge) adj5 (cloud computing)	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:23 PM
L24	4	23 AND 22	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:23 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
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N2	4224	H04L41/0866-0876.CPC.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:10 PM
N3	18633	H04L9/08-0838.cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:10 PM
N4	1541	N1 AND (N2 N3) AND (@pd @ptad @prad @ad @rlad)<20130613	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:11 PM
N5	350083	(key token).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:12 PM
N6	227	N4 AND N5	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:13 PM
N7	509125	(container tenant mult$1tenant sandbox$4 virtual adj2 machine docker).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:13 PM

N8	29	N6 AND N7	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/01 05:14 PM

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Exploiting locality in **distributed SDN** control [PDF] acm.org
Full Text @ USPTO-STIC
S Schmid, J Suomela - Proceedings of the second ACM SIGCOMM ..., 2013 - dl.acm.org
... However, the controller may not necessarily represent a single, centralized device, but the control plane may consist of multiple controllers in charge of **managing** different administrative ...
Save Cite Cited by 235 Related articles All 20 versions

Towards an elastic **distributed SDN** controller [PDF] acm.org
Full View
A Dixit, F Hao, S Mukherjee, TV Lakshman... - ACM SIGCOMM ..., 2013 - dl.acm.org
... assumed ownership of X in the previous phase, the protocol is not complete unless A detaches from **managing** switch X. However, it cannot just detach immediately from the switch ...
Save Cite Cited by 717 Related articles All 16 versions

Towards a **distributed SDN** control: Inter-platform signaling among flow processing platforms [PDF] semanticscholar.org
Full Text @ USPTO-STIC
F Salvestrini, G Carrozzo, N Ciulli - 2013 IEEE SDN for Future ..., 2013 - ieeexplore.ieee.org
... a **management** challenge that involves significant modification to the network configuration. ... Also, most of the SDN products adopt a centralized SDN controller to **manage** the overall ...
Save Cite Cited by 11 Related articles All 3 versions

Logically centralized? State distribution trade-offs in software defined networks [PDF] acm.org
D Levin, A Wundsam, B Heller, N Handigol... - Proceedings of the first ..., 2012 - dl.acm.org
... Consequently, we ask: "How does **distributed SDN** state impact the performance of a ... the underlying **distributed SDN** state. The more complex application state **management** approach is ...
Save Cite Cited by 431 Related articles All 13 versions

A **Distributed SDN** Control Plane for Consistent Policy Updates [PDF] arxiv.org
M Canini, P Kuznetsov, D Levin, S Schmid - arXiv preprint arXiv ..., 2013 - arxiv.org
... This paper studies a **distributed SDN** control plane that enables concurrent and robust policy ... Our interface is however intended to model realistic network **management** operations, ...
Save Cite Cited by 1 Related articles All 5 versions

[PDF] Routing and State Distribution Trade-Offs in SDN [PDF] euroview2012.org
N Sarrar, D Levin, A Feldmann - euroview2012.org
... We compare two different control application approaches which operate on **distributed SDN** ... **distributed SDN** state. Alternately, the more complex application state **management** ...
Save Cite Related articles

Thales Communications & Security
K Phemius, M Bouet, J Leguay - 2013 - Citeseer
... extensible **DIstributed SDN** COntrol plane able to cope with the distributed and heterogeneous nature of modern overlay networks and wide area networks. DISCO controllers **manage** ...
Save Cite Cited by 2 Related articles

[PDF] SmartBlock-SDN: An Optimized Blockchain-SDN Framework for Resource **Management** in IoT [PDF] researchgate.net
A Mosavi, A Rahman - 2000 - researchgate.net
... [35] proposed SADFIR, an interactive clustering routing protocol that enables **distributed SDN** controllers to collaborate with forwarding network devices for routing the sensed ...
Save Cite Related articles

[PDF] Seamless interworking of SDN and IP [PDF] acm.org
Full View
P Lin, J Hart, U Krishnaswamy, T Murakami... - Proceedings of the ..., 2013 - dl.acm.org

... to make it easier to program and **manage** the networks. Transitioning the widely deployed
... The SDN AS is controlled by ONOS (an experimental **distributed SDN** Operating System) [2]...
Save Cite Cited by 127 Related articles All 11 versions

Using SDN for cloud services provisioning: the XIFI use-case Full Text @ USPTO-STIC

E Escalona, JIA Baranda, LMC Murillo... - 2013 IEEE SDN for ..., 2013 - ieeexplore.ieee.org
... In this paper we will present the architecture that XIFI plans to setup and **manage** several DC
... The provisioning manager will instruct **distributed SDN** controllers local to each XIFI DC for ...
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Related searches

distributed sdn **control**

blockchain sdn **resource** management

data store distributed sdn **control plane**

Web Search History

date, time	web site	search string
1/1/2022 5:30:23 PM	Google Scholar	distributed SDN or DSDN
1/1/2022 5:30:37 PM	Google Scholar	"distributed SDN"
1/1/2022 5:30:43 PM	Google Scholar	"distributed SDN" [before:2013]
1/1/2022 5:31:05 PM	Google Scholar	[before:2013] "distributed SDN" key token
1/1/2022 5:31:13 PM	Google Scholar	[before:2013] "distributed SDN" key or token
1/1/2022 5:31:32 PM	Google Scholar	[before:2013] "distributed SDN" verification or authentication
1/1/2022 5:32:07 PM	Google Scholar	[before:2013] "distributed SDN" sandbox
1/1/2022 5:32:26 PM	Google Scholar	[before:2013] "distributed SDN" management

Main Concept Document
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US10893095
Title: Distributed software defined networking

Concept Modifiers (2)
==========
2. More Like Text: distributed SDN

1. More Like Text: key or token

Filters (1)
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Publication Date: To 2013-12-31

Options
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De-dup: Extended Family Numbers (PAT only)
Cut-off: None
Sort: Relevance

Content: Patents + NPL (187)
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US Patents
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EPO Applications
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China Applications
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OnePetro.org: Conferences at OnePetro.org
Other Literature: IBM Redbooks
Other Literature: PubMed Central
Other Literature: arXiv.org

Bibliographic Data

Application No: 17/142,983

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /BRENDAN Y HIGA/ (Examiner's Signature) | BH (Initials)

Title: Distributed Software Defined Networking

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
01/06/2021	709	2441	TAAG001CONT3
RULE			

APPLICANTS

Big Data Federation, Inc., Santa Clara, CA,

INVENTORS

Pouya Taaghol, San Jose, CA, UNITED STATES

Vivek Ramanna, San Jose, CA, UNITED STATES

CONTINUING DATA

This application is a CON of 16900963 06/14/2020 PAT 10893095

16900963 is a CON of 15836824 12/09/2017 PAT 10686871

15836824 is a CON of 14295331 06/04/2014 PAT 9843624

14295331 has PRO of 61834807 06/13/2013

FOREIGN APPLICATIONS

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Sheet 1 of 4

Complete if Known	
Application Number	17/142983
Filing Date	01/06/2021
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

U.S.PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 7114021	9-2006	Seshadri	
		US- 7630706	12-2009	Weigand	
		US- 8132166	3-2012	DeHaan	
		US- 8528108	9-2013	Ammer	
		US- 8650299	2-2014	Huang	
		US- 8756595	6-2014	Arcilla	
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		US- 20020016954	2-2002	Charisius	
		US- 20040107417	6-2004	Chia	
		US- 20040237081	11-2004	Homiller	
		US- 20050246703	11-2005	Ahonen	
		US- 20070078988	4-2007	Miloushev	
		US- 20080209491	8-2008	Hasek	
		US- 20090007091	1-2009	Appiah	
		US- 20090113327	4-2009	Pogrebinsky	
		US- 20090276771	11-2009	Nickolov	
		US- 20090300057	12-2009	Friedman	
		US- 20110075611	3-2011	Choi	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear

Examiner Signature	/BRENDAN Y HIGA/	Date Considered	12/30/2021

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. Applicant is to place a check mark here if English language Translation is attached.

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Sheet 2 of 4

Complete if Known	
Application Number	17/142983
Filing Date	01/06/2021
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

U.S.PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 20120300615	11-2012	Kempf	
		US- 20130007254	01-2013	Fries	
		US- 20130160147	06-2013	Draluk	
		US- 20130263104	10-2013	Basel	
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		US- 8843933	09-2014	Holler	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear

Examiner Signature	/BRENDAN Y HIGA/	Date Considered	12/30/2021

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PTO/SB/08a (07-09)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 3 of 2

Complete if Known	
Application Number	17/142983
Filing Date	01/06/2021
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 8495611	07-2013	McCarthy	
		US- 20120266156	10-2012	Spivak	
		US- 20060271341	11-2016	Brown	
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]

Examiner Signature	/BRENDAN Y HIGA/	Date Considered	12/30/2021

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 4 of 4

Complete if Known	
Application Number	17/142983
Filing Date	01/06/2021
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		McKeown, et al. "OpenFlow: Enabling Innovation in Campus Networks", March 14, 2008.	
		Li et al. "Toward Software-Defined Cellular Networks", "2012 European Workshop on Software Defined Networking".	
		"Network Functions Virtualisation", "SDN and OpenFlow World Congress", Darmstadt-Germany, October 22-24, 2012.	
		Yap et al., "OpenRoads: Empowering Research in Mobile Networks", ACM SIGCOMM Computer Communication Review, 2010.	
		Bansal et al., "OpenRadio: A Programmable Wireless Dataplane", HotSDN'12, August 13, 2012, Helsinki, Finland.	
		Stallings et al., "Software-Defined Networks and OpenFlow", The Internet Protocol Journal, vol. 16, No. 1, March 2013.	
		Luo et al., "Software Defined Networking across Distributed Datacenters over Cloud", IEEE Int. Conference on Cloud Computing Tech, 2013	
		Chappell, David, "A Short Introduction to Cloud Platforms", Aug. 2008.	

Examiner Signature	/BRENDAN Y HIGA/	Date Considered	12/30/2021

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1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached.
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/142,983	01/06/2021	2425	830	TAAG001CONT3	18	3

CONFIRMATION NO. 2943

UPDATED FILING RECEIPT

112449
Roark IP
1438 Dahlia Loop
San Jose, CA 95126

OC000000125035813

Date Mailed: 04/21/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Pouya Taaghol, San Jose, CA;
Vivek Ramanna, San Jose, CA;

Applicant(s)

Big Data Federation, Inc., Santa Clara, CA;

Power of Attorney: The patent practitioners associated with Customer Number 112449

Domestic Priority data as claimed by applicant

This application is a CON of 16/900,963 06/14/2020 PAT 10893095
which is a CON of 15/836,824 12/09/2017 PAT 10686871
which is a CON of 14/295,331 06/04/2014 PAT 9843624
which claims benefit of 61/834,807 06/13/2013

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: No

Permission to Access Search Results: No

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 02/17/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/142,983**

Projected Publication Date: Request for Non-Publication Acknowledged

Non-Publication Request: Yes

Early Publication Request: No
**** SMALL ENTITY ****
Title

Distributed Software Defined Networking

Preliminary Class

725

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/142,983

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	18 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	830		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Taaghol
Serial No. 17/142,983
Filed: 1/6/2021
Attorney Docket No.: TAAG001CONT3

Examiner:
Art Unit:

For: DISTRIBUED SOFTWARE DEFINED NETWORKING

Mail Stop Missing Parts
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS

Applicants offer the following response to the Notice to File Corrected Application Papers mailed on February 18, 2021. Applicant has deleted the grey text on page 54 and inserted the proper color. A clean copy and marked up copy of the specification have been submitted. No new matter has been added.

Respectfully submitted,

ROARK IP

By: /Christopher J. Horgan/

Christopher J. Horgan
Registration No. 40,394
1438 Dahlia Loop
San Jose, CA 95126
Telephone: (408) 687-8306

Date: April 19, 2021
Attorney Docket: TAAG001CONT3

Exhibit 1007
Microsoft Corporation v. Edge Networking Systems, LLC
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DISTRIBUTED SOFTWARE DEFINED NETWORKING

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] The present invention claims priority from U.S. Provisional Patent Application Serial No. 61/834,807, filed June 13, 2013 the disclosure of which is herein specifically incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] This invention relates to a network architecture that facilitates secure and flexible programmability between a user device and across a network with full lifecycle management of services and infrastructure applications.

BACKGROUND

[0003] Existing network solutions are built on proprietary hardware and software. Network Operators & Information Technology (NOIT) can only configure the proprietary network infrastructure provided by vendors and are unable to add new and customized features or capabilities. As a result, the NOIT can only add new desired features by making such requests to their infrastructure vendors or pursuing standardization processes. But these existing approaches are time consuming and resource intensive.

SUMMARY OF THE INVENTION

[0004] An aspect of the disclosure herein is a plurality of network elements in a packet system, said network elements comprising: a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp; a flexible cloud platform having at least one fxCloudApp, wherein the at least one fxDeviceApp and at least one fxCloudApp are in secure communication to form a distributed application; and an application management portal which manages life cycle of the distributed applications.

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[0005] Another aspect of the disclosure is a plurality of network elements in a packet system, said network elements comprising: a flexible cloud platform having a plurality of virtual machines, wherein each of the virtual machines has at least one fxCloudApp; and a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

[0006] Another aspect of the disclosure is a plurality of network elements in a packet system, said network elements comprising: a flexible cloud platform having a plurality of zones, wherein each of the plurality of zones has at least one fxCloudApp; and a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 demonstrates the network architecture of a 4G system.

[0008] Figure 2 illustrates a network element (or system) upon which the Distributed Software Defined Network operates.

[0009] Figure 3 illustrates a Distributed Software Defined Network in accordance with the present disclosure.

[0010] Figure 4 is an exemplary view of the software layers in the Flexible Operation System (fxOS) Architecture.

[0011] Figure 5 illustrates the FastPath architecture.

[0012] Figure 6 presents a potential software layer of the fxOS co-existing alongside a general purpose OS.

[0013] Figure 7 is an exemplary view of the fxStore Portal.

[0014] Figure 8 demonstrates a shared fxCloud deployment.

[0015] Figure 9 demonstrates a Zoned Deployment.

[0016] Figure 10 demonstrates another deployment option as applied to cellular networks (especially Long Term Evolution (LTE)).

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[0017] Figure 11 shows an example of a signaling flow chart for the fxDevice Commissioning Procedure.

[0018] Figure 12 shows an example procedure for Application Provisioning.

[0019] Figure 13 presents the state machine for the application upgrade process.

[0020] Figures 14A-14C are examples of the Distributed Switch Controller during Upgrade.

[0021] Figure 15 shows how fxVF in the fxCloud and fxDevice.

[0022] Figure 16 demonstrates the logical interfaces between the platform resources and applications.

[0023] Figures 17A and 17B demonstrate example procedures for cloud breathing procedures.

DETAILED DESCRIPTION

[0024] The Distributed Software Defined Network (dSDN) disclosed herein is an architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

DEFINITIONS, ACRONYMS & ABBREVIATIONS

[0025] The following terms, acronyms, abbreviations and descriptions are explained below and are used throughout the detailed description of the dSDN:

TERM	DESCRIPTION
2G	2nd Generation Cellular Technology
3G	3Rd Generation Cellular Technology
4G	4th Generation Cellular Technology
AP	WiFi Access Point
API	Application Programming Interface

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AR	Application Repository
ASIC	Application Specification Integrated Circuit
AuC	Authentication Center
BS	Base Station
BSC	Base Station Controller
BTS	Base Station
CDN	Content Distribution Network
CN	Core Network
CNIE	Core Network Internet Edge
CPU	Central Processing Unit
dAP	Distributed Application Package
dApp	Distributed App
dCP	Distributed Content Service
dNS	Distributed Notification Service
DNS	Domain Name System
DPDK	Data Plane Development Kit
DPI	Deep Packet Inspection
dRS	Distributed Resource Service
DSCP	Differentiated Service Code Point (QoS)
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
EIR	Equipment Identity Register
eNB	Enhanced Node B (4G)
FIB	Flow Information Base
FQDN	Fully Qualified Domain Name
fxApp	FleXible Application, which has a fxDeviceApp and fxCloudApp component. fxDeviceApp and fxCloudApp of one application represent fxApp.
fxDeviceApp	FleXible Application which runs on fxDevice
fxBS	FleXible Base Station that is a BS that is powered by fxOS (an example of an fxDevice)

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fxCloud	FleXible Cloud that interacts with fxDevice and on other network elements on the northbound interface
fxCloudApp	FleXible Cloud Application that is the application that runs on fxCloud and can be associated to one or more fxDeviceApp in fxDevice
fxManager	FleXible Manager that manager the fxOS lifecycle (provisioning, usage, de-provisioning)
fxOS	FleXible Operation System which run on the fxDevice as the OS and firmware
fxSDK:	FleXible Software Development Kit
fxSimulator	FleXible Simulator
fxStore	FleXible Store that presents fxApp to the network
administratorsGERAN	GPRS Edge Radio Access Network
GGSN	Gateway GPRS Support Node (used in core network of 2G/3G systems)
GMSC	Gateway Mobile Switching Center
GPRS	General Packet Radio Service
GPS	Global Positioning System
GTP	GPRS Tunneling Protocol
GW	Gateway
HAL	Hardware Abstraction Layer
HD	High Definition
HLR	Home Location Register
HSS	Home Subscriber Server
IAC	Inter Application Communication

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IMS	IP Multimedia Sub-system
IMSI	International Mobile Subscriber Identifier
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
JVM	Java Virtual Machine
LA	Location Area
LAN	Local Area Network
LSP	Label Switching Protocol
M2M	Machine to Machine
MAC	Medium Access Control
MCP	Multi Chip Packaging
MIMO	Multi Input Multi Output
MME	Mobility Management Entity (used in core network of LTE)
MNO	Mobile Operator Network
MPLS	Multi Protocol Label Switching
MSC	Mobile Switching Center
MSISDN	Mobile Station
NAS	Non-Access Stratum
NB	Node B (3G)
NFC	Near Field Communication
NFV	Network Function Virtualization
NOIT	Network Operations & Information Technology; this term network broadly includes carriers, service providers, enterprise networks, and designated/contacted 3rd party administrators.

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OS	Operating System
OTT	Over the Top
P-GW	Packet Gateway
PaaS	Platform-as-a-Service
PBX	Private Branch exchange (telephony)
PDG	Packet Data Gateway
PDN	Packet Data Network
PHY	Physical Layer
PLMN	Public Land Mobile Network
PnP	Plug and Play
PP	Packet Processor
PR	Platform Resources
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RA	Routing Area
RAN	Radio Access Network of cellular networks
RAPI	Resources API
RFID	Radio Frequency Identifier
RNC	Radio Network Controller
S-GW	Serving Gateway
S1-AP	S1 Interface Application Protocol (an LTE protocol between MME and eNodeB)
SaaS	Software-as-a-Software
SDK	Software Development Kit
SDN	Software Defined Network
SGSN	Serving GPRS Support Node (used in core

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	network of 2G/3G systems)
SIM	Subscriber Identity Module
SiP	System in a Package
SMS	Short Message Service
SoC	System on a Chip
SON	Self-Optimizing Network
SSDP	Simple Service Discovery Protocol
TA	Target Area
TNE	Test Network Environment
TTM	Time to Market
UMTS	Universal Mobile Telecommunication System
UPnP	Universal Plug and Play
URA	UMTS Routing Area
URI	Uniform Resource Identifier
UTRAN	UMTS Terrestrial Radio Access Network
VLR	Visitor Location Register
VM	Virtual Machine
VPN	Virtual Private Network
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WLAN	Wireless Local Area Network
XMPP	Extensible Messaging and Presence Protocol

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[0026] Database. One or more large structured sets of persistent data maintained upon a computer system organized and structured according to a software system defining rules for organization as well as responding to queries to read, write, or modify data as well as provide statistical information regarding the contained data. As used in this disclosure in describing the dSDN, a database may be either a single unified system or a distributed system wherein certain database elements are located upon different systems or servers which may be in different physical locations, acting in harmony to appear as one unified database. Where databases are described, it will be understood by one of ordinary skill in the art that (i) alternative database structures to those described may be readily employed, and (ii) other memory structures besides databases may be readily employed. Any illustrations or descriptions of any sample databases presented herein are illustrative arrangements for stored representations of information. The database formats may include relational databases, object-based models and/or distributed databases which could be used to store and manipulate the data types described herein. Likewise, object methods or behaviors of a database can be used to implement various processes, such as the described herein. In addition, the databases may, in a known manner, be stored locally or remotely from a device which accesses data in such a database.

[0027] The term "determining" and grammatical variants thereof (e.g., to determine a price, determining a value, determine an object which meets a certain criterion) is used in an extremely broad sense. The term "determining" encompasses a wide variety of actions and therefore "determining" can include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" can include resolving, selecting, choosing, establishing, and the like. The term "determining" does not imply certainty or absolute precision, and therefore "determining" can include estimating, extrapolating, predicting, guessing and the like. The term "determining" does not imply that mathematical processing must be performed, and does not imply that numerical methods must be used, and does not imply that an algorithm or process is used.

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[0028] The functionality and/or the features of a single device that is described may be alternatively embodied by one or more other devices which are described but are not explicitly described as having such functionality/features. Thus, other embodiments need not include the described device itself, but rather can include the one or more other devices which would, in those other embodiments, have such functionality/features.

[0029] Devices that are described as in "communication" with each other or "coupled" to each other need not be in continuous communication with each other or in direct physical contact, unless expressly specified otherwise. On the contrary, such devices need only transmit to each other as necessary or desirable, and may actually refrain from exchanging data most of the time. For example, a machine in communication with or coupled with another machine via the Internet may not transmit data to the other machine for long period of time (e.g. weeks at a time). In addition, devices that are in communication with or coupled with each other may communicate directly or indirectly through one or more intermediaries.

[0030] Although process (or method) steps may be described or claimed in a particular sequential order, such processes may be configured to work in different orders. Further, some steps may be performed simultaneously despite being described or implied as occurring non-simultaneously (e.g., because one step is described after the other step) unless specifically indicated. Moreover, the illustration of a process by its depiction in a drawing does not imply that the illustrated process is exclusive of other variations and modifications thereto, does not imply that the illustrated process or any of its steps are necessary to the embodiment(s), and does not imply that the illustrated process is preferred. Where a process is described in an embodiment the process may operate without any user intervention.

[0031] It will be readily apparent to one of ordinary skill in the art that the various processes of the dSDN described herein may be implemented by, e.g., appropriately programmed general purpose computer(s), special purpose computer(s) and computing device(s). Typically a processor (e.g., one or more microprocessors, one or more microcontrollers, one or more digital signal processors) will receive instructions (e.g., from a memory or like device), and execute those instructions,

thereby performing one or more processes defined by those instructions. Instructions may be embodied in, e.g., one or more computer programs, one or more scripts.

[0032] A "processor" means one or more microprocessors, central processing units (CPUs), computing devices, controllers, microcontrollers, digital signal processors, or like devices or any combination thereof, regardless of the architecture (e.g., chip-level multiprocessing/multi-core, Reduced Instruction Set Computer (RISC), Complex Instruction Set Computer (CISC), Microprocessor without Interlocked Pipeline Stages, pipelining configuration, or simultaneous multithreading).

[0033] Further, programs that implement methods described herein may be stored and transmitted using a variety of media (e.g., computer readable media) in a number of manners. In some embodiments, hard-wired circuitry or custom hardware may be used in place of, or in combination with, some or all of the software instructions that can implement the processes of various embodiments. Thus, various combinations of hardware and software may be used instead of software only to implement the embodiments.

[0034] The term "non-transitory computer readable medium" in this disclosure refers to any medium, a plurality of the same, or a combination of different media, that participate in providing data (e.g., instructions, data structures) which may be read by a computer, a processor or a like device. Such a medium may take many forms, including but not limited to, non-volatile media, volatile media, and transmission media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include dynamic random access memory (DRAM), which typically constitutes the main memory. Transmission media may include coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to the processor. Transmission media may include or convey acoustic waves, light waves and electromagnetic emissions, such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of non-transitory computer-readable media in which the dSDN may be implemented include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper

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tape, any other physical medium with patterns of holes, a Random Access Memory (RAM), a programmable read only memory (PROM), an erasable programmable read only memory (EPROM), a flash electrically erasable programmable read only memory (FLASH-EEPROM), any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read.

[0035] Various forms of computer readable media in this disclosure may be involved in carrying data (e.g. sequences of instructions) to a processor. For example, data may be (i) delivered from RAM to a processor; (ii) carried over a wireless transmission medium; (iii) formatted and/or transmitted according to numerous formats, standards or protocols, such as Ethernet (or IEEE 802.3), Bluetooth, and Transmission Control Protocol/Internet Protocol ("TCP/IP"), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), and 2G/3G; and/or (iv) encrypted to ensure privacy or prevent fraud in any of a variety of ways well known in the art.

[0036] Thus in some embodiments in this disclosure a description of a process may be a description of a non-transitory computer-readable medium storing a program for performing the process. The computer readable medium may store (in any appropriate format) those program elements which are appropriate to perform the method.

[0037] In an embodiment, a server computer, network element or centralized authority may not be necessary or desirable. For example, an embodiment may be practiced on one or more devices without a central authority. In such an embodiment, any functions described herein as performed by the server computer or data described as stored on the server computer may instead be performed by or stored on one or more such devices.

[0038] In interpreting the present application (which includes the claims), one of ordinary skill in the art shall refer to the prosecution history of the present application, but not to the prosecution history of any other patent or patent application, regardless of whether there are other patent applications that are considered related to the present application, and regardless of whether there are other patent applications that share a claim of priority with the present application.

[0039] Numerous embodiments are described in the present application, and are presented for illustrative purposes only. The described embodiments are not, and are not intended to be, limiting in any sense. One of ordinary skill in the art will recognize that the disclosed embodiment(s) may be practiced with various modifications and alterations, such as structural, logical, software, and electrical modifications. Although particular features of the disclosed invention(s) may be described with reference to one or more particular embodiments and/or drawings, it should be understood that such features are not limited to usage in the one or more particular embodiments or drawings with reference to which they are described, unless expressly specified otherwise.

[0040] The present disclosure is not a literal description of all embodiments of the invention(s). Also, the present disclosure is not a listing of features of the invention(s) which must be present in all embodiments. A description of an embodiment with several components or features does not imply that all or even any of such components/features are required. On the contrary, a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention(s).

[0041] The following description has been presented for purposes of illustration and description and is not intended to be exhaustive or to limit the embodiments to the precise form disclosed. Many modifications and variations are possible in light of the teachings disclosed herein.

[0042] The embodiments were chosen and described to explain principles of operation and their practical applications. However, the scope of the invention is to be defined by the claims.

[0043] The major technical reason for inflexibility in network infrastructure has been related mostly to the proprietary hardware and rigid software architecture in the existing network elements (routers, switches, gateways, cellular base-stations, WiFi access points, etc.). With recent advancements in semiconductor device manufacturing, there is no longer a cost barrier to add computing power to many electronics in the market including networking infrastructure. The addition of such compute capabilities would open up new opportunities for programmable platforms in the network and ultimately creating more flexible network architecture

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and business models.

[0044] The Distributed Software Defined Network (dSDN) disclosed herein is an end-to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and applications (fxApp). The dSDN also harmonizes fxApp deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning. In this disclosure, the dSDN is applied to the wireless networks as an exemplary embodiment. However, the dSDN is not limited to wireless networks embodiments and it could be applied to many other network types including enterprise, wireline service providers, data centers, and Internet of Things (IoT).

[0045] Figure 1 demonstrates the network architecture of a 4G system 100. (In alternative embodiments, the system and method disclosed may also be implemented in a 2G/3G network as well). In a cellular network, the base station or BS (denoted as BTS in 2G, NodeB or NB in 3G, and eNodeB or eNB in 4G systems) is responsible for termination of a wireless link (air-interface) to the mobile device (also known as the User Equipment (UE)). The BS then transports the user data to the core network and communicates control-signaling messages with the core network. In a typical cellular network, there are thousands of BS's covering nations. Each BS covers an area known as a cell. As the demand for mobile Internet expands, the mobile network operator (MNO) needs to deploy smaller cells so it can reuse the frequency more often.

[0046] A BS is made up of the following main functional blocks: 1) radio frequency (RF) front end; 2) clock; 3) baseband; 4) power manager; and 5) central processing unit (CPU). Some BS's also have a dedicated packet processor (PP) to accelerate packet processing in hardware. BS vendors may also use custom or merchant System-on-a-Chip (SoC) or Multi-Chip-Packaging (MCP) solutions to combine various functions into a single chip (e.g., PP, CPU, and baseband).

[0047] Even though there has been attempts to open up various interfaces in the BS (such as the Open BS Architecture Initiative that defines interfaces between these functional modules in the BS), there has been very little to no efforts to unify the

programmability of the BS itself. As a result, the MNOs suffer from the following difficulties. First, the core network Internet edge (CNIE), Packet Data Gateway (PDG) and the surrounding functions are becoming extremely complicated, non-scalable, and expensive. Second, each MNO needs certain customization and feature sets. Currently, they depend on their vendors for these customizations, which could cost the MNO tremendously both financially and in regards to time-to-market (TTM); hence, hindering innovation. In addition, usually these features are put into standards or in the vendor's feature set, thus eliminating the MNO differentiation against the other MNOs. Third, if the MNO is multi-vendor in their CNIE, coordinating all the vendors to implement the same features is usually a difficult and a time-consuming effort. As a result, more add-on network appliances are introduced into the CNIE which adds to the network management complexity. Fourth, as a BS becomes Internet Protocol (IP) based, there is more visibility into the user traffic types and new innovative opportunities are missed for creative traffic shaping features, backhaul bandwidth optimization, prioritization at radio edge, power management algorithms, etc. Fifth, many features implemented in CNIE present suboptimal performance. For example, the filtering enforcement at CNIE is fundamentally inefficient since the packets have to travel all the way through the expensive air-interface, the backhaul, various other core network elements and transport networks to get to the CNIE. Sixth, the Radio Access Network (RAN) deployments are a very expensive endeavor for MNOs. The current rigid BS designs limit innovation and force the MNOs to undergo major upgrades every few years.

[0048] The problems stated above apply to many different types of networks even though here they are presented in cellular networks as a focus. In the present disclosure, the dSDN exhibits a new paradigm in the software programmability of networks that would address the problems above and enable many more advanced features.

[0049] The dSDN may be located at a network element (or system) 200 which is shown in detail in Figure 2 or in alternative embodiments the functions of the dSDN may be divided among a plurality of network elements (or systems) which are similar in structure to network element 200. Each network element 200 may comprise one or

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more system control logic 202 coupled with at least one or a plurality of processor(s) 204, system memory 206, a network interface 208 (including a transceiver 208a), and input/output (I/O) devices 210. The processor(s) 204 may include one or more single-core or multi-core processors. The processor(s) 204 may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, baseband processors, etc.). System control logic 202 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 204 and/or to any suitable device or component in a packet network in communication with system control logic 202. System control logic 202 for one embodiment may include one or more memory controller(s) to provide an interface to system memory 206. System memory 206 may be used to load and store data and/or instructions, for example, for network element 200. System memory 206 for one embodiment may include any suitable volatile memory, such as suitable dynamic random access memory (DRAM), for example. System memory 206 may also include non-volatile memory including one or more tangible, non-transitory computer-readable media used to store data and/or instructions, for example, such as the embodiments described herein with regard to the dSDN. The non-volatile memory may include flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disk (CD) drive(s), and/or one or more digital versatile disk (DVD) drive(s). The system memory 206 may include a storage resource physically part of a device on which the network element 200 is installed or it may be accessible by, but not necessarily a part of, the device. For example, the system memory 206 may be accessed over a network via the network interface 208 and/or over Input/Output (I/O) devices 210. Network interface 208 may include a transceiver 208a to provide a radio interface for network element 200 to communicate over one or more network(s) and/or with any other suitable device. Network interface 208 may include any suitable hardware and/or firmware. The network interface 208 may include a plurality of antennas to provide a multiple input, multiple output radio interface. Network interface 208 for one embodiment may include, for example, a wired network adapter, a wireless network adapter, a telephone modem, and/or a wireless modem. For one

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embodiment, at least one of the processor(s) 204 may be packaged together with logic for one or more controller(s) of system control logic 202. For one embodiment, at least one of the processor(s) 204 may be integrated on the same die with logic for one or more controller(s) of system control logic 202. In various embodiments, the I/O devices 210 may include user interfaces designed to enable user interaction with the network element or system 200, peripheral component interfaces designed to enable peripheral component interaction with the network element or system 200, and/or sensors designed to determine environmental conditions and/or location information related to the network element or system 200. In various embodiments, the peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface.

dSDN Architecture

[0050] In the dSDN architecture, the network features are virtualized and may be distributed across separate network elements that cooperate together to create an advanced, programmable, and scalable network. In an alternative embodiment, the network features may be located at a single network element. A high-level overview of a dSDN system 300 is depicted in Figure 3. The dSDN system 300 consists of a flexible network device (fxDevice) 302, a flexible cloud platform (fxCloud) 304, an application management portal (fxManager) 306, and an infrastructure application market place (fxStore) 308. The fxDevice 302 is a network device that is powered by a sandboxing operating system named flexible operating system (fxOS) 302a. The sandboxing operating system ensures each application runs as a dedicated process in sure isolation from the other applications. The fxOS 302a may be built based on an existing sandboxed operating system (OS) (e.g., Android®) by extending several aspects of such an OS with routing/networking layers and supports for operating as the wireless infrastructure. The fxDevice 302 may host several independent and securely isolated applications (on top of fxOS 302a) named here fxDeviceApp 302b.

[0051] In the dSDN system, fxDeviceApp 302b may have a sister app in the backend cloud infrastructure (i.e., flexible cloud platform 304) referenced here as fxCloudApp 304a. The fxCloudApp 304a in the cloud is paired with its fxDeviceApp 302b in the fxDevice 302. The fxCloudApp 304a and the fxDeviceApp 302b

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collectively form a distributed application (dApp or fxApp). In this description, when fxDeviceApp is referenced it shall mean any application that may have software components in the fxDevice, fxCloud, or both. In general, an fxApp package may include the following software components:

fxDeviceApp binary;

fxCloudApp binary;

Manifest files; and

Signatures.

[0052] It is important to note that the fxDeviceApp 302b and fxCloudApp 304a could use any protocol to communicate with each other and there is no need for standardizing this communication allowing for ultimate freedom for the developers. This allows for the system to operate in a loosely coupled autonomous fashion allowing for asynchronous communication in a distributed fashion.

[0053] The fxApps lifecycle is managed via fxManager 306. The fxManager 306 presents a user-friendly portal to the network administrator (admin) to discover, test prior to deployment, provision, and deprovision dApps. Using fxManager 306, the admin may discover new fxApps from the fxStore 308, which presents all the tested and certified vApps as well as showing the supported fxOS version, support hardware platforms, and other information such as reviews and number of commercial deployments by all NOIT customers.

fxOS

[0054] fxDevice 302 is defined as any networking equipment embedded with a special flexible operating system (fxOS) 302a. The purpose of fxOS 302a is to enable a carrier-class programmable platform. The fxOS 302a is configured to do, but is not limited to, the following. First, since fxOS 302a is designed for network equipment, it allows for efficient execution and running all the time. A plurality of power save modes may be implemented to ensure energy saving schemes without hindering the functionality of the fxDevice 302. Second, it enables simultaneous execution of several flexible applications (fxDeviceApp 302b) on the fxDevice 302. Third, it allows for application of a legacy compiled binary or byte-code of another language (for example, Java or Android®) in addition to fxDeviceApps 302b. Fourth, it allows

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FastPath processing for data plane packets. The packet forwarding in this case separated from the control plane operations. The FastPath engine allows integration with specialized hardware accelerators or packet processors (PP). The packet forwarding may be implemented with software/kernel enhancements all in software. Another FastPath implementation may use both software/kernel enhancement and hardware packet processors (PP). Fifth, the fxOS 302a is capable of Deep Packet Inspection (DPI) and identifying all the flows and their related protocols, services and present this information in a format useful to application developers. The fxOS 302a can act on the data flows as the directed by the application developer. Sixth, applications are securely isolated from each other and to communicate with them is completely configurable by policies defined by the admin. Seventh, resource utilization of each application is policed such that an application may not be able to exceed its usage. For example, an application is pre-allocated the memory size, cache/storage space, and CPU cycles. Eighth, the applications may be signed with unique certificate security keys. The security keys and certificates may be allocated and/or signed by a certificate authority. The fxDevice 302 may be protected by validating signed applications to run or to install in the device. Ninth, it allows hot upgrade of the software and applications on the platform with little to no interruption to the operational aspect of the platform and its applications. Tenth, the fxOS 302a may boot by using the secure code from the network servers (cloud-booting). This would ensure tamper-proof software foundation for the fxDevice 302. Eleventh, there may be a secure and programmable firewall in the fxOS 302a. This embedded firewall protects against attacks to the fxDevice 302 and network attached to the network. The fxOS 302a firewall may be configured by the developer and it does allow replacing of attack detection algorithms (e.g., man-in-the-middle detection algorithm). The fxOS 302a may allow secure caching of user data, web pages, and media files (video and audio) in the fxDevice 302. The secure connections to the cloud (fxCloud 304) can enable sharing and control of the caching between the fxCloud 304, fxDevice 302, or the rest of the network. Twelfth, the fxOS 302a can support multi-threading and multi-core CPUs. This feature may dynamically distribute the threads to various CPU core without developers assistance.

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[0055] The fxOS 302a allows secure connection to the fxCloud 304. This secure connection allows communication between fxDeviceApps 302b in the fxDevice 302 and fxCloudApp 304a in the fxCloud 304. The fxOS 302a controls the access of applications to platform APIs. An application is categorized into an Access Level (AL) based on which the fxOS 302a decides that the application does not exceed its AL and access APIs that it is not authorized. The fxCloud 304 and the fxOS 302a create a virtual fabric (fxVF) for messaging between applications. The actual message can travel directly between two fxDevices or it may traverse the fxCloud 304. The messaging complexity may be abstract for the developer.

[0056] Figure 4 demonstrates an examplary view of the software layers in the fxOS 302a. Each layer of this software stack is modified and redefined to optimize for embedded networking equipment of wireless and wireline nature. Starting from the bottom of the stack, the kernel also connects to the hardware resources via the device drivers. Examples of such resources are wireless baseband SoC 402, hardware packet processor 404, Wide Area Network (WAN) uplink interface 406, cache and storage 408, and multi-core CPU 410. The OS kernel 412 is enhanced with the FastPath function 414 to accelerate packet processing (by help of hardware features such as Intel's Data Plane Development Kit (DPDK) or pure software enhancements) and other related data path functions. The enhanced kernel with FastPath 412, 414 would enable visibility into the data flows, sniffing the Non-Access Stratum (NAS) signaling (which is the signaling between the UE and the Core Network and the RAN is supposed to be transparent to), policy enforcements, regular packet forwarding functions, collection of flow statistics into Flow Information Base (FIB), and encryption/decryption functions.

[0057] Above the kernel, there are several tools 416, native daemons 418, native libraries 420 and Hardware Abstraction Layers (HAL) 422. These tools abstract out the hardware dependencies for the upper layers and programmers. The Runtime 424 is an embedded virtual machine capable of securely isolating and executing the applications. System Services 426 are a set of services always running and available to the developers (e.g., timing and messaging services).

[0058] fx-Framework Library 428 consists of several Frameworks. The new

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frameworks are the library extensions introduced explicitly for the dSDN framework. Each of these frameworks adds a set of methods of (functions) and data structures for the following examples:

Wireless Manager 428a: manipulation, monitoring, and configuration of the wireless interfaces;

System Manager 428b: configuration, provisioning, and changing major settings of the fxDevice 302;

Flow Controller 428c: allows for manipulation of data path, tunneling, switching, and optionally coordinate this activity with fxCloud 304;

Energy Management 428d: enables fine-grained control over various elements in the fxDevice 302 that could be moved into various power stares, for example: ON, OFF, SLEEP, SUSPEND;

Big Data Manager 428e: manipulation, processing, and organization of data collected from various elements. This framework could enable close coordination between the fxDevice 302 and the fxCloud 304;

Content Manager 428f: for data sharing (database sharing) between the applications within the fxDevice 302 or the fxCloud 304 and between applications in fxDevice 302 and fxCloud 304. The Content Manager 428f may use URI to address the contents to be shared. The Content Manager 428f allows access to the application data according to the policy settings and permissions;

Policy Manager 428g: responsible for execution and implementation of polices set up by the admin. The application developers could use this framework to perform queries about the permissions, limitations, and rules;

Security Manager 428h: allows for access to the security protocol libraries and rewriting some of security algorithms such as the man-in-the-middle detection algorithm;

General Framework: general compute and logic building that may be

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inherited from existing general OS frameworks.

[0059] Using the frameworks, there are potentially at least two types of application types that are possible. First, the System Native Applications 430 that are provided as the initial application load into the platform. These applications could be used by other applications by links or API. Second, the fxDeviceApps 302b that are written by third party developers or the NOIT.

[0060] Figure 5 further details the FastPath 414 architecture. In this approach, the FastPath 414 is divided into the Virtual Switch (data-plane) 502 and the Switch Controller (control-plane) 504. Such separation makes possible flexible deployment wherein the function of the Switch Controller 504 could move to the fxCloud 304 by an admin decision or by the dSDN system intelligence for example in the case of failure, redundancy, stateful reboot, or Hot Upgrade. The Virtual Switch 502 may include several functions and may interact with the Switch Controller 504 in the following exemplary ways:

Firewall 502a: implements the policies given to it by the firewall logic 504a in the fxOS Daemons.

Flow/NAS Discover 502b: continuously monitors data packets and discovers new flows and NAS signaling. It would then report it to the DPI Logic 504b where the flow intelligence resides and matching to meta-data happens. DPI Logic 504b in turn updates the Flow Information Base Information (FIB) 502c of the Virtual Switch 502.

FastPath & DPI Processing 502d: forwards, routes packets, and performs DPI functions as instructed by the FIB 502c. It also collects statistics of packets and reports them to the Monitoring Logic 504c.

Policy Enforcement 502e: this function enforces various policies on the traffic such as QoS marking according to the policies received from the Policy Logic 504d.

Shaper 502f: this function could shape (queue) the traffic according to the available bandwidth on the uplink or WAN interface.

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Virtual Fabric (fxVF) 504e: enables transparent switching of application and system messages of a dApp between the fxCloud 304 and the fxDevice 302 and between different dApps. The fxVF 504e is an abstraction layer that hides most of the complexities of messaging from the developers. The fxVF 504e uses the policies and firewall rules to enforce security and policies.

[0061] The fxOS 302a is mostly used for networking applications. There are some potential use cases where there is a need for a general purpose OS to run the legacy software applications with no need of recompilation. An example of a double OS situation may be where a digital signage (using a general purpose OS such as Android®) in a shopping mall also acts as a smart small-cell (using the fxOS 302a). In such a solution, any existing Android® application (for example) could be loaded in the fxDevice 302 and in parallel networking applications (fxDeviceApps 302b) could run on the same fxDevice 302.

[0062] Figure 6 presents a potential software layer of the fxOS 302a co-existing alongside a General Purpose OS 602. Another implementation may be a standalone fxOS without the company of another general OS. It is important to note that the shown co-existence allows reuse of the kernel so there would be no need to re-port the drivers of hardware resources twice.

fxCloud

[0063] The fxCloud 304 is an integral part of the dSDN framework. The fxCloud 304 connects to various parts of the fxDevice 302 to form a single virtual view of the system. Examples of the main fxCloud 304 responsibilities include the following. First, it interacts and manages all applications, firmware, and fxOS 302a in the fxDevice 302. Second, it secures isolation environments for distributed apps. Third, it directs the Virtual Machine lifecycle management including load-linked VM creations and destruction (Cloud Breathing). Fourth, the fxCloud 304 executes instructions defined by the fxManager 306. Fifth, it implements uniform policy (including security) distribution and execution across dSDN 300 (including the fxDevice 302, fxDeviceApps 302b, fxCloudApps 304a, and dApps). Sixth, Plug-and-Play commissioning of the fxDevice 302 introduction

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and network expansion. Seventh, Distributed Resource Service (dRS) by which distributed applications can seamlessly communicate and message to each other using published APIs or proprietary methods within the pre-defined policies. Eighth, security violation discovery and alert system. Ninth, translation and/or exposure of Resources APIs (RAPI) to the systems outside the dSDN 300 within pre-defined policies. Tenth, fxCloud 304 in coordination with the fxDevice 302 creates a Distributed Notification Service (dNS) across the dSDN 300 by which the applications could be notified of an event to wakeup and/or respond to the event. Eleventh, fxCloud 304 in coordination with the fxDevice 302 creates a Distributed Content Management Service (dCMP) which provides a virtualized and distributed database system for applications to share application-specific or system-specific information with the pre-defined policies. Twelfth, the Switch Controller 504 function in the fxCloud 304 could take control of the controller function of the fxOS 302a in the fxDevice 302. This would allow controller switching from local to remote and back. Examples of such a configuration is a temporary reason where the fxOS Switch Controller 504 may not be available during reboot or software upgrade.

[0064] In the discussion below, these services and features are expanded upon.

fxDeviceApp-0 & fxCloudApp-0

[0065] The fxDevice 302 and fxCloud 304 have embedded System Applications categorized as fxDeviceApp-0 and fxCloudApp-0, respectively. The fxDeviceApp-0 is responsible for all default and core functional capabilities of the fxDevice 302 as listed below:

Firmware of the fxDevice;

Default communication protocols (e.g. LTE S1-AP, baseband software, security protocols, GTP, DNS, tunneling protocols);

Message communication protocol between the fxDevice and fxCloud;

Initial fxDevice settings;

Boot Loader;

fxDevice X.509 digital certificate;

OS and Kernel upgrades;

Upgrade and commissioning agents for the fxDeviceApp-0 upgrades and related procedures;

Establishing and initiating the message communication protocol between the fxDevice and fxCloud;

General fxDeviceApp install and upgrades;

Access to fxDevice hardware and software information.

The fxCloudApp-0 is responsible for all default and core functional capabilities of the fxCloud 304 such as:

Upgrade and commissioning agents for the fxCloudApp-0 upgrades and related procedures;

Hypervisor upgrades;

Virtual Machine lifecycle management (e.g. creation, suspension, destruction);

fxCloud X.509 digital certificate management;

OS and kernel upgrades;

General fxCloudApp install and upgrades;

Default communication protocols (e.g. security protocols, DNS, tunneling protocols).

Each software component can be managed and updated individually. To simplify the management of these software components, each software components can be sub-numbered such as fxDeviceApp-0.1, fxDeviceApp-0.2, fxCloudApp-0.1, fxCloudApp-0.2, etc.

fxManager

[0066] The network administrator may use the fxManager 306 to control much of the dSDN system 300. The fxManager portal could use HTML5, for example, as

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a frontend technology. The major functions of the fxManager 306 may include the following.

fxDevice Management:

Commissioning (plug-and-play), de-commissioning, firmware/OS upgrading/downgrading;

Suspend/resume functions;

Unification of zones and partitions for example in case of network merger;

Detailed management of fxDevices (remote secure login) where the administrator may zoom into a particular or a group of fxDevices to monitor and set management alarms;

Security policy setting.

Application lifecycle management: fxManager 306 may work, coordinate, and/or perform these tasks in conjunctions with fxCloud 304 for:

Provisioning, de-provisioning, upgrade/downgrade applications. Some applications may only have a fxDevice component (Device-Centric Apps), may only have fxCloud component (Cloud-Centric Apps), or may have both fxDevice and fxCloud components (Hybrid Apps);

Creating a Test Network Environment (TNE) where the administrator can test certain configuration and applications without impacting the production networks;

Uploading applications developed by the NOIT or their partners into the Application Repository (AR). The AR is placeholder where the application packages are downloaded and stored for testing and verification prior to installation into the live dSDN system. An application could have several components (e.g. fxDeviceApp binaries, fxCloudApp signatures, manifest files, signatures) bundled together to form the Distributed Application Package (dAP);

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Browsing through the certified applications in the fxStore and downloading them to the AR;

Application license accounting services by which a secure and accurate accounting of the installed applications are performed regularly. This inventory management function allows the administrator and the 3rd party ISV to account for live and active instants of the software in the network;

Application review tool where the network admin could use to review feedbacks and comments of other NOIT (maybe anonymous reviews) and could input his/her reviews for others (maybe anonymous reviews).

fxCloud Management:

Zoning and partitioning the network for administrative purposes. Zones and partitions could optionally put into different Virtual Machine (VM);

VM load management and Cloud Breathing policies;

The configuration conflict resolutions. Some configurations applied to the resources may conflict with each other (e.g., one firewall rule may state drop Netflix packets explicitly and another rule may state allowing Netflix explicitly). The fxCloud resource manager could monitor these configurations and discover the conflicts and signal those to the network administrator.

Security Management:

Security policy setting;

Inter-App communication setting;

Security of communication between fxDevice and fxCloud;

API Access Level (AL) definitions and (re-)assignment to the applications (permissions);

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Risk Analysis of the applications;

Certificate and signature verification of the applications;

Content sharing between applications and associated policies.

[0067] An fxManager Portal per the above description may have an "Account" button which can be used to create admin users and their privileges. The fxManager Portal could also include a geographical map illustrating locations of fxDevices and their status. The fxManager 306 functions could be integrated into other network management tools. The fxManager 306 could potentially build the inventory of the network devices (fxDevices) showing all the available devices and statistics. As described above, the network administrator could optionally procure the applications a third party hosted application store (fxStore). The fxStore 308 could potentially categorize the applications several groups (as shown in Figure 7 which is an example view of the fxStore portal). The fxStore 308 could also show the reviews of the advertised applications. In order to maintain quality, the third party fxStore 308 may perform rigorous testing of the applications and accompany those results with the advertised application.

fxSDK

[0068] The flexible Software Development Kit (fxSDK) may include a development environment and other tools to facilitate development, testing, debugging and verifications of applications for dSDN environments. The fxSDK is unique in several aspects exemplified as follows. First, since the dSDN applications may have a device component (fxDevice 302) and cloud component (fxCloud 304), the fxSDK allows the developer to develop the components together to simplify the development and testing. Second, the dRMS offers various system level APIs with remote accessibility. In other words, the APIs in the fxDevice 302 could be accessed via the applications in the fxCloud (fxCloudApps) and vice versa. The fxSDK simplifies the usage system created APIs and application created APIs. Third, it is essential for the dSDN to ensure quality and security of applications in the network. The fxSDK may be accompanied with an extensive Risk Analysis Utility (RAU) which verifies all the APIs that are being used by the application and based on its potential danger to the

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network, it would show the risk analysis and may make specific suggestions to reduce the risk. Once completed, the risk analysis result is included in the dAP for posting to the fxStore and consumed by the fxManager user (the admin). Fourth, the fxSDK would also ensure that the applications do not exceed their planned memory and resource usage. Fifth, the Integrated Development Environment (IDE) may provide various tools to actively demonstrate errors, defined APIs, security dangers, and excessive resource usage. Sixth, the IDE could also provide a flexible Simulator (fxSimulator) for the developer test the application in a network setup in presence of other network elements.

Deployment Examples

[0069] The dSDN 300 offers flexible deployment options. In this section, a few exemplary embodiments are presented.

[0070] Figure 8 demonstrates a shared cloud deployment where several NOITs (802, 804, 806) share an fxCloud 808. In order to ensure complete isolations, each NOIT may be assigned a separate Virtual Machine (VM) 802a, 804a, 806a. A good example of this deployment option may be when multiple service providers outsource their fxCloud deployment to a third party vendor that offers a SaaS/PaaS solution. It is important to note that in this option, each NOIT should have its own secure instance of the whole system. This option could potentially create a full outsourcing model for network operations including possibilities of seamless merging of networks of two or more NOITs.

[0071] Another deployment option may be a Zoned Deployment as shown in Figure 9. In this option, a large NOIT may partition their network into a plurality of zones (Zone #1, Zone#2,… Zone#n) for administrative, software compatibility grouping, or other reason. For example, it is possible that in a large network deployment, there would be different versions of fxOS with varying capabilities in the network (the older hardware may not support newer fxOS version). In this case, the service provider may decide to group the fxDevices per fxOS versions for management simplifications.

[0072] Figure 10 is another embodiment deployed in a Programmable & Virtualized Cellular Network. In this example, the dSDN is applied to the cellular

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networks (e.g., LTE). As shown, the fxDevice 1002 here is the LTE eNB (4G base-station) and the fxCloud 1004 hosts the LTE core network (EPC) functions such as MME, S-GW, and P-GW in separate VMs. Within each EPC function, new features could be added using the dSDN framework. For example, a new application to optimize signaling for Machine-2-Machine (M2M) devices could be loaded into the fxDevice 1002 and the MME function in the fxCloud 1004.

PRINCIPAL PROCEDURES & SERVICES

[0073] The dSDN framework could offer extensive services and capabilities that would simplify the programmability of the network. In this section below, a set of main procedures and services are presented as further exemplary embodiments.

fxDevice Commissioning Provisioning

[0074] Figure 11 illustrates a signaling flow chart for a fxDevice Plug-and-Play Commissioning Procedure. This procedure enables fxDevice commissioning and initial setup to provide a seamless and Plug-and-Play (PnP) deployment. The fxDevice relies on the fxDeviceApp-0 and the fxCloudApp-0 to connect to the backend management system and perform the commissioning procedure. In step 1101, the fxDevice 1120 tries to discover the fxManager 1130 using the fxManager Fully Qualified Domain Name (FQDN). The fxDevice 1120 is configured to always look for the same FQDN. If the NOIT has a private cloud deployment, the DNS server in the NOIT will be configured to point to its own fxManager IP address. If the cloud is shared, the NOIT will configure their DNS server to point to the shared cloud IP address. In step 1102, the fxDevice 1120 receives the IP address of the fxManager 1130. In step 1103, the mutual authentication may be performed where the fxDevice 1120 authenticates the fxManager 1130 and vice versa. In step 1104, a secure tunnel may be created between the fxDevice 1120 and the fxManager 1130. In step 1105, the fxDevice 1120 may optionally request for the latest firmware/OS version. In this phase, the fxDevice 1120 informs the fxManager 1130 of its hardware information (e.g. vendor, model number, CPU model/speed, memory/cache size) and software information (e.g., current firmware version, current OS version, fxDeviceApp-0 version package stating versions of fxDeviceApp-0 components). In step 1106, the fxManager 1120 may send the latest firmware/OS version (or point

the fxDevice to the right URL to download the latest load). In step 1107, if a new firmware/OS load is downloaded and verified, the fxDevice 1120 installs it. In step 1108, the fxDevice 1120 requests the default settings and the default application package (the initial applications that the NOIT admin would like to install in fxDevice 1120 prior to other applications). In step 1109, the fxManager 1130 prepares the fxCloud 1140 for the new fxDevice 1120 integration into the network. In step 1110, once completed, the fxCloud 1140 informs the fxManager 1130 of its readiness. In step 1111, the fxManager 1120 sends all the default settings and the default application package to the fxDevice 1120. In step 1112, the fxDevice 1120 then sets up a secure connection to the fxCloud 1140 (more precisely the fxCloudApp-0). In step 1113, a commissioning completion message is set from the fxCloud 1140 to the fxManager 1130. In step 1114, the fxManager 1130 signal to the fxDevice 1120 the completion of the commissioning and starts th regular operation of the fxDevice 1120. At this phase, fxManager 1130 can optionally modify the settings in the security connections between fxDeviceApp-0 and fx-CloudApp-0 and between fxDeviceApp-0 and fxManager 1130.

Application Provisioning Procedure

[0075] The Application Provisioning Procedure enables provisioning and de-provisioning of applications across the dSDN system. For simplicity, the term provisioning in this disclosure is used to present all similar procedures of provisioning and de-provisioning. The application provisioning procedures are usually triggered by the network administrator and are orchestrated by the fxManager, which works in collaboration with the fxDeviceApp-0 and fxCloudApp-0.

[0076] Figure 12 shows an example procedure for Application (dApp) Provisioning. In step 1201, the network admin identifies the applications that would need to be installed in the dSDN system. These applications are already downloaded (from the fxStore or other sources) into the Application Repository (AR). Prior to installation in the live network, the authorized network admin 1220 has probably performed rigorous testing of the application in the test network. In step 1202, the fxManager 1230 performs a detailed analysis on the potential risks that this application may

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create on various parts of the network and other applications. The analysis tool uses the secure manifest file and other information to discover, for example, all the APIs used by the application, the required access-level authorization level for each of those APIs, requirements on the fxVF (inter-app, intra-app communication needs), and usage of platform resources including conflict discovery and resolutions. In step 1203, the admin defines the deployment scope that the application would be applied. Examples of deployment scopes could be a given zip code, a city, an administrative domain (zone), a shopping mall, an office building, or manual handpicking of sites or fxDevices 1240. The fxManager 1230 verifies compatibility of the OS version and resouces requirements of the application and the fxDevices 1240. If the fxManager 1230 discovers incompatibility, it informs the admin and request adjustment to the deployment scope or proposes upgrading incompatible fxDevice if possible. In step 1204, the admin 1220 initiates the installation process. In step 1205, the fxManager 1230 unpacks the dApp and if there is fxDeviceApp component, it would prepare it for submission to the fxDeviceApp-0 of fxDevices in the deployment scope. In step 1206, installation commands are sent to the fxDeviceApp-0s in a secure connection already set up as part of the fxDevice Commissioning. In step 1207, the fxDevice 1240 verifies the fxDeviceApp package and performs necessary integrity checks of the received software package. Once verified, the fxDeviceApp is installed and re-verified. In step 1208, the completion of successful install is sent to the fxManager 1230 by the fxDevice 1240. In step 1209, the fxManager 1230 prepares the fxCloudApp component of the dApp (if any). In step 1210, installation commands are sent to the fxCloudApp-0s in a existing secure connection. In step 1211, the fxCloud 1250 verifies the fxCloudApp package and performs necessary integrity checks of the received software package. Once verified, the fxCloudApp is installed and re-verified. In step 1212, the completion of successful install is sent to the fxManager 1230 by the fxCloud 1250. In step 1213, the fxManager 1230 informs the admin 1220 of the successful installation process.

Hot Upgrade Procedure

[0077] The Hot Upgrade refers to a procedure by which the software upgrades

on the system have no or minimal implication on the functionalities offered by the software component subject to the upgrade process. Herein are presented two types of software upgrades. For simplicity, the use of the term upgraded in this disclosure represents both upgrade and downgrade since they both use identical processes. First, upgrade of applications on the fxDevice (i.e., fxDeviceApp) and fxCloud (i.e., fxCloudApp). Second, upgrade of core functions in the fxDevice (aka fxDeviceApp-0) or fxCloud (aka fxCloudApp-0).

[0078] The upgrade procedures for fxDevice and fxCloud are similar. Here, the focus is on the fxDevice upgrade process since it is technically more challenging due to stricter resource limitations in the fxDevice.

General Application Upgrade

[0079] The applications could be upgraded automatically or manually by the network admin. In either case, the installation of the upgrade follows a similar procedure as the Application Provisioning Procedure. Figure 13 presents the state of the machine for the application upgrade process. In state 1301, the old version of the application is still running. In Load state 1302: the new version of the application is downloaded in the local storage while the old version is still running. In Install state 1303: the new version is installed (in the memory) while the old version is still running. In Run state 1304: the new version is activated taking charge of all the related data and application state and the old version is deactivated while still remaining in the local storage. In Commit state 1305: the old version is fully removed after ensuring the new version is running properly as expected.

fxDeviceApp-0 Upgrade

[0080] The fxDeviceApp-0 is a collection of software components that perform the core functionalities of the fxDevice. As a result, this hot upgrade is quite challenging. The most important thing is to ensure that major functionalities of the fxDevice (such as packet forwarding) remain

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intact during the upgrade process. The fxDeviceApp-0 upgrades may be categorized as:

- No OS Kernel upgrade; or
- OS Kernel upgrade.

No Kernel Upgrade

[0081] As described earlier, the packet forwarding function could be broken into the Virtual Switch and the Switch Controller. In order to maintain, the packet forwarding function, the Switch Controller function could be performed by another device or a second processor in the same device while the fxDevice is being upgraded. Figures 14A-14C demonstrate a few examples of distributed Switch Controller function during the upgrade. In some cases, it may be possible for the fxCloud to take over the Switch Controller function (Figure 14A), or a neighboring fxDevice (Figure 14B), or second CPU in the same fxDevice (Figure 14C). The actual software upgrade procedure would be similar to Application Provisioning Procedure and the state machines are the same as the one shown in Figure 13.

Kernel Upgrade

[0082] In this case, the packet forwarding process is mostly unavailable. Therefore, one potential solution might be for the fxDevice to redirect the entire bit stream to a neighboring fxDevice. In other words, the fxDevice would have just a bare minimum routing function working and the rest of the function would be performed by a neighboring fxDevice.

[0083] All the other upgrade procedures and state machines are similar to the ones performed for the No Kernel Upgrade process.

Virtual Fabric Service

[0084] The Virtual Fabric (fxVF) provides an abstraction layer for application to communicate with each other whether they are in the fxDevice or fxCloud. Various frameworks and services may use the fxVF service. Figure 15 illustrates fxVF 1502a, 1503a, 1504a in the fxDevices 1502 and 1503 and fxCloud 1504. The fxVF 1502a,

1503a, 1504a may use Extensible Messaging and Presence Protocol (XMPP) for this messaging as the default protocol. It is important that the developers may use their own communication protocols between the fxDeviceApps 1502b, 1503b and the associated fxCloudApp 1504b. fxVF 1502a, 1503a, 1504a provide a secure routing mechanism.

Intra-App Messaging

[0085] This is an example of where one application in the fxDevice communicates with the same instance of the app in another instance of the same application in another fxDevice. The actual messages could go directly between the fxDevice or via the fxCloud. As an example, in the case of mobile networks, this messaging could be used to transfer user specific context from one eNB to another as a user hands off to a new eNB. In LTE, Private Messages on X2 interface could be used for messaging between the eNBs that act as the fxDevices.

Inter-App Messaging

[0086] In some cases, different applications may need to communicate with each other via their published APIs. In this case, the security policies set up by the network administrator determines which applications could communicate with each other for what purpose. The fxVF follows the security policies determined by the network administrator for inter-application communications.

distributed Resources Service (dRS)

[0087] The resources could be platform resources or APIs offered by the applications. The fxCloud and fxDevice resources could include (as examples):

Firewall;
Data and statistics;
Storage (usually abundant at fxCloud);
Compute (usually abundant at fxCloud);
Load evaluator;
General settings;

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Routing engine (usually relevant to the fxDevice);

Virtual Machine master controller (usually relevant to the fxCloud);

Power controller (usually relevant to the fxDevice); and

Wireless engine (usually relevant to the fxDevice).

[0088] An app (fxDeviceApp or fxCloudApp) could expose APIs to be used by the other apps. The inter-app communication is enabled by the fxVF where the policy and security provisions are enforced. The APIs exposed may be RESTful (representational state transfer) and could travel across physical network elements. Since the fxManager defines fxVF policies, the administrator could ultimately specify which APIs between which apps could communicate with each other. Figure 16 demonstrates the logical interfaces between the platform resources and applications. As shown in Figure 16, the distributed Resources Service (dRS) 1602, 1603 comprises software agents residing in the fxDevice 1604 and the fxCloud 1606. These dRS agents manage the access to the platform resolutions (including potential configuration conflict resolution) as well as facilitating inter-app APIs. The dRS 1602, 1603 allows or disallows access to platform resource or inter-app communication according to the policies defined by the network administrator using the fxManager. In summary, the dRS 1602, 1603 provides services to application developers for:

Exposing APIs to other applications;

Configuring and managing platform resource;

Policy enforcement and authorization of applications access to platform resource and other app's APIs; and

Policy conflict resolution.

distributed Content Service (dCS)

[0089] The distributed Content Service (dCS) allows the developers to seamlessly store and share the contents generated by one application with other applications and its associated application in the cloud. The dCS simplifies access to the data and brings in storage virtualization to the applications. In other words, the developers no longer would need to know where the data is actually stored (in

the cloud or on the device) and would be able to access them easily. The dCS implementation may use Virtual Fabric (fxVF) and distributed Resources Service (dRS).

distributed Notification Service (dNS)

[0090] The distributed Notification Service (dNS) is another potential tool for developers that could wake or ping an application when a particular event has occurred. For example, a load monitoring application could be notified when the CPU load on a particular fxDevice (or a target area) exceeds a certain threshold. In turn, such an exemplary application could make smart decisions on reducing the load on the CPU by forcing handoffs of users to neighboring cells (i.e. fxDevices). The dCS implementation may use Virtual Fabric (fxVF), distributed Resources Service (dRS) and distributed Content Service (dCS).

Cloud Breathing Procedures

[0091] In general, resources (compute, storage) at the cloud are more abundant. However, software licensing costs and other limitation may require smart management of resources. The Cloud Breathing, here, is defined as a mechanism where the cloud resources are automatically expanded as load increases on the system or reduced as the load decreases. This creates an automatic elasticity in the cloud dimensions. Figures 17A and 17B demonstrate procedures for the cloud breathing. Figure 17A is expansion and Figure 17B is reduction. The Load Controller in the dRS 1602, 1603 could be used to monitor the load (step 1702) on the existing VMs (e.g. CPU or memory utilization loads). The VM Master of the fxCloudApp-0 1608 could effectively act on the decisions made by the dRS's Load Controller. Again, the network administrator via the fxManager defines the policies and thresholds for such decisions.

Security Aspects

[0092] The security aspects of this solution are of outmost importance in order to ensure quality in the product networks.

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Identity

[0093] To create a security model, the dSDN network elements should have unique identities. The following identities may be defined:

fxDevice Identity (DID): this identity is unique globally and may be allocated at manufacturing and included in the X.509 digital certificate of the fxDevice;

fxCloud Identity (CID): this identity is unique to the NOIT domain and may be allocated by the network administrator and included in the X.509 digital certificate of the fxCloud;

fxDeviceApp Identity (DAID): this identity may be globally unique and may be allocated by the fxSDK at the point of code creation by a globally accessible server;

fxCloudApp Identity (CAID): this identity may be globally unique and may be allocated by the fxSDK at the point of code creation by a globally accessible server;

dApp Identity (AID): This identity may be globally unique and may be constructed by concatenation of DAID and CAID together;

Application Developer Identity (ADID): this is a globally unique identity allocated by a globally accessible server and may be included in the developer's X.509 digital certificate and is used to sign the final developed applications.

[0094] For addressability purposes, the identities may be presented in a URI format using the FQDN of the NOIT.

Access Level

[0095] The applications are given different access levels. The AL is used by the dRS to determine which APIs or class of APIs an application can access (e.g., a fxDeviceApp running on fxDevice should not be able normally to reboot the fxDevice). The required AL is generated by the fxSDK and included in the manifest files. It may also be published in the fxStore for that give application. A preset of ALs could be defined to categorize the applications security risks.

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Software Security Verification

[0096] It is important for the target network element to verify the authenticity and integrity loaded software prior to install. The uniquely defined security keys of the application developers sign the applications. The following rules may be followed to ensure software security verification:

Only the verified OS/Firmware software can install on verified hardware;

Only the verified OS/Firmware software can run on verified hardware (continuous verification of essential parts of the software);

Only the verified fxDeviceApp software can install on verified hardware;

Only the verified fxDeviceApp software can run on verified hardware (continuous verification of essential parts of the software).

[0097] Each fxDeviceApp is accompanied by a manifest that is generated by the Integrated Device Electronics (IDE) at the time of compilation of the fxDeviceApp. The manifest file specifies which libraries and frameworks the fxDeviceApp uses. The fxManager uses this information to determine the security risk of the fxDeviceApp as well as the required Access Level (AL) to run this fxDeviceApp. In order to ensure that manifest file is actually genuine manifestation of the fxDeviceApp and its integrity remains intact, a hashing algorithm could be used to generate a signature. An example is shown below:

Signature = HMAC-SHA256(K, Message);

where

Message = fxDeviceApp + Manifest

K = shared secret key between fxStore and fxManager.

[0098] The signature is generated by the IDE/fxSDK at the compile/build phase and is packaged with application binary and the manifest file. Once the distributed application package (dAP) is downloaded into the fxManager (Application Repository), the components of the signature, application binary, and manifest file are unpackaged. The fxManager then uses the same hashing algorithm to calculate

the signature as above using the pre-shared key (K). If the calculated signature and the unpackaged signature match, it would prove the authenticity of the manifest file and the integrity of both manifest file and the fxDeviceApp.

[0099] Code Generation Process (Compilation):

fxDeviceApp compiled→ Manifest file generation→ Signature calculation→ Create fxDeviceApp Package

[0100] Install Process (Consumption):

Un-package fxDeviceApp→ Signature calculation→ Signature comparison

[0101] This model works if the key K can be shared with two trusted parties (fxManager and fxStore). The manifest file that is generated by the fxSDK shall be secured by integrity checks to ensure it remains intact throughout the transaction (i.e. from compilation to consumption).

Communication Security

[0102] Security mechanisms built into the fxDeviceApp-0 and fxCloudApp-0 forces the fxDevice to only use the configured fxCloud servers for Software Security Verification, fxDeviceApp downloads, and fxDeviceApp-fxCloud communication. Optionally, the fxDeviceApp-fxCloud communication can be customized per application requirements. One implementation of this interface could use SPDY Protocol or per-application VPN.

[0103] For the purpose of inter-App communication, an Inter-App Communication (IAC) policy template is applied to an fxDeviceApp that defied the communication policies between the fxDeviceApps and fxCloudApps. The network administrator may use one of the pre-configured IAC policy templates (exemplified below):

Isolated: this type of applications cannot communicate with any other application in the same fxDevice and does not have any associated fxCloudApp;

Isolated-Extended: this type of fxDeviceApps cannot communicate with any other fxDeviceApps in the same fxDevice but could communicate with its associated fxCloudApp;

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Private: a private fxDeviceApp in one fxDevice could communicate with same private fxDeviceApps in other fxDevice but does not have any associated fxCloudApp;

Private-Extended: a Private fxDeviceApps in one fxDevice could communicate with same private fxDeviceApp in other fxDevice and has its associated fxCloudApp;

Community: a group of fxDeviceApps that belong to the same community can communicate with each other;

Promiscuous: a Promiscuous app could communicate with any other Promiscuous application and Community application;

Custom: the network administrator could create custom IAC Policy templates and could include (as examples):

Template name;

Inherited pre-configured template if any;

The protocols allowed to use for communication;

The maximum data rate allowed for inter-app communication between a pair of fxDeviceApps or between an fxDeviceApps and an fxCloudApp;

Policies related to the other fxDeviceApps in the same fxDevice, in other fxDevice, associated fxCloudApp and unassociated fxCloudApps;

Policies related to direct fxDeviceApp to fxDeviceApp communication or relayed via fxCloud communication.

Secure Boot

[0104] The secure boot refers to a capability where the main boot code is in the fxCloud with the following exemplary procedure:

The Boot Loader (BL) in the fxDeviceApp-0 of the fxDevice looks for a particular DNS (DNSSEC) name of the fxCloud. The network administrator should define the DNS entry in their network. If there is a private fxCloud, the resolved domain name points to the fxCloud. If using shared cloud, the resolved

domain name points to the cloud point of presence;

A secure tunnel (TLS) is created between the BL in fxDevice and the fxCloud using pre-burned X.509 certificate;

BL identify itself to the fxCloud and include System Information;

fxCloud determines the appropriate boot file and points the BL to the exact address of the boot file in the fxCloud;

BL downloads the correct boot file;

BL runs Software Security Verification;

BL reboots the fxDevice and the system will be ready for operation.

Frameworks

[0105] The following describes an example of the API Framework for the dSDN. Some APIs are purely local to the fxDevice or the fxCloud and some may be extended from the fxDevice all the way to the fxCloud using dRS.

General Framework

[0106] This framework refers to general libraries and APIs inherited from the legacy OS. An example of the legacy OS may be Embedded Android®. This framework allows for general processing and may be used for algorithmic applications.

Wireless Framework

[0107] The Wireless Framework adds a set up functions related to managing and controlling the wireless module. Table 1 highlights some examples of methods/functions that may be available in the Wireless Framework.

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Table 1: Wireless Framework	
Method	Description
discoverNeighbors	Discovers wireless neighbors and returns their identities
retrieveNeighborInfo	Retrieves detail information of neighboring BS/AP information. This method may transparently call cloud servers to gather more information
measureInterference	Measures wireless interference observed on a frequency or a set of frequency channels
setWirelessConfig	Sets various parameters in the wireless module such as power, frequency channels, Multiple Input/Multiple Output (MIMO) antenna configuration, etc.
definePHYReceiverAlgorithm	Defines the physical layer receiver algorithm
connectedDevice	Returns details about the connected mobile devices (length of connection, data tx/rx) to a given wireless interface (channel, band, sector)
forceOffload	Offloads connected mobile devices to other access technologies (e.g. from cellular to WiFi)
homeAreaNetworking	Control of home automation wireless technologies such as ZigBee or Z-Wave
setNeighborCells	Sets neighboring cells information
forceHandoff	Handoffs connected mobile devices to the same access technology but different channel or frequency
topMovers	Identifies the mobile devices with highest degree of mobility

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positionDevice	Accurate positioning of mobile devices which may include geo-fencing data
borrowSpectrum	Allows one BS to borrow spectrum from another
configureMACScheduler	Configures the MAC scheduler (for example prioritize a particular user)
loadBalance	Enables load balancing across radio channels
defineMACScheduler	Defines the MAC scheduler algorithm

Security Framework

[0108] The Security Framework allows the developers to use a specialized security functions/methods. Some of these new methods may use the legacy OS frameworks. Table 2 highlights some examples of methods/functions that may be available in the Security Framework.

Table 2: Security Framework

Method	Description
setDOSDetect	Detects DOS attacks on user plane as requested
configureFirewall	Provides firewall functions such as traffic filtering, permissions (this may use dRS)
defineDOSDetectAlgorithm	Allows replacing and redefining the DOS algorithm
encryptTraffic	Encrypts the content of a message or a class of traffic as requested
authenticateUser	Authenticate users as requested
integrityCheckContent	Verifies authenticity of a message using its checksum information
configuresIPS	Configures IPS functions on the user plane

FastPath Framework

[0109] The FastPath Framework allows the developers to identify and manipulate the data path with a DPI capability. Table 3 highlights some

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examples of methods/functions that may be available in the FastPath framework.

Table 3: FastPath Framework	
Method	Description
matchTraffic	Identifies and matches the traffic type requested by the developer
detectCongestion	Detects if there is congestion on the data path
identifyTopURLs	Identifies the most visited URLs by the users
detectLocalConversation	Detect conversations and packet routing between the end user on the same fxDevice
detectDevice	Detects traffic of a given mobile user device
redirectTraffic	Redirect data traffic to a given network element. The traffic may be identified with a user or a class of traffic
connectedDevices	Returns all the connected mobile devices to a given fxDevice
assignAddress	Allocates a particular IP address to the mobile device
setPriority	Set traffic priority to a class of traffic
markTraffic	Marks the user traffic with the desired QoS tags
setupTunnel	Sets up data tunnel from fxDevice to a destination
Adscript	Adds a JavaScript to an active transiting web page
detectIdenticalFlows	Identifies the identical flows coming from the WAN/uplink interface on the fxDevice
aggregateFlows	Enables aggregation of flows to save WAN/uplink utilization
routeTunnel	Routes a packet or a class of traffic onto an established tunnel
identifyTopDevices	Identifies users that generate most traffic load

Messaging Framework

[0110] The Messaging Framework allows the developers to send messaging between the applications residing in the fxDevice and fxCloud. Table 4 highlights some examples of methods/functions that may be available in the Messaging Framework.

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Table 4: Messaging Framework	
Method	Description
sendIntraApp	Sends an Intra-App message from one fxDevice to another
sendInterApp	Sends an InterApp message from one application to another
sendfxCloud	Sends a message to the fxCloud
sendSMS	Sends an SMS to the user of choice

Caching Framework

[0111] The Caching Framework allows the developers to cache particular contents or files that are accessed frequently in the caching engine. The caching can be done locally in the fxDevice, clustered cache (shared amongst a few fxDevice), or cloud caching. Table 5 highlights some examples of methods/functions that may be available in the Caching Framework.

Table 5: Caching Framework	
Method	Description
storeForward	Enables Store and forward model for a target class of traffic where the target traffic is matched and stored upon a condition and forwarded the condition is relieved
cacheWebSite	Caches the most visited web sites
cacheVideo	Caches the most viewed videos
cacheCloud	Caches the requested content or traffic type in the cloud storage in fxCloud

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Management Framework

[0112] The Management Framework enables the developers to manage the BS platforms and perform administrative procedures. Table 6 highlights some examples of methods/functions that may be available in the Management Framework.

Table 6: Management Framework

Method	Description
upgradeFirmware	Started and executes the firmware upgrade procedure on the fxDevice
upgradeOS	Started and executes the operating system upgrade procedure on the fxDevice
remoteBootup	Performs remote boot up process where the fxDevice works closely with the fxCloud to perform the bootup
remotePower	Allows fxCloudApps to remotely turn on and off a fxDevice or elements in the fxDevice (e.g. the wireless)
gatherStatistics	Instructs fxDevice to gather specific statistics. Various commands may be consolidated for gathering statistics. Number of active users Stats of time spent by users in the cell Stats of quality perceived by the users Neighboring cell info Overall traffic passed through the system Total number of connected devices per frequency, per carrier, per site, per location Handover failure statistics Cloud aggregated data processing and full report Total traffic passed Applications used (meta-data correlated) Bandwidth consumed User's mobility pattern

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setMonitoring	Allows the developer to get reports and statistics of the fxDevice traffics, errors, and neighboring environment. The reporting criteria could be set up as: 1) Period, 2) Event based (reports only if a threshold is passed; a threshold could be based on absolute numbers or deltas), 3) One-time (i.e. the information is pulled once). The exact parameters to get report on may use the same data structures used by the method “getStatistics”.

getSystemInfo	Retrieves static and dynamic system info such as: • Hardware info: vendor, model number, capability profile. GPS, Cellular, WAN interfaces, RFID/NFC • Heat temperature • Vendor Specific Information • Software info: OS version, firmware information • CPU load, per-application load (CPU, memory, accelerators) • Loaded apps and status • Memory utilization • Storage utilization • Interface status & utilization (RF, backhaul, management...)
getfxDeviceLocation	Retrieves location of the fxDevice • Location would be presented in GPS coordinates and civil address • Location enhancement: Cloud, map data, and neighbor discovery could help more accurate positioning
getPowerConsumption Rate	Retrieves current power consumption rate of the fxDevice
configureWAN	Configures the WAN settings
retrieveNeighborInfo	Retrieves neighbor information from the fxCloud
getRFIDInfo	Returns the RFID/NFC information of the fxDevice
setRFIDInfo	Sets the RFID/NFC information of the fxDevice

Extensible API Framework

[0113] This framework allows the developer to create custom APIs and make it accessible for other applications (in the fxDevice or in the fxCloud). In turn, the fxCloud could present these APIs using e.g. REST technologies (via the fxCloud

Northbound Interface) to the developer outside the dSND system. There might be limits put on the APIs exposed through the cloud to avoid potential misuse or security threats. The dRS enforces the security policies defined by the admin (via fxManager). The applications take a role of Client Application (CA) or Server Application Role (SA). The CA and SA could be distributed in the fxDevice or fxCloud. The CA makes requests and SA serves the requests.

[0114] The Extensible APIs could be categorized (as examples) into:

Read-Only Data: this type of APIs allows a CA to read data from SAs without the ability to change or request any particular action from the SAs

Read-Write Data: this type of APIs allows CA application to read data from SAs with the ability to change some of their data but no option for requesting any particular action from SAs;

Procedural: this type of APIs allows CAs to execute a particular procedure in SAs. The rights to change any data still depends on whether the API allows Read-Only Data or Read-Write Data types.

Cloud Management Framework

[0115] The Cloud Management Framework presents a collection of methods enables management of the cloud services and resource. Table 7 highlights some examples of methods/functions that may be available in the Cloud Management Framework.

Table 7: Cloud Management Framework

Method	Description
detectCloudCongestion	Detects congestions on a particular VM
deleteVM	Deletes an active VM permanently
suspendVM	Suspends an active VM but doesn't remove it
activateVM	Activates an already created VM
createVM	Creates a new VM but doesn't activate it

EXAMPLES OF DAPPS

[0116] The dSDN create an end-to-end programming platform and the possibilities of vApps are only limited by the developers' imagination. An example list of potential vApps are presented in Table 8 below.

Table 8 highlights examples of use cases possible by the Distributed Software Defined Network (dSDN)

Use	Description	Framework {Methods} used
1	Distributed SON: For example, the WiFi AP could search for the least crowded channel to minimize the interference	Wireless {discoverNeighbor, retrieveNeighborInfo, measure nterference, setWirelessConfig, loadBalance}, General Framework, Messaging {sendIntraApp}
2	BS Hot Firmware Upgrade without impact to the basic functions of the BS. For this function to support full hot upgrade without operational impact, the Communication SoC should be able to	Management {upgradeFirmware}
3	BS Hot infOS Upgrade without impact to the basic functions of the BS. For this function to support full hot upgrade without operational impact, the full platform should have dual processor.	Management {upgradeOS}
4	Secure network---based booting. This allows to keep the code securely in the cloud to avoid tampering by the ODM/CM or Man---in---the---Middle attacks	Management {remoteBoot}
5	Turning on or off APs if nobody is in the office. Sensors in the building send information to fxCloudApp which in turn orders power control of the APs	Management {remotePower}
6	Store and forward model for low priority M2M applications where the target traffic is matched and stored in the case of network congestion and forwarded once the network congestion is relieved.	DataPath {matchTraffic, detectCongestion}, Cache {storeForward}
7	Replacing MAC Scheduler	Wireless {defineMacScheduler}
8	Replacing Receiver Algorithms	Wireless {definePHYReceiverAlgorithm}
9	Caching most visited website or video clip in the enterprise	DataPath {identifyTopURL}, Cache {cacheWebSite}
10	The most viewed videos and webcasts are cached in the wireless edge	DataPath {identifyTopVideos}, Cache {cacheVideo}
11	Local Routing: data and voice sessions between two parties on the same cell are routed within the same cell bypassing the core network	DataPath {detectLocalConversation, RouteLocal}
12	Local Routing: data and voice sessions between two parties on the nearby cells are routed locally bypassing the core network	DataPath {detectConversationDetect, routeLocal}
13	Temporary redirection of a data flow for monitoring and security reasons. In this use case, a particular user's traffic is tracked by redirection to a monitoring station. If user is mobile, such profile of tracking and associated redirection is transferred from fxDevice to fxDevice either directly or via the fxCloud	DataPath {detectDevice, matchTraffic, redirectTraffic}
14	Power Calendar: On---demand coverage (triggered by passing traffic thresholds in certain cells or by calendaring): Operators need to design their network for peak usage rates at high costs, leaving their network underutilized most of the time	DataPath {detectCongestion}, Management {remotePower}
15	DOS attack recognition and action could be blocking the user, the app, and/or notifying the user via an SMS message	Security {setDOSDetect, configureFirewall}, Messaging {sendfxCloud}
16	Applying certain ACLs to the BS. For example, the students in the class can only access Facebook between the breaks and access to Facebook is blocked during the class	Security {configureFirewall}
17	Forced offloading of some cellular users (users that have attached to the same cell for a while) to WiFi by changing "something" in the cellular connection to force WiFi connection (Heterogeneous)	Wireless {identifyConnectedDevice, forceOffload}
18	Service continuity and anchoring at eNB for WiFi using the same LTE IP address (Heterogeneous)	DataPath {identifyConnectedDevices, assignAddress}
19	Graphic/general processing for special use cases such as City BS	General Frameworks
20	Application filtering/throttling (secondary conditions: time---based, location---based, subscriber---type, none)	DataPath {matchTraffic}, Security {configureFirewall}
21	Local Services: The enterprise user can discover Bonjour or UPnP devices and services (e.g. printer) even when connected to LTE/3G small---cell in the enterprise. In this case, the small cell or fxDevice pro---actively listens to Bonjour and UPnP discovery and advertisement messages (SSDP) and cache the available services until a device request for such information. In the case of Bonjour, fxDevice could listen to Multicast DNS (mDNS) messages sent over cellular connection (LTE/3G) and multicast them on the LAN or WLAN interfaces.	DataPath {matchTraffic, routeLocal}
22	Local Services: The premise---owner (e.g. airport, hotel) can provide ads under the browser for sponsored WiFi or cellular (3G/LTE) access over multi---mode small cell. The premise owner could use this service to advertise special offers or third party ads. This technique uses HTML <script> for example to add special content to the bottom of the page.	DataPath {matchTraffic, addScript}

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23	Distributed Content Distribution Network (CDN). In this use case, the fxDevices function as CDN that bring the contact closer to the end users.	DataPath {matchTraffic}, Cache {cacheVideo}
24	In case of national security, the service provider may limit the access to the network so only the law enforcement can use the cellular network. In this case, the admin defines a Target Area (TA) using an fxCloudApp in the fxCloud where the emergency lockdown needs to be applied. The IMSI/MSISDN number of law enforcement mobile devices are sent to the fxDevice in the TA which in turn enforce the policy. The policy may allow the public to just sent SMS while the law enforcement could have full access and priority to the system.	DataPath {matchTraffic, setPriority}, Security {configureFirewall}
25	Emails and web browsing monitored by the cloud services assisted by the agent in the dSDN network. In this case, the fxDevice detects certain traffic (email or web in this case) and redirects them to a cloud service for security cleansing.	DataPath {matchTraffic, redirectTraffic}
26	Analytics pre---analysis: The data collected from M2M devices could be processed (noise could be filtered out) and packaged (compressed) for consumption by cloud services	DataPath {matchTraffic}, General Framework, Messaging {sendfxCloud}
27	Certain traffic could be marked with QoS DSCP codes for further processing in the network	DataPath {matchTraffic, markTraffic}
28	Proprietary SP services and applications that run purely between the phone and the BS . For example, the SP may implement a certain application for the law enforcement to get direct feed of surveillance cameras in a target area (TA).	DataPath {matchTraffic}, Security {configureFirewall}, General Framework
29	IP---PBX implementation in the small---cell or WiFi AP for enterprise use. This would allow a simple out of a box solution. The VoIP phones connect to the fxDevice via the LAN connections. The WAN connection could connect to an fxCloudApp for PSTN calls	DataPath {matchTraffic}, General Framework
30	Network management system can add its own agent/probe to collect and consolidate data and transmit it to its cloud element using any protocol	Management {gatherStatistics, getSystemInfo, control}, General Framework
31	Application based performance monitoring on the wireless link (number of packets sent in idle mode, retransmit rate…). Such information could be shared with the app developer to optimize its application	Management {gatherStatistics}, General Framework
32	Seamless network sharing and mergers. This is the case where two Network Operators would like to share or merge their network. Using dSDN's infManager, the network administrators could merge the network administration control. This process may include setting up the desirable default fxApp packages of the network operator	fxManager Portal Service
33	Following a user to understand where it faces coverage issues or call drops. Once discovered, the system could send a message to the user acknowledging an issue and that the SP is trying to fix this. The information is uploaded to the cloud for further analysis	Management {gatherStatistics}, General Framework, Messaging {sendSMS}
34	Reporting: This allows the developer to get reports and statistics of the fxDevice traffics, errors, and neighboring environment. The reporting criteria could be set up as: 1) Period, 2) Event based (reports only if a threshold is passed; a threshold could be based on absolute numbers or deltas), 3) One---time (i.e. the information is	Management {setMonitoring}, General Framework
35	Proprietary security protocol between the application in the mobile device and the BS in enterprise deployment. This would allow SP to create enterprise---class LTE for indoor using small cells	Security {encryptContent, authenticateUser, Integrity, configureFirewall}, DataPath {RouteLocal}, General Framework
36	The femto cell at home that can't scan neighboring cells, gets a list of neighboring cells from the fxCloud or neighbors to broadcast to improve outbound handoffs	Wireless {discoverNeighbors, retrieveNeighborInfo, setNeighborCells}, Management {retrieveNeighborInfo}
37	IMS---capable femto enabling various SP services to initiate or transferred between home network and mobile devices	Messaging {sendfxCloud}, General Framework
38	Integrated smart home with multi---mode femto/WiFi router. For example, the application in the smart home router (fxDevice) allows for coordination of home physical security service (such as ADT services). With the fxCloudApp, the user could control the security status of his/her home and remotely control the setting of the	Wireless {homeAreaNetworking}, Messaging {fxCloud}, General Framework
39	Home CCTV DVR implementation in an integrated home router. The camera feeds are recorded on the same router caching engine	Cache {cacheVideo}, Messaging {sendfxCloud}, General Framework
40	Enterprise CCTV DVR implementation in an integrated router with cloud backup. The camera feeds are recorded in the cloud.	Cache {CacheVideo, CacheCloud}, Messaging {fxCloud}, General Framework
41	User traffic separation into various MPLS/LSP (integrating VPN and BS). In this case, users are classified into groups and each group is tunneled to the core network. For example, law enforcement use the encrypted tunnel while the other users use the default tunnel	DataPath {Match, SetupTunnel, RouteTunnel}
42	Dynamic spectrum allocation where a BS borrows unused spectrum from the neighboring BS in case of temporary congestions	DataPath {detectCongestion}, Wireless {discoverNeighbors, setWirelessConfig}, Management {retrieveNeighborInfo, borrowCarrier}, Messaging {fxCloud}

43	Proxy ANDSF (Access Network Discovery and Control Function) in the BS. When the UE tries to access the ANDSF, the Proxy ANDSF fxDeviceApp in the BS intercept the ANDSF messages and replies on behalf of the ANDSF. This would speed up the WiFi network discovery for example.	DataPath {matchTraffic}, General Framework, Messaging {sendfxCloud}
44	HD Audio calling: audio codecs in BS allows the phones with the right capabilities to communicate with HD Audio quality calling. If one of the mobile devices can't handle the HD quality audio, the BS performs the transcoding of the audio.	DataPath {matchTraffic}, General Framework
45	Enabling mobility on White Space Spectrum: The latest white space database will be downloaded. The mobile devices with special software applications make requests to the BS to retrieve the local available white space frequencies. This would allow the mobile device to handoff seamless between BS using the white space spectrum. The BS would advertise such a capability to the UEs. The secure communication allows peer---to---peer communication between the UE and the BS for certain applications such as White Space Channel lookup or site acquisition tools for field engineering and RF planning.	Messaging {sendfxCloud}, General Framework
46	Site acquisition tool where the technician uses a software tool on his mobile phone to interact with BSs to determine the best place to deploy the new BS. The phone app interests with fxDeviceApps in BSs and fxCloudApp. For example, fxDeviceApp performs air interface quality and gives a priority to traffic generated by for this	Messaging {sendfxCloud}, General Framework. DataPath {matchTraffic, setPriority}
47	DNS caching at BS to accelerate DNS lookup for subsequent users. This would improve the user experience by reducing response delays	DataPath {matchTraffic}, General Framework
48	Continuous SLA monitory for certain protocols, applications or general link quality for jitter, delays, bandwidth	DataPath {matchTraffic}, Management {gatherStatistics}, General Framework
49	Enterprise users can use the small cell deployed in their enterprise free of charge. The DPI engine in fxDevice classifies the traffic and identifies the enterprise private data and they would be routed locally and charging records are generated by the BS (the SP decides how to bill the enterprise user and it may decide to make such usage free	DataPath {matchTraffic, routeLocal}
50	On---premise small---cell aggregation where on fxDevice takes the responsibility of aggregating multiple small---cells on the premise and presenting them as a single BS/Node---B/eNodeB to the core network. In this case the aggregating fxDevice (AfxE) may take responsibility of local radio resource manager (RRM) or self---optimizing network (SON) server. AfxE can also implement and enforce policies concerning local service access on the premise (enterprise) as well as enable seamless handover between cellular technologies and on---premise (enterprise) local area network (LAN) for example using WiFi technology.	General Frameworks, Wireless {discoverNeighbors, retrieveNeighborInfo, setNeighborCells, setWirelessConfig}, Messaging {sendIntraApp}
51	Self adjusting fxCloud compute resources: The fxCloud creates and tears down virtual machines (VMs) based on the traffic load measured by itself or the packet processing and data plane engine. It is also possible that the VM adjustments are made based on the rush hour or pre---configured hours of the day or manually by the administrator.	CloudManagement {removeVM, createVM, detectCloudCongestion, actiavteVM, suspendVM}
52	Core Network Function Virtualization (cNFV) using distributed Software Defined Networking (dSDN): In the case, once an fxDevice is commissioned, its fxDeviceApp0 (i.e. firmware) uses predefined DNS names to discover the rest of the core network (e.g. MME, S---GW, etc.). The core network elements could be created and	General Frameworks, Messaging {sendInterApp, sendIntraApp), CloudManagement {deleteVM, suspendVM, createVM, activateVM, detectCloudCongestion}
53	Smart display and digital signage as wireless base stations: this use case allows combining the capabilities of a base station and the smart display in shopping malls, airports, and enterprises. There is a already electric power and connectivity for the smart display that the base station function could use.	General Frameworks
54	Tracking a mobile user at base station level even if the UE is in the idle mode. Currently in the idle mode, the MME, SGSN, or VLR/MSC can only know the location of the UE in with a accuracy of LA/RA/URA which is a very large area. The administrator uses the fxCloudApp and requests tracking of the user/UE (the admin may provide target area where the user/UE may be located; e.g. zip code or town name). The fxCloudApp contacts its fxDeviceApp in the fxDevices in the target area (TA) requesting information of a particular IMSI/MSISD/TMSI. Once an fxDevice responds indicating knowledge of the user location, the fxCloudApp directs that serving fxDevice to inform the fxDeviceApp in the next fxDevice of the instructions to track the user and contact fxCloudApp when they user hands off to due to its mobility. fxCloud could create user friendly interfaces and presentations to show for example the direction the user is moving, predict next location of the user, and estimate arrival of the user to a certain location	DataPath {matchTraffic}, Messaging {sendIntraApp, sendfxCloud}
55	In case of emergency, fxDevices in a target area block all public traffic and only allow law enforcement sessions using specially encryption and authentication between the UE and the fxDevice or fxCloud (depending on the requirements)	DataPath {matchTraffic, setPriority}, Security {configureFirewall, encryptTraffic, authenticateUser}, General Framework

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56	SON triggered by the data traffic consumption. In this case, the mobile cell configuration is adjusted based on the current traffic of the cell. It could for example force handoff some users (high users or users moving fast) to neighboring cells.	DataPath {identifyTopDevices}, Wireless {forceHandoff}
57	Time based QoS and policy. In this use case, the infManager pushes certain policies in target area (TA). Such polices could be turning on extra capacity (frequency channels) or QoS policies and traffic prioritization on the WAN like	DataPath {matchTraffic, setPriority}, Wireless {discoverNeighbors, setWirelessConfig}
58	Fast moving users detection: in this use case, the application in the BS measures the speed of the user (based on the time was handed off to this cell until it was handed over to the next cell). This information could be used by the fxDevice or fxCloud to force handoff the mobile user to a larger cell to reduce handoff rates	General Frameworks, Wireless {identifyTopMovers, forceHandoff}
59	Emergency broadcast of information and live camera feeds. In case of emergency, the enterprise network administrator temporarily block all traffic and only allow emergency related traffic across the target area in the enterprise network. For example, the network admin broadcasts the camera feeds and alerts over the WiFi access points using multicast IP techniques. The client devices and digital sinages can listen to that particular multicast and show the camera feeds and emergency alerts	DataPath {matchTraffic, setPriority}, Security {configureFirewall}, General Framework
60	Dynamic advertising in shopping malls. The shopper would use an app from the shopping mall. When the shopper brings up or refreshes the app, the dSDN allows the shopping mall to pinpoint the exact indoor/outdoor location of the user (e.g. the shop the shopper is in) and send special coupon and ads for that store to the shopper.	General Frameworks, Wireless {positionDevice}, Messaging {sendIntraApp, sendfxCloud}, Security {configureFirewall}, DataPath {matchTraffic, redirectTraffic}
61	Smart tour guide. The tourist would use an app from the tourism board or museum. When the user brings up or refreshes the app, the dSDN allows to pinpoint the exact location of the tourist (e.g. the painting he/she is looking at) and send tour guide information (e.g. audio, video, hypertext). dSDN allows to localize the positioning and	General Frameworks, Wireless {positionDevice}, Messaging {sendIntraApp, sendfxCloud}, Security {configureFirewall}, DataPath {matchTraffic, redirectTraffic}
62	General hotspot landing page	DataPath {matchTraffic, redirectTraffic}, Security {authenticateUser}
63	Proprietary wireless mesh implementation	Wireless {discoverNeighbor, retrieveNeighborInfo, measureInterference, setWirelessConfig}, General Framework, Messaging {sendIntraApp}
64	Power and energy consumption map of the network. A real---time fxCloudApp pulls the power consumption details from each fxDevice periodicaly or on demand. The pulled data then are combined with the location information and correlated into a map to present a viewable consumption map	Management {getfxDeviceLocation, getPowerConsumptionRate}
65	Network deployment optimization. This application allows network operator to get advice for best optimal reconfiguration and/or redeployment of the network. For example, the network admin could get suggestion that based on the power consumptions and coverage perceived and spectrum utilization, it might be better to replace a particular group of smaller cells with a single macro---cell. This app could also pull information from larger OEMs based on the subject deployment scenario (the OEMs either provide this information statically to the tool or provide network APIs for use by this app e.g. using REST protocol)	Management {getfxDeviceLocation, getPowerConsumptionRate, gatherStatistics}
66	High availability. This app allows two or more fxDevice to form a redundancy cluster where they participate in statueful redundancy and load---balancing	Messaging {sendIntraApp}, General Framework
67	Bandwidth Bursting. This feature enables the dynamic adjustment of backhaul or WAN link bandwidth as the demands change in the enterprise or public wireless deployments. In this case, the fxDeviceApp in the fxDevice monitors the WAN link utilization, once a preset threshold percentage has reached, it messages its sister fxCloudApp which in turn would send a request to the fxDeviceApp to increase or decrease the WAN bandwidth. If additional backend reconfiguration is needed, the fxCloudApp performs those additional changes prior to informing the fxDeviceApp of the bandwidth	Management {getStatistics, configureWAN}
68	Wireless link quality measurement by the small---cell or WiFi AP: The wireless SoC in the small---cell or WiFi AP continuously monitors the link quality for power adjustment and handover reasons. Such information could be exposed to the app developers to create cell---level analytics and reports without the need to have test--- drives or field testing of service quality	Management {gatherStatistics}, General Framework
69	Data Path Consolidation: An application on the fxDevice discovers identical data feeds from a cloud server to two or more users. The fxDeviceApp in the fxDevice can discover this potential duplicate flows at the session establishment (via a proxy function) and it would consolidate those sessions into one on the uplink towards the cloud server. A good example of this use case is the web---based desktop sharing where different many users in the same office site get the same feed from the cloud server.	FastPath {detectIdenticalFlows, aggregateFlows}

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[0117] The following references are herein specifically incorporated by reference in their entirety into this disclosure:

[1] 3GPP TS 23.002, “Network Architecture”;
[2] 3GPP TS 23.402, “Architecture enhancements for non-3GPP accesses”;
[3] 3GPP TS 23.401, ~~“General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access”;~~
, “General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access”;
[4] Open Base Station Architecture Initiative (OBSAI); and
[5] SPDY Protocol (http://datatracker.ietf.org/doc/draft-mbelshe-httpbis-spdy/).

CLAIMS

1. A plurality of network elements in a packet system, said network elements comprising:

a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp;

a flexible cloud platform having at least one fxCloudApp, wherein the at least one fxDeviceApp and at least one fxCloudApp are in secure communication to form a distributed application; and

an application management portal which manages life cycle of the distributed applications.

2. The system of claim 1, wherein each of the flexible network device, flexible cloud platform and application management portal include an access network interface unit configured to send and receive communications and a processor with a memory associated with the network interface unit.

3. The system of claim 1 further comprising:

an infrastructure application market place in communication with the application management portal, said infrastructure market place capable of providing tested and certified applications to the application management portal.

4. The system of claim 1, wherein the at least one fxDeviceApp is responsible for a plurality of functional capabilities of the flexible network device and is capable of at least one of the group consisting of: updating the firmware of the flexible network device; updating default communication protocols of the flexible network device; initializing flexible network device settings; boot loading the flexible network device; providing

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security digital certificates; providing OS and kernal upgrades; and upgrading and commissing agents for the fxDeviceApp upgrades and related procedures.

5. The system of claim 1, wherein the at least one fxCloudApp is responsible for a plurality of functional capabilities of the flexible cloud platform and is capable of at least one of the group consisting of: upgrading and commissioning agents for the fxCloudApp updates and related procedures; hypervisor upgrades; virtual machine and/or isolated execution environment lifecycle management; security digital certificate management; OS and kernel upgrades; and default communication protocols.

6. The system of claim 1, wherein the application management portal is capable of at least one of the group consisting of: receiving new applications from the infrastructure application market place; test said distributed application prior to deployment; provision said distributed application; and deprovision said distributed application.

7. The system of claim 1, wherein the flexible network device is an LTE eNB and the flexible cloud platform hosts an LTE core network functions in separate virtual machines from the group consisting of: MME, S-GW, and P-GW.

8. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:
a virtual fabric which provides a secure communication layer for said at least one fxDeviceApp and said at least one fxCloudApp.

9. The system of claim 1, further comprising:
a second flexible network device which includes at least one fxDeviceApp which is the same as the at least one fxDeviceApp in the first flexible network device and where each of the fxDeviceApps can communicate directly.

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10. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed resource service (DRS) which controls access to a plurality of resources upon receiving instructions from the application management portal.

11. The system of claim 10, wherein the resources include at least one of a group consisting of: firewall; data and statistics; storage; compute; load evaluator; general settings; routing engine; virtual machine master controller; power controller; and wireless engine.

12. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed resource service which is capable of providing at least one service from a group consisting of: exposing APIs to other applications; configuring and managing platform resources; policy enforcement and authorization of applications access to platform resource and other app's APIs; and policy conflict resolution.

13. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed content service wherein contents generated by the at least one fxDeviceApp may be shared with the at least one fxCloudApp.

14. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed notification service wherein notice of a particular event is sent from the at least one fxDeviceApp to the at least one fxCloudApp.

15. The system of claim 10, wherein the DRS further includes a load controller; and wherein the load controller is adapted to monitor loads on the at least one fxDeviceApp and at least one fxCloudApp and effect change in accordance with thresholds received from the application management portal.

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16. The system of claim 1, wherein the fxDevice, at least one fxDeviceApp, flexible cloud platform, and the at least one fxCloudApp each have unique identities.

17. The system of claim 1, wherein the at least one fxDeviceApp and and at least one fxCloudApp are given an access level to determine which APIs can be accessed.

18. The system of claim 1, wherein the at least one flexible network device and flexible cloud platform are adapted to verify the authenticity and integrity of updates.

19. A plurality of network elements in a packet system, said network elements comprising:

a flexible cloud platform having a plurality of virtual machines, wherein each of the virtual machines has at least one fxCloudApp; and

a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

20. A plurality of network elements in a packet system, said network elements comprising:

a flexible cloud platform having a plurality of zones, wherein each of the plurality of zones has at least one fxCloudApp; and

a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

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ABSTRACT

The Distributed Software Defined Network (dSDN) disclosed herein is an end-to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

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2	Specification	TAAG001CONT3_SPECIFICATION_CLEANv2.pdf	2553883 d1a223b6a12c5b8eca381ebfde9683535d0a94ad	no	59
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DISTRIBUTED SOFTWARE DEFINED NETWORKING

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] The present invention claims priority from U.S. Provisional Patent Application Serial No. 61/834,807, filed June 13, 2013 the disclosure of which is herein specifically incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] This invention relates to a network architecture that facilitates secure and flexible programmability between a user device and across a network with full lifecycle management of services and infrastructure applications.

BACKGROUND

[0003] Existing network solutions are built on proprietary hardware and software. Network Operators & Information Technology (NOIT) can only configure the proprietary network infrastructure provided by vendors and are unable to add new and customized features or capabilities. As a result, the NOIT can only add new desired features by making such requests to their infrastructure vendors or pursuing standardization processes. But these existing approaches are time consuming and resource intensive.

SUMMARY OF THE INVENTION

[0004] An aspect of the disclosure herein is a plurality of network elements in a packet system, said network elements comprising: a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp; a flexible cloud platform having at least one fxCloudApp, wherein the at least one fxDeviceApp and at least one fxCloudApp are in secure communication to form a distributed application; and an application management portal which manages life cycle of the distributed applications.

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[0005] Another aspect of the disclosure is a plurality of network elements in a packet system, said network elements comprising: a flexible cloud platform having a plurality of virtual machines, wherein each of the virtual machines has at least one fxCloudApp; and a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

[0006] Another aspect of the disclosure is a plurality of network elements in a packet system, said network elements comprising: a flexible cloud platform having a plurality of zones, wherein each of the plurality of zones has at least one fxCloudApp; and a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 demonstrates the network architecture of a 4G system.

[0008] Figure 2 illustrates a network element (or system) upon which the Distributed Software Defined Network operates.

[0009] Figure 3 illustrates a Distributed Software Defined Network in accordance with the present disclosure.

[0010] Figure 4 is an exemplary view of the software layers in the Flexible Operation System (fxOS) Architecture.

[0011] Figure 5 illustrates the FastPath architecture.

[0012] Figure 6 presents a potential software layer of the fxOS co-existing alongside a general purpose OS.

[0013] Figure 7 is an exemplary view of the fxStore Portal.

[0014] Figure 8 demonstrates a shared fxCloud deployment.

[0015] Figure 9 demonstrates a Zoned Deployment.

[0016] Figure 10 demonstrates another deployment option as applied to cellular networks (especially Long Term Evolution (LTE)).

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[0017] Figure 11 shows an example of a signaling flow chart for the fxDevice Commissioning Procedure.

[0018] Figure 12 shows an example procedure for Application Provisioning.

[0019] Figure 13 presents the state machine for the application upgrade process.

[0020] Figures 14A-14C are examples of the Distributed Switch Controller during Upgrade.

[0021] Figure 15 shows how fxVF in the fxCloud and fxDevice.

[0022] Figure 16 demonstrates the logical interfaces between the platform resources and applications.

[0023] Figures 17A and 17B demonstrate example procedures for cloud breathing procedures.

DETAILED DESCRIPTION

[0024] The Distributed Software Defined Network (dSDN) disclosed herein is an architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

DEFINITIONS, ACRONYMS & ABBREVIATIONS

[0025] The following terms, acronyms, abbreviations and descriptions are explained below and are used throughout the detailed description of the dSDN:

TERM	DESCRIPTION
2G	2nd Generation Cellular Technology
3G	3Rd Generation Cellular Technology
4G	4th Generation Cellular Technology
AP	WiFi Access Point
API	Application Programming Interface

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AR	Application Repository
ASIC	Application Specification Integrated Circuit
AuC	Authentication Center
BS	Base Station
BSC	Base Station Controller
BTS	Base Station
CDN	Content Distribution Network
CN	Core Network
CNIE	Core Network Internet Edge
CPU	Central Processing Unit
dAP	Distributed Application Package
dApp	Distributed App
dCP	Distributed Content Service
dNS	Distributed Notification Service
DNS	Domain Name System
DPDK	Data Plane Development Kit
DPI	Deep Packet Inspection
dRS	Distributed Resource Service
DSCP	Differentiated Service Code Point (QoS)
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
EIR	Equipment Identity Register
eNB	Enhanced Node B (4G)
FIB	Flow Information Base
FQDN	Fully Qualified Domain Name
fxApp	FleXible Application, which has a fxDeviceApp and fxCloudApp component. fxDeviceApp and fxCloudApp of one application represent fxApp.
fxDeviceApp	FleXible Application which runs on fxDevice
fxBS	FleXible Base Station that is a BS that is powered by fxOS (an example of an fxDevice)

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fxCloud	FleXible Cloud that interacts with fxDevice and on other network elements on the northbound interface
fxCloudApp	FleXible Cloud Application that is the application that runs on fxCloud and can be associated to one or more fxDeviceApp in fxDevice
fxManager	FleXible Manager that manager the fxOS lifecycle (provisioning, usage, de-provisioning)
fxOS	FleXible Operation System which run on the fxDevice as the OS and firmware
fxSDK:	FleXible Software Development Kit
fxSimulator	FleXible Simulator
fxStore	FleXible Store that presents fxApp to the network
administratorsGERAN	GPRS Edge Radio Access Network
GGSN	Gateway GPRS Support Node (used in core network of 2G/3G systems)
GMSC	Gateway Mobile Switching Center
GPRS	General Packet Radio Service
GPS	Global Positioning System
GTP	GPRS Tunneling Protocol
GW	Gateway
HAL	Hardware Abstraction Layer
HD	High Definition
HLR	Home Location Register
HSS	Home Subscriber Server
IAC	Inter Application Communication

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IMS	IP Multimedia Sub-system
IMSI	International Mobile Subscriber Identifier
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
JVM	Java Virtual Machine
LA	Location Area
LAN	Local Area Network
LSP	Label Switching Protocol
M2M	Machine to Machine
MAC	Medium Access Control
MCP	Multi Chip Packaging
MIMO	Multi Input Multi Output
MME	Mobility Management Entity (used in core network of LTE)
MNO	Mobile Operator Network
MPLS	Multi Protocol Label Switching
MSC	Mobile Switching Center
MSISDN	Mobile Station
NAS	Non-Access Stratum
NB	Node B (3G)
NFC	Near Field Communication
NFV	Network Function Virtualization
NOIT	Network Operations & Information Technology; this term network broadly includes carriers, service providers, enterprise networks, and designated/contacted 3rd party administrators.

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OS	Operating System
OTT	Over the Top
P-GW	Packet Gateway
PaaS	Platform-as-a-Service
PBX	Private Branch exchange (telephony)
PDG	Packet Data Gateway
PDN	Packet Data Network
PHY	Physical Layer
PLMN	Public Land Mobile Network
PnP	Plug and Play
PP	Packet Processor
PR	Platform Resources
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RA	Routing Area
RAN	Radio Access Network of cellular networks
RAPI	Resources API
RFID	Radio Frequency Identifier
RNC	Radio Network Controller
S-GW	Serving Gateway
S1-AP	S1 Interface Application Protocol (an LTE protocol between MME and eNodeB)
SaaS	Software-as-a-Software
SDK	Software Development Kit
SDN	Software Defined Network
SGSN	Serving GPRS Support Node (used in core

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	network of 2G/3G systems)
SIM	Subscriber Identity Module
SiP	System in a Package
SMS	Short Message Service
SoC	System on a Chip
SON	Self-Optimizing Network
SSDP	Simple Service Discovery Protocol
TA	Target Area
TNE	Test Network Environment
TTM	Time to Market
UMTS	Universal Mobile Telecommunication System
UPnP	Universal Plug and Play
URA	UMTS Routing Area
URI	Uniform Resource Identifier
UTRAN	UMTS Terrestrial Radio Access Network
VLR	Visitor Location Register
VM	Virtual Machine
VPN	Virtual Private Network
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WLAN	Wireless Local Area Network
XMPP	Extensible Messaging and Presence Protocol

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[0026] Database. One or more large structured sets of persistent data maintained upon a computer system organized and structured according to a software system defining rules for organization as well as responding to queries to read, write, or modify data as well as provide statistical information regarding the contained data. As used in this disclosure in describing the dSDN, a database may be either a single unified system or a distributed system wherein certain database elements are located upon different systems or servers which may be in different physical locations, acting in harmony to appear as one unified database. Where databases are described, it will be understood by one of ordinary skill in the art that (i) alternative database structures to those described may be readily employed, and (ii) other memory structures besides databases may be readily employed. Any illustrations or descriptions of any sample databases presented herein are illustrative arrangements for stored representations of information. The database formats may include relational databases, object-based models and/or distributed databases which could be used to store and manipulate the data types described herein. Likewise, object methods or behaviors of a database can be used to implement various processes, such as the described herein. In addition, the databases may, in a known manner, be stored locally or remotely from a device which accesses data in such a database.

[0027] The term "determining" and grammatical variants thereof (e.g., to determine a price, determining a value, determine an object which meets a certain criterion) is used in an extremely broad sense. The term "determining" encompasses a wide variety of actions and therefore "determining" can include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" can include resolving, selecting, choosing, establishing, and the like. The term "determining" does not imply certainty or absolute precision, and therefore "determining" can include estimating, extrapolating, predicting, guessing and the like. The term "determining" does not imply that mathematical processing must be performed, and does not imply that numerical methods must be used, and does not imply that an algorithm or process is used.

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[0028] The functionality and/or the features of a single device that is described may be alternatively embodied by one or more other devices which are described but are not explicitly described as having such functionality/features. Thus, other embodiments need not include the described device itself, but rather can include the one or more other devices which would, in those other embodiments, have such functionality/features.

[0029] Devices that are described as in "communication" with each other or "coupled" to each other need not be in continuous communication with each other or in direct physical contact, unless expressly specified otherwise. On the contrary, such devices need only transmit to each other as necessary or desirable, and may actually refrain from exchanging data most of the time. For example, a machine in communication with or coupled with another machine via the Internet may not transmit data to the other machine for long period of time (e.g. weeks at a time). In addition, devices that are in communication with or coupled with each other may communicate directly or indirectly through one or more intermediaries.

[0030] Although process (or method) steps may be described or claimed in a particular sequential order, such processes may be configured to work in different orders. Further, some steps may be performed simultaneously despite being described or implied as occurring non-simultaneously (e.g., because one step is described after the other step) unless specifically indicated. Moreover, the illustration of a process by its depiction in a drawing does not imply that the illustrated process is exclusive of other variations and modifications thereto, does not imply that the illustrated process or any of its steps are necessary to the embodiment(s), and does not imply that the illustrated process is preferred. Where a process is described in an embodiment the process may operate without any user intervention.

[0031] It will be readily apparent to one of ordinary skill in the art that the various processes of the dSDN described herein may be implemented by, e.g., appropriately programmed general purpose computer(s), special purpose computer(s) and computing device(s). Typically a processor (e.g., one or more microprocessors, one or more microcontrollers, one or more digital signal processors) will receive instructions (e.g., from a memory or like device), and execute those instructions,

thereby performing one or more processes defined by those instructions. Instructions may be embodied in, e.g., one or more computer programs, one or more scripts.

[0032] A "processor" means one or more microprocessors, central processing units (CPUs), computing devices, controllers, microcontrollers, digital signal processors, or like devices or any combination thereof, regardless of the architecture (e.g., chip-level multiprocessing/multi-core, Reduced Instruction Set Computer (RISC), Complex Instruction Set Computer (CISC), Microprocessor without Interlocked Pipeline Stages, pipelining configuration, or simultaneous multithreading).

[0033] Further, programs that implement methods described herein may be stored and transmitted using a variety of media (e.g., computer readable media) in a number of manners. In some embodiments, hard-wired circuitry or custom hardware may be used in place of, or in combination with, some or all of the software instructions that can implement the processes of various embodiments. Thus, various combinations of hardware and software may be used instead of software only to implement the embodiments.

[0034] The term "non-transitory computer readable medium" in this disclosure refers to any medium, a plurality of the same, or a combination of different media, that participate in providing data (e.g., instructions, data structures) which may be read by a computer, a processor or a like device. Such a medium may take many forms, including but not limited to, non-volatile media, volatile media, and transmission media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include dynamic random access memory (DRAM), which typically constitutes the main memory. Transmission media may include coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to the processor. Transmission media may include or convey acoustic waves, light waves and electromagnetic emissions, such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of non-transitory computer-readable media in which the dSDN may be implemented include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper

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tape, any other physical medium with patterns of holes, a Random Access Memory (RAM), a programmable read only memory (PROM), an erasable programmable read only memory (EPROM), a flash electrically erasable programmable read only memory (FLASH-EEPROM), any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read.

[0035] Various forms of computer readable media in this disclosure may be involved in carrying data (e.g. sequences of instructions) to a processor. For example, data may be (i) delivered from RAM to a processor; (ii) carried over a wireless transmission medium; (iii) formatted and/or transmitted according to numerous formats, standards or protocols, such as Ethernet (or IEEE 802.3), Bluetooth, and Transmission Control Protocol/Internet Protocol ("TCP/IP"), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), and 2G/3G; and/or (iv) encrypted to ensure privacy or prevent fraud in any of a variety of ways well known in the art.

[0036] Thus in some embodiments in this disclosure a description of a process may be a description of a non-transitory computer-readable medium storing a program for performing the process. The computer readable medium may store (in any appropriate format) those program elements which are appropriate to perform the method.

[0037] In an embodiment, a server computer, network element or centralized authority may not be necessary or desirable. For example, an embodiment may be practiced on one or more devices without a central authority. In such an embodiment, any functions described herein as performed by the server computer or data described as stored on the server computer may instead be performed by or stored on one or more such devices.

[0038] In interpreting the present application (which includes the claims), one of ordinary skill in the art shall refer to the prosecution history of the present application, but not to the prosecution history of any other patent or patent application, regardless of whether there are other patent applications that are considered related to the present application, and regardless of whether there are other patent applications that share a claim of priority with the present application.

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[0039] Numerous embodiments are described in the present application, and are presented for illustrative purposes only. The described embodiments are not, and are not intended to be, limiting in any sense. One of ordinary skill in the art will recognize that the disclosed embodiment(s) may be practiced with various modifications and alterations, such as structural, logical, software, and electrical modifications. Although particular features of the disclosed invention(s) may be described with reference to one or more particular embodiments and/or drawings, it should be understood that such features are not limited to usage in the one or more particular embodiments or drawings with reference to which they are described, unless expressly specified otherwise.

[0040] The present disclosure is not a literal description of all embodiments of the invention(s). Also, the present disclosure is not a listing of features of the invention(s) which must be present in all embodiments. A description of an embodiment with several components or features does not imply that all or even any of such components/features are required. On the contrary, a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention(s).

[0041] The following description has been presented for purposes of illustration and description and is not intended to be exhaustive or to limit the embodiments to the precise form disclosed. Many modifications and variations are possible in light of the teachings disclosed herein.

[0042] The embodiments were chosen and described to explain principles of operation and their practical applications. However, the scope of the invention is to be defined by the claims.

[0043] The major technical reason for inflexibility in network infrastructure has been related mostly to the proprietary hardware and rigid software architecture in the existing network elements (routers, switches, gateways, cellular base-stations, WiFi access points, etc.). With recent advancements in semiconductor device manufacturing, there is no longer a cost barrier to add computing power to many electronics in the market including networking infrastructure. The addition of such compute capabilities would open up new opportunities for programmable platforms in the network and ultimately creating more flexible network architecture

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and business models.

[0044] The Distributed Software Defined Network (dSDN) disclosed herein is an end-to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and applications (fxApp). The dSDN also harmonizes fxApp deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning. In this disclosure, the dSDN is applied to the wireless networks as an exemplary embodiment. However, the dSDN is not limited to wireless networks embodiments and it could be applied to many other network types including enterprise, wireline service providers, data centers, and Internet of Things (IoT).

[0045] Figure 1 demonstrates the network architecture of a 4G system 100. (In alternative embodiments, the system and method disclosed may also be implemented in a 2G/3G network as well). In a cellular network, the base station or BS (denoted as BTS in 2G, NodeB or NB in 3G, and eNodeB or eNB in 4G systems) is responsible for termination of a wireless link (air-interface) to the mobile device (also known as the User Equipment (UE)). The BS then transports the user data to the core network and communicates control-signaling messages with the core network. In a typical cellular network, there are thousands of BS's covering nations. Each BS covers an area known as a cell. As the demand for mobile Internet expands, the mobile network operator (MNO) needs to deploy smaller cells so it can reuse the frequency more often.

[0046] A BS is made up of the following main functional blocks: 1) radio frequency (RF) front end; 2) clock; 3) baseband; 4) power manager; and 5) central processing unit (CPU). Some BS's also have a dedicated packet processor (PP) to accelerate packet processing in hardware. BS vendors may also use custom or merchant System-on-a-Chip (SoC) or Multi-Chip-Packaging (MCP) solutions to combine various functions into a single chip (e.g., PP, CPU, and baseband).

[0047] Even though there has been attempts to open up various interfaces in the BS (such as the Open BS Architecture Initiative that defines interfaces between these functional modules in the BS), there has been very little to no efforts to unify the

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programmability of the BS itself. As a result, the MNOs suffer from the following difficulties. First, the core network Internet edge (CNIE), Packet Data Gateway (PDG) and the surrounding functions are becoming extremely complicated, non-scalable, and expensive. Second, each MNO needs certain customization and feature sets. Currently, they depend on their vendors for these customizations, which could cost the MNO tremendously both financially and in regards to time-to-market (TTM); hence, hindering innovation. In addition, usually these features are put into standards or in the vendor's feature set, thus eliminating the MNO differentiation against the other MNOs. Third, if the MNO is multi-vendor in their CNIE, coordinating all the vendors to implement the same features is usually a difficult and a time-consuming effort. As a result, more add-on network appliances are introduced into the CNIE which adds to the network management complexity. Fourth, as a BS becomes Internet Protocol (IP) based, there is more visibility into the user traffic types and new innovative opportunities are missed for creative traffic shaping features, backhaul bandwidth optimization, prioritization at radio edge, power management algorithms, etc. Fifth, many features implemented in CNIE present suboptimal performance. For example, the filtering enforcement at CNIE is fundamentally inefficient since the packets have to travel all the way through the expensive air-interface, the backhaul, various other core network elements and transport networks to get to the CNIE. Sixth, the Radio Access Network (RAN) deployments are a very expensive endeavor for MNOs. The current rigid BS designs limit innovation and force the MNOs to undergo major upgrades every few years.

[0048] The problems stated above apply to many different types of networks even though here they are presented in cellular networks as a focus. In the present disclosure, the dSDN exhibits a new paradigm in the software programmability of networks that would address the problems above and enable many more advanced features.

[0049] The dSDN may be located at a network element (or system) 200 which is shown in detail in Figure 2 or in alternative embodiments the functions of the dSDN may be divided among a plurality of network elements (or systems) which are similar in structure to network element 200. Each network element 200 may comprise one or

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more system control logic 202 coupled with at least one or a plurality of processor(s) 204, system memory 206, a network interface 208 (including a transceiver 208a), and input/output (I/O) devices 210. The processor(s) 204 may include one or more single-core or multi-core processors. The processor(s) 204 may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, baseband processors, etc.). System control logic 202 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 204 and/or to any suitable device or component in a packet network in communication with system control logic 202. System control logic 202 for one embodiment may include one or more memory controller(s) to provide an interface to system memory 206. System memory 206 may be used to load and store data and/or instructions, for example, for network element 200. System memory 206 for one embodiment may include any suitable volatile memory, such as suitable dynamic random access memory (DRAM), for example. System memory 206 may also include non-volatile memory including one or more tangible, non-transitory computer-readable media used to store data and/or instructions, for example, such as the embodiments described herein with regard to the dSDN. The non-volatile memory may include flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disk (CD) drive(s), and/or one or more digital versatile disk (DVD) drive(s). The system memory 206 may include a storage resource physically part of a device on which the network element 200 is installed or it may be accessible by, but not necessarily a part of, the device. For example, the system memory 206 may be accessed over a network via the network interface 208 and/or over Input/Output (I/O) devices 210. Network interface 208 may include a transceiver 208a to provide a radio interface for network element 200 to communicate over one or more network(s) and/or with any other suitable device. Network interface 208 may include any suitable hardware and/or firmware. The network interface 208 may include a plurality of antennas to provide a multiple input, multiple output radio interface. Network interface 208 for one embodiment may include, for example, a wired network adapter, a wireless network adapter, a telephone modem, and/or a wireless modem. For one

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embodiment, at least one of the processor(s) 204 may be packaged together with logic for one or more controller(s) of system control logic 202. For one embodiment, at least one of the processor(s) 204 may be integrated on the same die with logic for one or more controller(s) of system control logic 202. In various embodiments, the I/O devices 210 may include user interfaces designed to enable user interaction with the network element or system 200, peripheral component interfaces designed to enable peripheral component interaction with the network element or system 200, and/or sensors designed to determine environmental conditions and/or location information related to the network element or system 200. In various embodiments, the peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface.

dSDN Architecture

[0050] In the dSDN architecture, the network features are virtualized and may be distributed across separate network elements that cooperate together to create an advanced, programmable, and scalable network. In an alternative embodiment, the network features may be located at a single network element. A high-level overview of a dSDN system 300 is depicted in Figure 3. The dSDN system 300 consists of a flexible network device (fxDevice) 302, a flexible cloud platform (fxCloud) 304, an application management portal (fxManager) 306, and an infrastructure application market place (fxStore) 308. The fxDevice 302 is a network device that is powered by a sandboxing operating system named flexible operating system (fxOS) 302a. The sandboxing operating system ensures each application runs as a dedicated process in sure isolation from the other applications. The fxOS 302a may be built based on an existing sandboxed operating system (OS) (e.g., Android®) by extending several aspects of such an OS with routing/networking layers and supports for operating as the wireless infrastructure. The fxDevice 302 may host several independent and securely isolated applications (on top of fxOS 302a) named here fxDeviceApp 302b.

[0051] In the dSDN system, fxDeviceApp 302b may have a sister app in the backend cloud infrastructure (i.e., flexible cloud platform 304) referenced here as fxCloudApp 304a. The fxCloudApp 304a in the cloud is paired with its fxDeviceApp 302b in the fxDevice 302. The fxCloudApp 304a and the fxDeviceApp 302b

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collectively form a distributed application (dApp or fxApp). In this description, when fxDeviceApp is referenced it shall mean any application that may have software components in the fxDevice, fxCloud, or both. In general, an fxApp package may include the following software components:

fxDeviceApp binary;

fxCloudApp binary;

Manifest files; and

Signatures.

[0052] It is important to note that the fxDeviceApp 302b and fxCloudApp 304a could use any protocol to communicate with each other and there is no need for standardizing this communication allowing for ultimate freedom for the developers. This allows for the system to operate in a loosely coupled autonomous fashion allowing for asynchronous communication in a distributed fashion.

[0053] The fxApps lifecycle is managed via fxManager 306. The fxManager 306 presents a user-friendly portal to the network administrator (admin) to discover, test prior to deployment, provision, and deprovision dApps. Using fxManager 306, the admin may discover new fxApps from the fxStore 308, which presents all the tested and certified vApps as well as showing the supported fxOS version, support hardware platforms, and other information such as reviews and number of commercial deployments by all NOIT customers.

fxOS

[0054] fxDevice 302 is defined as any networking equipment embedded with a special flexible operating system (fxOS) 302a. The purpose of fxOS 302a is to enable a carrier-class programmable platform. The fxOS 302a is configured to do, but is not limited to, the following. First, since fxOS 302a is designed for network equipment, it allows for efficient execution and running all the time. A plurality of power save modes may be implemented to ensure energy saving schemes without hindering the functionality of the fxDevice 302. Second, it enables simultaneous execution of several flexible applications (fxDeviceApp 302b) on the fxDevice 302. Third, it allows for application of a legacy compiled binary or byte-code of another language (for example, Java or Android®) in addition to fxDeviceApps 302b. Fourth, it allows

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FastPath processing for data plane packets. The packet forwarding in this case separated from the control plane operations. The FastPath engine allows integration with specialized hardware accelerators or packet processors (PP). The packet forwarding may be implemented with software/kernel enhancements all in software. Another FastPath implementation may use both software/kernel enhancement and hardware packet processors (PP). Fifth, the fxOS 302a is capable of Deep Packet Inspection (DPI) and identifying all the flows and their related protocols, services and present this information in a format useful to application developers. The fxOS 302a can act on the data flows as the directed by the application developer. Sixth, applications are securely isolated from each other and to communicate with them is completely configurable by policies defined by the admin. Seventh, resource utilization of each application is policed such that an application may not be able to exceed its usage. For example, an application is pre-allocated the memory size, cache/storage space, and CPU cycles. Eighth, the applications may be signed with unique certificate security keys. The security keys and certificates may be allocated and/or signed by a certificate authority. The fxDevice 302 may be protected by validating signed applications to run or to install in the device. Ninth, it allows hot upgrade of the software and applications on the platform with little to no interruption to the operational aspect of the platform and its applications. Tenth, the fxOS 302a may boot by using the secure code from the network servers (cloud-booting). This would ensure tamper-proof software foundation for the fxDevice 302. Eleventh, there may be a secure and programmable firewall in the fxOS 302a. This embedded firewall protects against attacks to the fxDevice 302 and network attached to the network. The fxOS 302a firewall may be configured by the developer and it does allow replacing of attack detection algorithms (e.g., man-in-the-middle detection algorithm). The fxOS 302a may allow secure caching of user data, web pages, and media files (video and audio) in the fxDevice 302. The secure connections to the cloud (fxCloud 304) can enable sharing and control of the caching between the fxCloud 304, fxDevice 302, or the rest of the network. Twelfth, the fxOS 302a can support multi-threading and multi-core CPUs. This feature may dynamically distribute the threads to various CPU core without developers assistance.

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[0055] The fxOS 302a allows secure connection to the fxCloud 304. This secure connection allows communication between fxDeviceApps 302b in the fxDevice 302 and fxCloudApp 304a in the fxCloud 304. The fxOS 302a controls the access of applications to platform APIs. An application is categorized into an Access Level (AL) based on which the fxOS 302a decides that the application does not exceed its AL and access APIs that it is not authorized. The fxCloud 304 and the fxOS 302a create a virtual fabric (fxVF) for messaging between applications. The actual message can travel directly between two fxDevices or it may traverse the fxCloud 304. The messaging complexity may be abstract for the developer.

[0056] Figure 4 demonstrates an examplary view of the software layers in the fxOS 302a. Each layer of this software stack is modified and redefined to optimize for embedded networking equipment of wireless and wireline nature. Starting from the bottom of the stack, the kernel also connects to the hardware resources via the device drivers. Examples of such resources are wireless baseband SoC 402, hardware packet processor 404, Wide Area Network (WAN) uplink interface 406, cache and storage 408, and multi-core CPU 410. The OS kernel 412 is enhanced with the FastPath function 414 to accelerate packet processing (by help of hardware features such as Intel's Data Plane Development Kit (DPDK) or pure software enhancements) and other related data path functions. The enhanced kernel with FastPath 412, 414 would enable visibility into the data flows, sniffing the Non-Access Stratum (NAS) signaling (which is the signaling between the UE and the Core Network and the RAN is supposed to be transparent to), policy enforcements, regular packet forwarding functions, collection of flow statistics into Flow Information Base (FIB), and encryption/decryption functions.

[0057] Above the kernel, there are several tools 416, native daemons 418, native libraries 420 and Hardware Abstraction Layers (HAL) 422. These tools abstract out the hardware dependencies for the upper layers and programmers. The Runtime 424 is an embedded virtual machine capable of securely isolating and executing the applications. System Services 426 are a set of services always running and available to the developers (e.g., timing and messaging services).

[0058] fx-Framework Library 428 consists of several Frameworks. The new

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frameworks are the library extensions introduced explicitly for the dSDN framework. Each of these frameworks adds a set of methods of (functions) and data structures for the following examples:

Wireless Manager 428a: manipulation, monitoring, and configuration of the wireless interfaces;

System Manager 428b: configuration, provisioning, and changing major settings of the fxDevice 302;

Flow Controller 428c: allows for manipulation of data path, tunneling, switching, and optionally coordinate this activity with fxCloud 304;

Energy Management 428d: enables fine-grained control over various elements in the fxDevice 302 that could be moved into various power stares, for example: ON, OFF, SLEEP, SUSPEND;

Big Data Manager 428e: manipulation, processing, and organization of data collected from various elements. This framework could enable close coordination between the fxDevice 302 and the fxCloud 304;

Content Manager 428f: for data sharing (database sharing) between the applications within the fxDevice 302 or the fxCloud 304 and between applications in fxDevice 302 and fxCloud 304. The Content Manager 428f may use URI to address the contents to be shared. The Content Manager 428f allows access to the application data according to the policy settings and permissions;

Policy Manager 428g: responsible for execution and implementation of polices set up by the admin. The application developers could use this framework to perform queries about the permissions, limitations, and rules;

Security Manager 428h: allows for access to the security protocol libraries and rewriting some of security algorithms such as the man-in-the-middle detection algorithm;

General Framework: general compute and logic building that may be

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inherited from existing general OS frameworks.

[0059] Using the frameworks, there are potentially at least two types of application types that are possible. First, the System Native Applications 430 that are provided as the initial application load into the platform. These applications could be used by other applications by links or API. Second, the fxDeviceApps 302b that are written by third party developers or the NOIT.

[0060] Figure 5 further details the FastPath 414 architecture. In this approach, the FastPath 414 is divided into the Virtual Switch (data-plane) 502 and the Switch Controller (control-plane) 504. Such separation makes possible flexible deployment wherein the function of the Switch Controller 504 could move to the fxCloud 304 by an admin decision or by the dSDN system intelligence for example in the case of failure, redundancy, stateful reboot, or Hot Upgrade. The Virtual Switch 502 may include several functions and may interact with the Switch Controller 504 in the following exemplary ways:

Firewall 502a: implements the policies given to it by the firewall logic 504a in the fxOS Daemons.

Flow/NAS Discover 502b: continuously monitors data packets and discovers new flows and NAS signaling. It would then report it to the DPI Logic 504b where the flow intelligence resides and matching to meta-data happens. DPI Logic 504b in turn updates the Flow Information Base Information (FIB) 502c of the Virtual Switch 502.

FastPath & DPI Processing 502d: forwards, routes packets, and performs DPI functions as instructed by the FIB 502c. It also collects statistics of packets and reports them to the Monitoring Logic 504c.

Policy Enforcement 502e: this function enforces various policies on the traffic such as QoS marking according to the policies received from the Policy Logic 504d.

Shaper 502f: this function could shape (queue) the traffic according to the available bandwidth on the uplink or WAN interface.

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Virtual Fabric (fxVF) 504e: enables transparent switching of application and system messages of a dApp between the fxCloud 304 and the fxDevice 302 and between different dApps. The fxVF 504e is an abstraction layer that hides most of the complexities of messaging from the developers. The fxVF 504e uses the policies and firewall rules to enforce security and policies.

[0061] The fxOS 302a is mostly used for networking applications. There are some potential use cases where there is a need for a general purpose OS to run the legacy software applications with no need of recompilation. An example of a double OS situation may be where a digital signage (using a general purpose OS such as Android®) in a shopping mall also acts as a smart small-cell (using the fxOS 302a). In such a solution, any existing Android® application (for example) could be loaded in the fxDevice 302 and in parallel networking applications (fxDeviceApps 302b) could run on the same fxDevice 302.

[0062] Figure 6 presents a potential software layer of the fxOS 302a co-existing alongside a General Purpose OS 602. Another implementation may be a standalone fxOS without the company of another general OS. It is important to note that the shown co-existence allows reuse of the kernel so there would be no need to re-port the drivers of hardware resources twice.

fxCloud

[0063] The fxCloud 304 is an integral part of the dSDN framework. The fxCloud 304 connects to various parts of the fxDevice 302 to form a single virtual view of the system. Examples of the main fxCloud 304 responsibilities include the following. First, it interacts and manages all applications, firmware, and fxOS 302a in the fxDevice 302. Second, it secures isolation environments for distributed apps. Third, it directs the Virtual Machine lifecycle management including load-linked VM creations and destruction (Cloud Breathing). Fourth, the fxCloud 304 executes instructions defined by the fxManager 306. Fifth, it implements uniform policy (including security) distribution and execution across dSDN 300 (including the fxDevice 302, fxDeviceApps 302b, fxCloudApps 304a, and dApps). Sixth, Plug-and-Play commissioning of the fxDevice 302 introduction

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and network expansion. Seventh, Distributed Resource Service (dRS) by which distributed applications can seamlessly communicate and message to each other using published APIs or proprietary methods within the pre-defined policies. Eighth, security violation discovery and alert system. Ninth, translation and/or exposure of Resources APIs (RAPI) to the systems outside the dSDN 300 within pre-defined policies. Tenth, fxCloud 304 in coordination with the fxDevice 302 creates a Distributed Notification Service (dNS) across the dSDN 300 by which the applications could be notified of an event to wakeup and/or respond to the event. Eleventh, fxCloud 304 in coordination with the fxDevice 302 creates a Distributed Content Management Service (dCMP) which provides a virtualized and distributed database system for applications to share application-specific or system-specific information with the pre-defined policies. Twelfth, the Switch Controller 504 function in the fxCloud 304 could take control of the controller function of the fxOS 302a in the fxDevice 302. This would allow controller switching from local to remote and back. Examples of such a configuration is a temporary reason where the fxOS Switch Controller 504 may not be available during reboot or software upgrade.

[0064] In the discussion below, these services and features are expanded upon.

fxDeviceApp-0 & fxCloudApp-0

[0065] The fxDevice 302 and fxCloud 304 have embedded System Applications categorized as fxDeviceApp-0 and fxCloudApp-0, respectively. The fxDeviceApp-0 is responsible for all default and core functional capabilities of the fxDevice 302 as listed below:

Firmware of the fxDevice;

Default communication protocols (e.g. LTE S1-AP, baseband software, security protocols, GTP, DNS, tunneling protocols);

Message communication protocol between the fxDevice and fxCloud;

Initial fxDevice settings;

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Boot Loader;

fxDevice X.509 digital certificate;

OS and Kernel upgrades;

Upgrade and commissioning agents for the fxDeviceApp-0 upgrades and related procedures;

Establishing and initiating the message communication protocol between the fxDevice and fxCloud;

General fxDeviceApp install and upgrades;

Access to fxDevice hardware and software information.

The fxCloudApp-0 is responsible for all default and core functional capabilities of the fxCloud 304 such as:

Upgrade and commissioning agents for the fxCloudApp-0 upgrades and related procedures;

Hypervisor upgrades;

Virtual Machine lifecycle management (e.g. creation, suspension, destruction);

fxCloud X.509 digital certificate management;

OS and kernel upgrades;

General fxCloudApp install and upgrades;

Default communication protocols (e.g. security protocols, DNS, tunneling protocols).

Each software component can be managed and updated individually. To simplify the management of these software components, each software components can be sub-numbered such as fxDeviceApp-0.1, fxDeviceApp-0.2, fxCloudApp-0.1, fxCloudApp-0.2, etc.

fxManager

[0066] The network administrator may use the fxManager 306 to control much of the dSDN system 300. The fxManager portal could use HTML5, for example, as

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a frontend technology. The major functions of the fxManager 306 may include the following.

fxDevice Management:

Commissioning (plug-and-play), de-commissioning, firmware/OS upgrading/downgrading;

Suspend/resume functions;

Unification of zones and partitions for example in case of network merger;

Detailed management of fxDevices (remote secure login) where the administrator may zoom into a particular or a group of fxDevices to monitor and set management alarms;

Security policy setting.

Application lifecycle management: fxManager 306 may work, coordinate, and/or perform these tasks in conjunctions with fxCloud 304 for:

Provisioning, de-provisioning, upgrade/downgrade applications. Some applications may only have a fxDevice component (Device-Centric Apps), may only have fxCloud component (Cloud-Centric Apps), or may have both fxDevice and fxCloud components (Hybrid Apps);

Creating a Test Network Environment (TNE) where the administrator can test certain configuration and applications without impacting the production networks;

Uploading applications developed by the NOIT or their partners into the Application Repository (AR). The AR is placeholder where the application packages are downloaded and stored for testing and verification prior to installation into the live dSDN system. An application could have several components (e.g. fxDeviceApp binaries, fxCloudApp signatures, manifest files, signatures) bundled together to form the Distributed Application Package (dAP);

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Browsing through the certified applications in the fxStore and downloading them to the AR;

Application license accounting services by which a secure and accurate accounting of the installed applications are performed regularly. This inventory management function allows the administrator and the 3rd party ISV to account for live and active instants of the software in the network;

Application review tool where the network admin could use to review feedbacks and comments of other NOIT (maybe anonymous reviews) and could input his/her reviews for others (maybe anonymous reviews).

fxCloud Management:

Zoning and partitioning the network for administrative purposes. Zones and partitions could optionally put into different Virtual Machine (VM);

VM load management and Cloud Breathing policies;

The configuration conflict resolutions. Some configurations applied to the resources may conflict with each other (e.g., one firewall rule may state drop Netflix packets explicitly and another rule may state allowing Netflix explicitly). The fxCloud resource manager could monitor these configurations and discover the conflicts and signal those to the network administrator.

Security Management:

Security policy setting;

Inter-App communication setting;

Security of communication between fxDevice and fxCloud;

API Access Level (AL) definitions and (re-)assignment to the applications (permissions);

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Risk Analysis of the applications;

Certificate and signature verification of the applications;

Content sharing between applications and associated policies.

[0067] An fxManager Portal per the above description may have an "Account" button which can be used to create admin users and their privileges. The fxManager Portal could also include a geographical map illustrating locations of fxDevices and their status. The fxManager 306 functions could be integrated into other network management tools. The fxManager 306 could potentially build the inventory of the network devices (fxDevices) showing all the available devices and statistics. As described above, the network administrator could optionally procure the applications a third party hosted application store (fxStore). The fxStore 308 could potentially categorize the applications several groups (as shown in Figure 7 which is an example view of the fxStore portal). The fxStore 308 could also show the reviews of the advertised applications. In order to maintain quality, the third party fxStore 308 may perform rigorous testing of the applications and accompany those results with the advertised application.

fxSDK

[0068] The flexible Software Development Kit (fxSDK) may include a development environment and other tools to facilitate development, testing, debugging and verifications of applications for dSDN environments. The fxSDK is unique in several aspects exemplified as follows. First, since the dSDN applications may have a device component (fxDevice 302) and cloud component (fxCloud 304), the fxSDK allows the developer to develop the components together to simplify the development and testing. Second, the dRMS offers various system level APIs with remote accessibility. In other words, the APIs in the fxDevice 302 could be accessed via the applications in the fxCloud (fxCloudApps) and vice versa. The fxSDK simplifies the usage system created APIs and application created APIs. Third, it is essential for the dSDN to ensure quality and security of applications in the network. The fxSDK may be accompanied with an extensive Risk Analysis Utility (RAU) which verifies all the APIs that are being used by the application and based on its potential danger to the

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network, it would show the risk analysis and may make specific suggestions to reduce the risk. Once completed, the risk analysis result is included in the dAP for posting to the fxStore and consumed by the fxManager user (the admin). Fourth, the fxSDK would also ensure that the applications do not exceed their planned memory and resource usage. Fifth, the Integrated Development Environment (IDE) may provide various tools to actively demonstrate errors, defined APIs, security dangers, and excessive resource usage. Sixth, the IDE could also provide a flexible Simulator (fxSimulator) for the developer test the application in a network setup in presence of other network elements.

Deployment Examples

[0069] The dSDN 300 offers flexible deployment options. In this section, a few exemplary embodiments are presented.

[0070] Figure 8 demonstrates a shared cloud deployment where several NOITs (802, 804, 806) share an fxCloud 808. In order to ensure complete isolations, each NOIT may be assigned a separate Virtual Machine (VM) 802a, 804a, 806a. A good example of this deployment option may be when multiple service providers outsource their fxCloud deployment to a third party vendor that offers a SaaS/PaaS solution. It is important to note that in this option, each NOIT should have its own secure instance of the whole system. This option could potentially create a full outsourcing model for network operations including possibilities of seamless merging of networks of two or more NOITs.

[0071] Another deployment option may be a Zoned Deployment as shown in Figure 9. In this option, a large NOIT may partition their network into a plurality of zones (Zone #1, Zone#2,… Zone#n) for administrative, software compatibility grouping, or other reason. For example, it is possible that in a large network deployment, there would be different versions of fxOS with varying capabilities in the network (the older hardware may not support newer fxOS version). In this case, the service provider may decide to group the fxDevices per fxOS versions for management simplifications.

[0072] Figure 10 is another embodiment deployed in a Programmable & Virtualized Cellular Network. In this example, the dSDN is applied to the cellular

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networks (e.g., LTE). As shown, the fxDevice 1002 here is the LTE eNB (4G base-station) and the fxCloud 1004 hosts the LTE core network (EPC) functions such as MME, S-GW, and P-GW in separate VMs. Within each EPC function, new features could be added using the dSDN framework. For example, a new application to optimize signaling for Machine-2-Machine (M2M) devices could be loaded into the fxDevice 1002 and the MME function in the fxCloud 1004.

PRINCIPAL PROCEDURES & SERVICES

[0073] The dSDN framework could offer extensive services and capabilities that would simplify the programmability of the network. In this section below, a set of main procedures and services are presented as further exemplary embodiments.

fxDevice Commissioning Provisioning

[0074] Figure 11 illustrates a signaling flow chart for a fxDevice Plug-and-Play Commissioning Procedure. This procedure enables fxDevice commissioning and initial setup to provide a seamless and Plug-and-Play (PnP) deployment. The fxDevice relies on the fxDeviceApp-0 and the fxCloudApp-0 to connect to the backend management system and perform the commissioning procedure. In step 1101, the fxDevice 1120 tries to discover the fxManager 1130 using the fxManager Fully Qualified Domain Name (FQDN). The fxDevice 1120 is configured to always look for the same FQDN. If the NOIT has a private cloud deployment, the DNS server in the NOIT will be configured to point to its own fxManager IP address. If the cloud is shared, the NOIT will configure their DNS server to point to the shared cloud IP address. In step 1102, the fxDevice 1120 receives the IP address of the fxManager 1130. In step 1103, the mutual authentication may be performed where the fxDevice 1120 authenticates the fxManager 1130 and vice versa. In step 1104, a secure tunnel may be created between the fxDevice 1120 and the fxManager 1130. In step 1105, the fxDevice 1120 may optionally request for the latest firmware/OS version. In this phase, the fxDevice 1120 informs the fxManager 1130 of its hardware information (e.g. vendor, model number, CPU model/speed, memory/cache size) and software information (e.g., current firmware version, current OS version, fxDeviceApp-0 version package stating versions of fxDeviceApp-0 components). In step 1106, the fxManager 1120 may send the latest firmware/OS version (or point

the fxDevice to the right URL to download the latest load). In step 1107, if a new firmware/OS load is downloaded and verified, the fxDevice 1120 installs it. In step 1108, the fxDevice 1120 requests the default settings and the default application package (the initial applications that the NOIT admin would like to install in fxDevice 1120 prior to other applications). In step 1109, the fxManager 1130 prepares the fxCloud 1140 for the new fxDevice 1120 integration into the network. In step 1110, once completed, the fxCloud 1140 informs the fxManager 1130 of its readiness. In step 1111, the fxManager 1120 sends all the default settings and the default application package to the fxDevice 1120. In step 1112, the fxDevice 1120 then sets up a secure connection to the fxCloud 1140 (more precisely the fxCloudApp-0). In step 1113, a commissioning completion message is set from the fxCloud 1140 to the fxManager 1130. In step 1114, the fxManager 1130 signal to the fxDevice 1120 the completion of the commissioning and starts th regular operation of the fxDevice 1120. At this phase, fxManager 1130 can optionally modify the settings in the security connections between fxDeviceApp-0 and fx-CloudApp-0 and between fxDeviceApp-0 and fxManager 1130.

Application Provisioning Procedure

[0075] The Application Provisioning Procedure enables provisioning and de-provisioning of applications across the dSDN system. For simplicity, the term provisioning in this disclosure is used to present all similar procedures of provisioning and de-provisioning. The application provisioning procedures are usually triggered by the network administrator and are orchestrated by the fxManager, which works in collaboration with the fxDeviceApp-0 and fxCloudApp-0.

[0076] Figure 12 shows an example procedure for Application (dApp) Provisioning. In step 1201, the network admin identifies the applications that would need to be installed in the dSDN system. These applications are already downloaded (from the fxStore or other sources) into the Application Repository (AR). Prior to installation in the live network, the authorized network admin 1220 has probably performed rigorous testing of the application in the test network. In step 1202, the fxManager 1230 performs a detailed analysis on the potential risks that this application may

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create on various parts of the network and other applications. The analysis tool uses the secure manifest file and other information to discover, for example, all the APIs used by the application, the required access-level authorization level for each of those APIs, requirements on the fxVF (inter-app, intra-app communication needs), and usage of platform resources including conflict discovery and resolutions. In step 1203, the admin defines the deployment scope that the application would be applied. Examples of deployment scopes could be a given zip code, a city, an administrative domain (zone), a shopping mall, an office building, or manual handpicking of sites or fxDevices 1240. The fxManager 1230 verifies compatibility of the OS version and resouces requirements of the application and the fxDevices 1240. If the fxManager 1230 discovers incompatibility, it informs the admin and request adjustment to the deployment scope or proposes upgrading incompatible fxDevice if possible. In step 1204, the admin 1220 initiates the installation process. In step 1205, the fxManager 1230 unpacks the dApp and if there is fxDeviceApp component, it would prepare it for submission to the fxDeviceApp-0 of fxDevices in the deployment scope. In step 1206, installation commands are sent to the fxDeviceApp-0s in a secure connection already set up as part of the fxDevice Commissioning. In step 1207, the fxDevice 1240 verifies the fxDeviceApp package and performs necessary integrity checks of the received software package. Once verified, the fxDeviceApp is installed and re-verified. In step 1208, the completion of successful install is sent to the fxManager 1230 by the fxDevice 1240. In step 1209, the fxManager 1230 prepares the fxCloudApp component of the dApp (if any). In step 1210, installation commands are sent to the fxCloudApp-0s in a existing secure connection. In step 1211, the fxCloud 1250 verifies the fxCloudApp package and performs necessary integrity checks of the received software package. Once verified, the fxCloudApp is installed and re-verified. In step 1212, the completion of successful install is sent to the fxManager 1230 by the fxCloud 1250. In step 1213, the fxManager 1230 informs the admin 1220 of the successful installation process.

Hot Upgrade Procedure

[0077] The Hot Upgrade refers to a procedure by which the software upgrades

on the system have no or minimal implication on the functionalities offered by the software component subject to the upgrade process. Herein are presented two types of software upgrades. For simplicity, the use of the term upgraded in this disclosure represents both upgrade and downgrade since they both use identical processes. First, upgrade of applications on the fxDevice (i.e., fxDeviceApp) and fxCloud (i.e., fxCloudApp). Second, upgrade of core functions in the fxDevice (aka fxDeviceApp-0) or fxCloud (aka fxCloudApp-0).

[0078] The upgrade procedures for fxDevice and fxCloud are similar. Here, the focus is on the fxDevice upgrade process since it is technically more challenging due to stricter resource limitations in the fxDevice.

General Application Upgrade

[0079] The applications could be upgraded automatically or manually by the network admin. In either case, the installation of the upgrade follows a similar procedure as the Application Provisioning Procedure. Figure 13 presents the state of the machine for the application upgrade process. In state 1301, the old version of the application is still running. In Load state 1302: the new version of the application is downloaded in the local storage while the old version is still running. In Install state 1303: the new version is installed (in the memory) while the old version is still running. In Run state 1304: the new version is activated taking charge of all the related data and application state and the old version is deactivated while still remaining in the local storage. In Commit state 1305: the old version is fully removed after ensuring the new version is running properly as expected.

fxDeviceApp-0 Upgrade

[0080] The fxDeviceApp-0 is a collection of software components that perform the core functionalities of the fxDevice. As a result, this hot upgrade is quite challenging. The most important thing is to ensure that major functionalities of the fxDevice (such as packet forwarding) remain

intact during the upgrade process. The fxDeviceApp-0 upgrades may be categorized as:

- No OS Kernel upgrade; or
- OS Kernel upgrade.

No Kernel Upgrade

[0081] As described earlier, the packet forwarding function could be broken into the Virtual Switch and the Switch Controller. In order to maintain, the packet forwarding function, the Switch Controller function could be performed by another device or a second processor in the same device while the fxDevice is being upgraded. Figures 14A-14C demonstrate a few examples of distributed Switch Controller function during the upgrade. In some cases, it may be possible for the fxCloud to take over the Switch Controller function (Figure 14A), or a neighboring fxDevice (Figure 14B), or second CPU in the same fxDevice (Figure 14C). The actual software upgrade procedure would be similar to Application Provisioning Procedure and the state machines are the same as the one shown in Figure 13.

Kernel Upgrade

[0082] In this case, the packet forwarding process is mostly unavailable. Therefore, one potential solution might be for the fxDevice to redirect the entire bit stream to a neighboring fxDevice. In other words, the fxDevice would have just a bare minimum routing function working and the rest of the function would be performed by a neighboring fxDevice.

[0083] All the other upgrade procedures and state machines are similar to the ones performed for the No Kernel Upgrade process.

Virtual Fabric Service

[0084] The Virtual Fabric (fxVF) provides an abstraction layer for application to communicate with each other whether they are in the fxDevice or fxCloud. Various frameworks and services may use the fxVF service. Figure 15 illustrates fxVF 1502a, 1503a, 1504a in the fxDevices 1502 and 1503 and fxCloud 1504. The fxVF 1502a,

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1503a, 1504a may use Extensible Messaging and Presence Protocol (XMPP) for this messaging as the default protocol. It is important that the developers may use their own communication protocols between the fxDeviceApps 1502b, 1503b and the associated fxCloudApp 1504b. fxVF 1502a, 1503a, 1504a provide a secure routing mechanism.

Intra-App Messaging

[0085] This is an example of where one application in the fxDevice communicates with the same instance of the app in another instance of the same application in another fxDevice. The actual messages could go directly between the fxDevice or via the fxCloud. As an example, in the case of mobile networks, this messaging could be used to transfer user specific context from one eNB to another as a user hands off to a new eNB. In LTE, Private Messages on X2 interface could be used for messaging between the eNBs that act as the fxDevices.

Inter-App Messaging

[0086] In some cases, different applications may need to communicate with each other via their published APIs. In this case, the security policies set up by the network administrator determines which applications could communicate with each other for what purpose. The fxVF follows the security policies determined by the network administrator for inter-application communications.

distributed Resources Service (dRS)

[0087] The resources could be platform resources or APIs offered by the applications. The fxCloud and fxDevice resources could include (as examples):

Firewall;
Data and statistics;
Storage (usually abundant at fxCloud);
Compute (usually abundant at fxCloud);
Load evaluator;
General settings;

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Routing engine (usually relevant to the fxDevice);

Virtual Machine master controller (usually relevant to the fxCloud);

Power controller (usually relevant to the fxDevice); and

Wireless engine (usually relevant to the fxDevice).

[0088] An app (fxDeviceApp or fxCloudApp) could expose APIs to be used by the other apps. The inter-app communication is enabled by the fxVF where the policy and security provisions are enforced. The APIs exposed may be RESTful (representational state transfer) and could travel across physical network elements. Since the fxManager defines fxVF policies, the administrator could ultimately specify which APIs between which apps could communicate with each other. Figure 16 demonstrates the logical interfaces between the platform resources and applications. As shown in Figure 16, the distributed Resources Service (dRS) 1602, 1603 comprises software agents residing in the fxDevice 1604 and the fxCloud 1606. These dRS agents manage the access to the platform resolutions (including potential configuration conflict resolution) as well as facilitating inter-app APIs. The dRS 1602, 1603 allows or disallows access to platform resource or inter-app communication according to the policies defined by the network administrator using the fxManager. In summary, the dRS 1602, 1603 provides services to application developers for:

Exposing APIs to other applications;

Configuring and managing platform resource;

Policy enforcement and authorization of applications access to platform resource and other app's APIs; and

Policy conflict resolution.

distributed Content Service (dCS)

[0089] The distributed Content Service (dCS) allows the developers to seamlessly store and share the contents generated by one application with other applications and its associated application in the cloud. The dCS simplifies access to the data and brings in storage virtualization to the applications. In other words, the developers no longer would need to know where the data is actually stored (in

the cloud or on the device) and would be able to access them easily. The dCS implementation may use Virtual Fabric (fxVF) and distributed Resources Service (dRS).

distributed Notification Service (dNS)

[0090] The distributed Notification Service (dNS) is another potential tool for developers that could wake or ping an application when a particular event has occurred. For example, a load monitoring application could be notified when the CPU load on a particular fxDevice (or a target area) exceeds a certain threshold. In turn, such an exemplary application could make smart decisions on reducing the load on the CPU by forcing handoffs of users to neighboring cells (i.e. fxDevices). The dCS implementation may use Virtual Fabric (fxVF), distributed Resources Service (dRS) and distributed Content Service (dCS).

Cloud Breathing Procedures

[0091] In general, resources (compute, storage) at the cloud are more abundant. However, software licensing costs and other limitation may require smart management of resources. The Cloud Breathing, here, is defined as a mechanism where the cloud resources are automatically expanded as load increases on the system or reduced as the load decreases. This creates an automatic elasticity in the cloud dimensions. Figures 17A and 17B demonstrate procedures for the cloud breathing. Figure 17A is expansion and Figure 17B is reduction. The Load Controller in the dRS 1602, 1603 could be used to monitor the load (step 1702) on the existing VMs (e.g. CPU or memory utilization loads). The VM Master of the fxCloudApp-0 1608 could effectively act on the decisions made by the dRS's Load Controller. Again, the network administrator via the fxManager defines the policies and thresholds for such decisions.

Security Aspects

[0092] The security aspects of this solution are of outmost importance in order to ensure quality in the product networks.

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Identity

[0093] To create a security model, the dSDN network elements should have unique identities. The following identities may be defined:

fxDevice Identity (DID): this identity is unique globally and may be allocated at manufacturing and included in the X.509 digital certificate of the fxDevice;

fxCloud Identity (CID): this identity is unique to the NOIT domain and may be allocated by the network administrator and included in the X.509 digital certificate of the fxCloud;

fxDeviceApp Identity (DAID): this identity may be globally unique and may be allocated by the fxSDK at the point of code creation by a globally accessible server;

fxCloudApp Identity (CAID): this identity may be globally unique and may be allocated by the fxSDK at the point of code creation by a globally accessible server;

dApp Identity (AID): This identity may be globally unique and may be constructed by concatenation of DAID and CAID together;

Application Developer Identity (ADID): this is a globally unique identity allocated by a globally accessible server and may be included in the developer's X.509 digital certificate and is used to sign the final developed applications.

[0094] For addressability purposes, the identities may be presented in a URI format using the FQDN of the NOIT.

Access Level

[0095] The applications are given different access levels. The AL is used by the dRS to determine which APIs or class of APIs an application can access (e.g., a fxDeviceApp running on fxDevice should not be able normally to reboot the fxDevice). The required AL is generated by the fxSDK and included in the manifest files. It may also be published in the fxStore for that give application. A preset of ALs could be defined to categorize the applications security risks.

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Software Security Verification

[0096] It is important for the target network element to verify the authenticity and integrity loaded software prior to install. The uniquely defined security keys of the application developers sign the applications. The following rules may be followed to ensure software security verification:

Only the verified OS/Firmware software can install on verified hardware;

Only the verified OS/Firmware software can run on verified hardware (continuous verification of essential parts of the software);

Only the verified fxDeviceApp software can install on verified hardware;

Only the verified fxDeviceApp software can run on verified hardware (continuous verification of essential parts of the software).

[0097] Each fxDeviceApp is accompanied by a manifest that is generated by the Integrated Device Electronics (IDE) at the time of compilation of the fxDeviceApp. The manifest file specifies which libraries and frameworks the fxDeviceApp uses. The fxManager uses this information to determine the security risk of the fxDeviceApp as well as the required Access Level (AL) to run this fxDeviceApp. In order to ensure that manifest file is actually genuine manifestation of the fxDeviceApp and its integrity remains intact, a hashing algorithm could be used to generate a signature. An example is shown below:

Signature = HMAC-SHA256(K, Message);

where

Message = fxDeviceApp + Manifest

K = shared secret key between fxStore and fxManager.

[0098] The signature is generated by the IDE/fxSDK at the compile/build phase and is packaged with application binary and the manifest file. Once the distributed application package (dAP) is downloaded into the fxManager (Application Repository), the components of the signature, application binary, and manifest file are unpackaged. The fxManager then uses the same hashing algorithm to calculate

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the signature as above using the pre-shared key (K). If the calculated signature and the unpackaged signature match, it would prove the authenticity of the manifest file and the integrity of both manifest file and the fxDeviceApp.

[0099] Code Generation Process (Compilation):

fxDeviceApp compiled→ Manifest file generation→ Signature calculation→ Create fxDeviceApp Package

[0100] Install Process (Consumption):

Un-package fxDeviceApp→ Signature calculation→ Signature comparison

[0101] This model works if the key K can be shared with two trusted parties (fxManager and fxStore). The manifest file that is generated by the fxSDK shall be secured by integrity checks to ensure it remains intact throughout the transaction (i.e. from compilation to consumption).

Communication Security

[0102] Security mechanisms built into the fxDeviceApp-0 and fxCloudApp-0 forces the fxDevice to only use the configured fxCloud servers for Software Security Verification, fxDeviceApp downloads, and fxDeviceApp-fxCloud communication. Optionally, the fxDeviceApp-fxCloud communication can be customized per application requirements. One implementation of this interface could use SPDY Protocol or per-application VPN.

[0103] For the purpose of inter-App communication, an Inter-App Communication (IAC) policy template is applied to an fxDeviceApp that defied the communication policies between the fxDeviceApps and fxCloudApps. The network administrator may use one of the pre-configured IAC policy templates (exemplified below):

Isolated: this type of applications cannot communicate with any other application in the same fxDevice and does not have any associated fxCloudApp;

Isolated-Extended: this type of fxDeviceApps cannot communicate with any other fxDeviceApps in the same fxDevice but could communicate with its associated fxCloudApp;

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Private: a private fxDeviceApp in one fxDevice could communicate with same private fxDeviceApps in other fxDevice but does not have any associated fxCloudApp;

Private-Extended: a Private fxDeviceApps in one fxDevice could communicate with same private fxDeviceApp in other fxDevice and has its associated fxCloudApp;

Community: a group of fxDeviceApps that belong to the same community can communicate with each other;

Promiscuous: a Promiscuous app could communicate with any other Promiscuous application and Community application;

Custom: the network administrator could create custom IAC Policy templates and could include (as examples):

Template name;

Inherited pre-configured template if any;

The protocols allowed to use for communication;

The maximum data rate allowed for inter-app communication between a pair of fxDeviceApps or between an fxDeviceApps and an fxCloudApp;

Policies related to the other fxDeviceApps in the same fxDevice, in other fxDevice, associated fxCloudApp and unassociated fxCloudApps;

Policies related to direct fxDeviceApp to fxDeviceApp communication or relayed via fxCloud communication.

Secure Boot

[0104] The secure boot refers to a capability where the main boot code is in the fxCloud with the following exemplary procedure:

The Boot Loader (BL) in the fxDeviceApp-0 of the fxDevice looks for a particular DNS (DNSSEC) name of the fxCloud. The network administrator should define the DNS entry in their network. If there is a private fxCloud, the resolved domain name points to the fxCloud. If using shared cloud, the resolved

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domain name points to the cloud point of presence;

A secure tunnel (TLS) is created between the BL in fxDevice and the fxCloud using pre-burned X.509 certificate;

BL identify itself to the fxCloud and include System Information;

fxCloud determines the appropriate boot file and points the BL to the exact address of the boot file in the fxCloud;

BL downloads the correct boot file;

BL runs Software Security Verification;

BL reboots the fxDevice and the system will be ready for operation.

Frameworks

[0105] The following describes an example of the API Framework for the dSDN. Some APIs are purely local to the fxDevice or the fxCloud and some may be extended from the fxDevice all the way to the fxCloud using dRS.

General Framework

[0106] This framework refers to general libraries and APIs inherited from the legacy OS. An example of the legacy OS may be Embedded Android®. This framework allows for general processing and may be used for algorithmic applications.

Wireless Framework

[0107] The Wireless Framework adds a set up functions related to managing and controlling the wireless module. Table 1 highlights some examples of methods/functions that may be available in the Wireless Framework.

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Table 1: Wireless Framework	
Method	Description
discoverNeighbors	Discovers wireless neighbors and returns their identities
retrieveNeighborInfo	Retrieves detail information of neighboring BS/AP information. This method may transparently call cloud servers to gather more information
measureInterference	Measures wireless interference observed on a frequency or a set of frequency channels
setWirelessConfig	Sets various parameters in the wireless module such as power, frequency channels, Multiple Input/Multiple Output (MIMO) antenna configuration, etc.
definePHYReceiverAlgorithm	Defines the physical layer receiver algorithm
connectedDevice	Returns details about the connected mobile devices (length of connection, data tx/rx) to a given wireless interface (channel, band, sector)
forceOffload	Offloads connected mobile devices to other access technologies (e.g. from cellular to WiFi)
homeAreaNetworking	Control of home automation wireless technologies such as ZigBee or Z-Wave
setNeighborCells	Sets neighboring cells information
forceHandoff	Handoffs connected mobile devices to the same access technology but different channel or frequency
topMovers	Identifies the mobile devices with highest degree of mobility

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positionDevice	Accurate positioning of mobile devices which may include geo-fencing data
borrowSpectrum	Allows one BS to borrow spectrum from another
configureMACScheduler	Configures the MAC scheduler (for example prioritize a particular user)
loadBalance	Enables load balancing across radio channels
defineMACScheduler	Defines the MAC scheduler algorithm

Security Framework

[0108] The Security Framework allows the developers to use a specialized security functions/methods. Some of these new methods may use the legacy OS frameworks. Table 2 highlights some examples of methods/functions that may be available in the Security Framework.

Table 2: Security Framework

Method	Description
setDOSDetect	Detects DOS attacks on user plane as requested
configureFirewall	Provides firewall functions such as traffic filtering, permissions (this may use dRS)
defineDOSDetectAlgorithm	Allows replacing and redefining the DOS algorithm
encryptTraffic	Encrypts the content of a message or a class of traffic as requested
authenticateUser	Authenticate users as requested
integrityCheckContent	Verifies authenticity of a message using its checksum information
configuresIPS	Configures IPS functions on the user plane

FastPath Framework

[0109] The FastPath Framework allows the developers to identify and manipulate the data path with a DPI capability. Table 3 highlights some

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examples of methods/functions that may be available in the FastPath framework.

Table 3: FastPath Framework	
Method	Description
matchTraffic	Identifies and matches the traffic type requested by the developer
detectCongestion	Detects if there is congestion on the data path
identifyTopURLs	Identifies the most visited URLs by the users
detectLocalConversation	Detect conversations and packet routing between the end user on the same fxDevice
detectDevice	Detects traffic of a given mobile user device
redirectTraffic	Redirect data traffic to a given network element. The traffic may be identified with a user or a class of traffic
connectedDevices	Returns all the connected mobile devices to a given fxDevice
assignAddress	Allocates a particular IP address to the mobile device
setPriority	Set traffic priority to a class of traffic
markTraffic	Marks the user traffic with the desired QoS tags
setupTunnel	Sets up data tunnel from fxDevice to a destination
Adscript	Adds a JavaScript to an active transiting web page
detectIdenticalFlows	Identifies the identical flows coming from the WAN/uplink interface on the fxDevice
aggregateFlows	Enables aggregation of flows to save WAN/uplink utilization
routeTunnel	Routes a packet or a class of traffic onto an established tunnel
identifyTopDevices	Identifies users that generate most traffic load

Messaging Framework

[0110] The Messaging Framework allows the developers to send messaging between the applications residing in the fxDevice and fxCloud. Table 4 highlights some examples of methods/functions that may be available in the Messaging Framework.

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Table 4: Messaging Framework	
Method	Description
sendIntraApp	Sends an Intra-App message from one fxDevice to another
sendInterApp	Sends an InterApp message from one application to another
sendfxCloud	Sends a message to the fxCloud
sendSMS	Sends an SMS to the user of choice

Caching Framework

[0111] The Caching Framework allows the developers to cache particular contents or files that are accessed frequently in the caching engine. The caching can be done locally in the fxDevice, clustered cache (shared amongst a few fxDevice), or cloud caching. Table 5 highlights some examples of methods/functions that may be available in the Caching Framework.

Table 5: Caching Framework	
Method	Description
storeForward	Enables Store and forward model for a target class of traffic where the target traffic is matched and stored upon a condition and forwarded the condition is relieved
cacheWebSite	Caches the most visited web sites
cacheVideo	Caches the most viewed videos
cacheCloud	Caches the requested content or traffic type in the cloud storage in fxCloud

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Management Framework

[0112] The Management Framework enables the developers to manage the BS platforms and perform administrative procedures. Table 6 highlights some examples of methods/functions that may be available in the Management Framework.

Table 6: Management Framework

Method	Description
upgradeFirmware	Started and executes the firmware upgrade procedure on the fxDevice
upgradeOS	Started and executes the operating system upgrade procedure on the fxDevice
remoteBootup	Performs remote boot up process where the fxDevice works closely with the fxCloud to perform the bootup
remotePower	Allows fxCloudApps to remotely turn on and off a fxDevice or elements in the fxDevice (e.g. the wireless)
gatherStatistics	Instructs fxDevice to gather specific statistics. Various commands may be consolidated for gathering statistics. Number of active users Stats of time spent by users in the cell Stats of quality perceived by the users Neighboring cell info Overall traffic passed through the system Total number of connected devices per frequency, per carrier, per site, per location Handover failure statistics Cloud aggregated data processing and full report Total traffic passed Applications used (meta-data correlated) Bandwidth consumed User's mobility pattern

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setMonitoring	Allows the developer to get reports and statistics of the fxDevice traffics, errors, and neighboring environment. The reporting criteria could be set up as: 1) Period, 2) Event based (reports only if a threshold is passed; a threshold could be based on absolute numbers or deltas), 3) One-time (i.e. the information is pulled once). The exact parameters to get report on may use the same data structures used by the method "getStatistics".

getSystemInfo	Retrieves static and dynamic system info such as: • Hardware info: vendor, model number, capability profile. GPS, Cellular, WAN interfaces, RFID/NFC • Heat temperature • Vendor Specific Information • Software info: OS version, firmware information • CPU load, per-application load (CPU, memory, accelerators) • Loaded apps and status • Memory utilization • Storage utilization • Interface status & utilization (RF, backhaul, management...)
getfxDeviceLocation	Retrieves location of the fxDevice • Location would be presented in GPS coordinates and civil address • Location enhancement: Cloud, map data, and neighbor discovery could help more accurate positioning
getPowerConsumption Rate	Retrieves current power consumption rate of the fxDevice
configureWAN	Configures the WAN settings
retrieveNeighborInfo	Retrieves neighbor information from the fxCloud
getRFIDInfo	Returns the RFID/NFC information of the fxDevice
setRFIDInfo	Sets the RFID/NFC information of the fxDevice

Extensible API Framework

[0113] This framework allows the developer to create custom APIs and make it accessible for other applications (in the fxDevice or in the fxCloud). In turn, the fxCloud could present these APIs using e.g. REST technologies (via the fxCloud

Northbound Interface) to the developer outside the dSND system. There might be limits put on the APIs exposed through the cloud to avoid potential misuse or security threats. The dRS enforces the security policies defined by the admin (via fxManager). The applications take a role of Client Application (CA) or Server Application Role (SA). The CA and SA could be distributed in the fxDevice or fxCloud. The CA makes requests and SA serves the requests.

[0114] The Extensible APIs could be categorized (as examples) into:

Read-Only Data: this type of APIs allows a CA to read data from SAs without the ability to change or request any particular action from the SAs

Read-Write Data: this type of APIs allows CA application to read data from SAs with the ability to change some of their data but no option for requesting any particular action from SAs;

Procedural: this type of APIs allows CAs to execute a particular procedure in SAs. The rights to change any data still depends on whether the API allows Read-Only Data or Read-Write Data types.

Cloud Management Framework

[0115] The Cloud Management Framework presents a collection of methods enables management of the cloud services and resource. Table 7 highlights some examples of methods/functions that may be available in the Cloud Management Framework.

Table 7: Cloud Management Framework

Method	Description
detectCloudCongestion	Detects congestions on a particular VM
deleteVM	Deletes an active VM permanently
suspendVM	Suspends an active VM but doesn't remove it
activateVM	Activates an already created VM
createVM	Creates a new VM but doesn't activate it

EXAMPLES OF DAPPS

[0116] The dSDN create an end-to-end programming platform and the possibilities of vApps are only limited by the developers' imagination. An example list of potential vApps are presented in Table 8 below.

Table 8 highlights examples of use cases possible by the Distributed Software Defined Network (dSDN)

Use	Description	Framework {Methods} used
1	Distributed SON: For example, the WiFi AP could search for the least crowded channel to minimize the interference	Wireless {discoverNeighbor, retrieveNeighborInfo, measure nterference, setWirelessConfig, loadBalance}, General Framework, Messaging {sendIntraApp}
2	BS Hot Firmware Upgrade without impact to the basic functions of the BS. For this function to support full hot upgrade without operational impact, the Communication SoC should be able to	Management {upgradeFirmware}
3	BS Hot infOS Upgrade without impact to the basic functions of the BS. For this function to support full hot upgrade without operational impact, the full platform should have dual processor.	Management {upgradeOS}
4	Secure network---based booting. This allows to keep the code securely in the cloud to avoid tampering by the ODM/CM or Man---in---the---Middle attacks	Management {remoteBoot}
5	Turning on or off APs if nobody is in the office. Sensors in the building send information to fxCloudApp which in turn orders power control of the APs	Management {remotePower}
6	Store and forward model for low priority M2M applications where the target traffic is matched and stored in the case of network congestion and forwarded once the network congestion is relieved.	DataPath {matchTraffic, detectCongestion}, Cache {storeForward}
7	Replacing MAC Scheduler	Wireless {defineMacScheduler}
8	Replacing Receiver Algorithms	Wireless {definePHYReceiverAlgorithm}
9	Caching most visited website or video clip in the enterprise	DataPath {identifyTopURL}, Cache {cacheWebSite}
10	The most viewed videos and webcasts are cached in the wireless edge	DataPath {identifyTopVideos}, Cache {cacheVideo}
11	Local Routing: data and voice sessions between two parties on the same cell are routed within the same cell bypassing the core network	DataPath {detectLocalConversation, RouteLocal}
12	Local Routing: data and voice sessions between two parties on the nearby cells are routed locally bypassing the core network	DataPath {detectConversationDetect, routeLocal}
13	Temporary redirection of a data flow for monitoring and security reasons. In this use case, a particular user's traffic is tracked by redirection to a monitoring station. If user is mobile, such profile of tracking and associated redirection is transferred from fxDevice to fxDevice either directly or via the fxCloud	DataPath {detectDevice, matchTraffic, redirectTraffic}
14	Power Calendar: On---demand coverage (triggered by passing traffic thresholds in certain cells or by calendaring): Operators need to design their network for peak usage rates at high costs, leaving their network underutilized most of the time	DataPath {detectCongestion}, Management {remotePower}
15	DOS attack recognition and action could be blocking the user, the app, and/or notifying the user via an SMS message	Security {setDOSDetect, configureFirewall}, Messaging {sendfxCloud}
16	Applying certain ACLs to the BS. For example, the students in the class can only access Facebook between the breaks and access to Facebook is blocked during the class	Security {configureFirewall}
17	Forced offloading of some cellular users (users that have attached to the same cell for a while) to WiFi by changing "something" in the cellular connection to force WiFi connection (Heterogeneous)	Wireless {identifyConnectedDevice, forceOffload}
18	Service continuity and anchoring at eNB for WiFi using the same LTE IP address (Heterogeneous)	DataPath {identifyConnectedDevices, assignAddress}
19	Graphic/general processing for special use cases such as City BS	General Frameworks
20	Application filtering/throttling (secondary conditions: time---based, location---based, subscriber---type, none)	DataPath {matchTraffic}, Security {configureFirewall}
21	Local Services: The enterprise user can discover Bonjour or UPnP devices and services (e.g. printer) even when connected to LTE/3G small---cell in the enterprise. In this case, the small cell or fxDevice pro---actively listens to Bonjour and UPnP discovery and advertisement messages (SSDP) and cache the available services until a device request for such information. In the case of Bonjour, fxDevice could listen to Multicast DNS (mDNS) messages sent over cellular connection (LTE/3G) and multicast them on the LAN or WLAN interfaces.	DataPath {matchTraffic, routeLocal}
22	Local Services: The premise---owner (e.g. airport, hotel) can provide ads under the browser for sponsored WiFi or cellular (3G/LTE) access over multi---mode small cell. The premise owner could use this service to advertise special offers or third party ads. This technique uses HTML <script> for example to add special content to the bottom of the page.	DataPath {matchTraffic, addScript}

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23	Distributed Content Distribution Network (CDN). In this use case, the fxDevices function as CDN that bring the contact closer to the end users.	DataPath {matchTraffic}, Cache {cacheVideo}
24	In case of national security, the service provider may limit the access to the network so only the law enforcement can use the cellular network. In this case, the admin defines a Target Area (TA) using an fxCloudApp in the fxCloud where the emergency lockdown needs to be applied. The IMSI/MSISDN number of law enforcement mobile devices are sent to the fxDevice in the TA which in turn enforce the policy. The policy may allow the public to just sent SMS while the law enforcement could have full access and priority to the system.	DataPath {matchTraffic, setPriority}, Security {configureFirewall}
25	Emails and web browsing monitored by the cloud services assisted by the agent in the dSDN network. In this case, the fxDevice detects certain traffic (email or web in this case) and redirects them to a cloud service for security cleansing.	DataPath {matchTraffic, redirectTraffic}
26	Analytics pre---analysis: The data collected from M2M devices could be processed (noise could be filtered out) and packaged (compressed) for consumption by cloud services	DataPath {matchTraffic}, General Framework, Messaging {sendfxCloud}
27	Certain traffic could be marked with QoS DSCP codes for further processing in the network	DataPath {matchTraffic, markTraffic}
28	Proprietary SP services and applications that run purely between the phone and the BS . For example, the SP may implement a certain application for the law enforcement to get direct feed of surveillance cameras in a target area (TA).	DataPath {matchTraffic}, Security {configureFirewall}, General Framework
29	IP---PBX implementation in the small---cell or WiFi AP for enterprise use. This would allow a simple out of a box solution. The VoIP phones connect to the fxDevice via the LAN connections. The WAN connection could connect to an fxCloudApp for PSTN calls	DataPath {matchTraffic}, General Framework
30	Network management system can add its own agent/probe to collect and consolidate data and transmit it to its cloud element using any protocol	Management {gatherStatistics, getSystemInfo, control}, General Framework
31	Application based performance monitoring on the wireless link (number of packets sent in idle mode, retransmit rate…). Such information could be shared with the app developer to optimize its application	Management {gatherStatistics}, General Framework
32	Seamless network sharing and mergers. This is the case where two Network Operators would like to share or merge their network. Using dSDN's infManager, the network administrators could merge the network administration control. This process may include setting up the desirable default fxApp packages of the network operator	fxManager Portal Service
33	Following a user to understand where it faces coverage issues or call drops. Once discovered, the system could send a message to the user acknowledging an issue and that the SP is trying to fix this. The information is uploaded to the cloud for further analysis	Management {gatherStatistics}, General Framework, Messaging {sendSMS}
34	Reporting: This allows the developer to get reports and statistics of the fxDevice traffics, errors, and neighboring environment. The reporting criteria could be set up as: 1) Period, 2) Event based (reports only if a threshold is passed; a threshold could be based on absolute numbers or deltas), 3) One---time (i.e. the information is	Management {setMonitoring}, General Framework
35	Proprietary security protocol between the application in the mobile device and the BS in enterprise deployment. This would allow SP to create enterprise---class LTE for indoor using small cells	Security {encryptContent, authenticateUser, Integrity, configureFirewall}, DataPath {RouteLocal}, General Framework
36	The femto cell at home that can't scan neighboring cells, gets a list of neighboring cells from the fxCloud or neighbors to broadcast to improve outbound handoffs	Wireless {discoverNeighbors, retrieveNeighborInfo, setNeighborCells}, Management {retrieveNeighborInfo}
37	IMS---capable femto enabling various SP services to initiate or transferred between home network and mobile devices	Messaging {sendfxCloud}, General Framework
38	Integrated smart home with multi---mode femto/WiFi router. For example, the application in the smart home router (fxDevice) allows for coordination of home physical security service (such as ADT services). With the fxCloudApp, the user could control the security status of his/her home and remotely control the setting of the	Wireless {homeAreaNetworking}, Messaging {fxCloud}, General Framework
39	Home CCTV DVR implementation in an integrated home router. The camera feeds are recorded on the same router caching engine	Cache {cacheVideo}, Messaging {sendfxCloud}, General Framework
40	Enterprise CCTV DVR implementation in an integrated router with cloud backup. The camera feeds are recorded in the cloud.	Cache {CacheVideo, CacheCloud}, Messaging {fxCloud}, General Framework
41	User traffic separation into various MPLS/LSP (integrating VPN and BS). In this case, users are classified into groups and each group is tunneled to the core network. For example, law enforcement use the encrypted tunnel while the other users use the default tunnel	DataPath {Match, SetupTunnel, RouteTunnel}
42	Dynamic spectrum allocation where a BS borrows unused spectrum from the neighboring BS in case of temporary congestions	DataPath {detectCongestion}, Wireless {discoverNeighbors, setWirelessConfig}, Management {retrieveNeighborInfo, borrowCarrier}, Messaging {fxCloud}

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43	Proxy ANDSF (Access Network Discovery and Control Function) in the BS. When the UE tries to access the ANDSF, the Proxy ANDSF fxDeviceApp in the BS intercept the ANDSF messages and replies on behalf of the ANDSF. This would speed up the WiFi network discovery for example.	DataPath {matchTraffic}, General Framework, Messaging {sendfxCloud}
44	HD Audio calling: audio codecs in BS allows the phones with the right capabilities to communicate with HD Audio quality calling. If one of the mobile devices can't handle the HD quality audio, the BS performs the transcoding of the audio.	DataPath {matchTraffic}, General Framework
45	Enabling mobility on White Space Spectrum: The latest white space database will be downloaded. The mobile devices with special software applications make requests to the BS to retrieve the local available white space frequencies. This would allow the mobile device to handoff seamless between BS using the white space spectrum. The BS would advertise such a capability to the UEs. The secure communication allows peer---to---peer communication between the UE and the BS for certain applications such as White Space Channel lookup or site acquisition tools for field engineering and RF planning.	Messaging {sendfxCloud}, General Framework
46	Site acquisition tool where the technician uses a software tool on his mobile phone to interact with BSs to determine the best place to deploy the new BS. The phone app interests with fxDeviceApps in BSs and fxCloudApp. For example, fxDeviceApp performs air interface quality and gives a priority to traffic generated by for this	Messaging {sendfxCloud}, General Framework. DataPath {matchTraffic, setPriority}
47	DNS caching at BS to accelerate DNS lookup for subsequent users. This would improve the user experience by reducing response delays	DataPath {matchTraffic}, General Framework
48	Continuous SLA monitory for certain protocols, applications or general link quality for jitter, delays, bandwidth	DataPath {matchTraffic}, Management {gatherStatistics}, General Framework
49	Enterprise users can use the small cell deployed in their enterprise free of charge. The DPI engine in fxDevice classifies the traffic and identifies the enterprise private data and they would be routed locally and charging records are generated by the BS (the SP decides how to bill the enterprise user and it may decide to make such usage free	DataPath {matchTraffic, routeLocal}
50	On---premise small---cell aggregation where on fxDevice takes the responsibility of aggregating multiple small---cells on the premise and presenting them as a single BS/Node---B/eNodeB to the core network. In this case the aggregating fxDevice (AfxE) may take responsibility of local radio resource manager (RRM) or self---optimizing network (SON) server. AfxE can also implement and enforce policies concerning local service access on the premise (enterprise) as well as enable seamless handover between cellular technologies and on---premise (enterprise) local area network (LAN) for example using WiFi technology.	General Frameworks, Wireless {discoverNeighbors, retrieveNeighborInfo, setNeighborCells, setWirelessConfig}, Messaging {sendIntraApp}
51	Self adjusting fxCloud compute resources: The fxCloud creates and tears down virtual machines (VMs) based on the traffic load measured by itself or the packet processing and data plane engine. It is also possible that the VM adjustments are made based on the rush hour or pre---configured hours of the day or manually by the administrator.	CloudManagement {removeVM, createVM, detectCloudCongestion, actiavteVM, suspendVM}
52	Core Network Function Virtualization (cNFV) using distributed Software Defined Networking (dSDN): In the case, once an fxDevice is commissioned, its fxDeviceApp0 (i.e. firmware) uses predefined DNS names to discover the rest of the core network (e.g. MME, S---GW, etc.). The core network elements could be created and	General Frameworks, Messaging {sendInterApp, sendIntraApp), CloudManagement {deleteVM, suspendVM, createVM, activateVM, detectCloudCongestion}
53	Smart display and digital signage as wireless base stations: this use case allows combining the capabilities of a base station and the smart display in shopping malls, airports, and enterprises. There is a already electric power and connectivity for the smart display that the base station function could use.	General Frameworks
54	Tracking a mobile user at base station level even if the UE is in the idle mode. Currently in the idle mode, the MME, SGSN, or VLR/MSC can only know the location of the UE in with a accuracy of LA/RA/URA which is a very large area. The administrator uses the fxCloudApp and requests tracking of the user/UE (the admin may provide target area where the user/UE may be located; e.g. zip code or town name). The fxCloudApp contacts its fxDeviceApp in the fxDevices in the target area (TA) requesting information of a particular IMSI/MSISD/TMSI. Once an fxDevice responds indicating knowledge of the user location, the fxCloudApp directs that serving fxDevice to inform the fxDeviceApp in the next fxDevice of the instructions to track the user and contact fxCloudApp when they user hands off to due to its mobility. fxCloud could create user friendly interfaces and presentations to show for example the direction the user is moving, predict next location of the user, and estimate arrival of the user to a certain location	DataPath {matchTraffic}, Messaging {sendIntraApp, sendfxCloud}
55	In case of emergency, fxDevices in a target area block all public traffic and only allow law enforcement sessions using specially encryption and authentication between the UE and the fxDevice or fxCloud (depending on the requirements)	DataPath {matchTraffic, setPriority}, Security {configureFirewall, encryptTraffic, authenticateUser}, General Framework

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56	SON triggered by the data traffic consumption. In this case, the mobile cell configuration is adjusted based on the current traffic of the cell. It could for example force handoff some users (high users or users moving fast) to neighboring cells.	DataPath {identifyTopDevices}, Wireless {forceHandoff}
57	Time based QoS and policy. In this use case, the infManager pushes certain policies in target area (TA). Such polices could be turning on extra capacity (frequency channels) or QoS policies and traffic prioritization on the WAN like	DataPath {matchTraffic, setPriority}, Wireless {discoverNeighbors, setWirelessConfig}
58	Fast moving users detection: in this use case, the application in the BS measures the speed of the user (based on the time was handed off to this cell until it was handed over to the next cell). This information could be used by the fxDevice or fxCloud to force handoff the mobile user to a larger cell to reduce handoff rates	General Frameworks, Wireless {identifyTopMovers, forceHandoff}
59	Emergency broadcast of information and live camera feeds. In case of emergency, the enterprise network administrator temporarily block all traffic and only allow emergency related traffic across the target area in the enterprise network. For example, the network admin broadcasts the camera feeds and alerts over the WiFi access points using multicast IP techniques. The client devices and digital sinages can listen to that particular multicast and show the camera feeds and emergency alerts	DataPath {matchTraffic, setPriority}, Security {configureFirewall}, General Framework
60	Dynamic advertising in shopping malls. The shopper would use an app from the shopping mall. When the shopper brings up or refreshes the app, the dSDN allows the shopping mall to pinpoint the exact indoor/outdoor location of the user (e.g. the shop the shopper is in) and send special coupon and ads for that store to the shopper.	General Frameworks, Wireless {positionDevice}, Messaging {sendIntraApp, sendfxCloud}, Security {configureFirewall}, DataPath {matchTraffic, redirectTraffic}
61	Smart tour guide. The tourist would use an app from the tourism board or museum. When the user brings up or refreshes the app, the dSDN allows to pinpoint the exact location of the tourist (e.g. the painting he/she is looking at) and send tour guide information (e.g. audio, video, hypertext). dSDN allows to localize the positioning and	General Frameworks, Wireless {positionDevice}, Messaging {sendIntraApp, sendfxCloud}, Security {configureFirewall}, DataPath {matchTraffic, redirectTraffic}
62	General hotspot landing page	DataPath {matchTraffic, redirectTraffic}, Security {authenticateUser}
63	Proprietary wireless mesh implementation	Wireless {discoverNeighbor, retrieveNeighborInfo, measureInterference, setWirelessConfig}, General Framework, Messaging {sendIntraApp}
64	Power and energy consumption map of the network. A real---time fxCloudApp pulls the power consumption details from each fxDevice periodicaly or on demand. The pulled data then are combined with the location information and correlated into a map to present a viewable consumption map	Management {getfxDeviceLocation, getPowerConsumptionRate}
65	Network deployment optimization. This application allows network operator to get advice for best optimal reconfiguration and/or redeployment of the network. For example, the network admin could get suggestion that based on the power consumptions and coverage perceived and spectrum utilization, it might be better to replace a particular group of smaller cells with a single macro---cell. This app could also pull information from larger OEMs based on the subject deployment scenario (the OEMs either provide this information statically to the tool or provide network APIs for use by this app e.g. using REST protocol)	Management {getfxDeviceLocation, getPowerConsumptionRate, gatherStatistics}
66	High availability. This app allows two or more fxDevice to form a redundancy cluster where they participate in statueful redundancy and load---balancing	Messaging {sendIntraApp}, General Framework
67	Bandwidth Bursting. This feature enables the dynamic adjustment of backhaul or WAN link bandwidth as the demands change in the enterprise or public wireless deployments. In this case, the fxDeviceApp in the fxDevice monitors the WAN link utilization, once a preset threshold percentage has reached, it messages its sister fxCloudApp which in turn would send a request to the fxDeviceApp to increase or decrease the WAN bandwidth. If additional backend reconfiguration is needed, the fxCloudApp performs those additional changes prior to informing the fxDeviceApp of the bandwidth	Management {getStatistics, configureWAN}
68	Wireless link quality measurement by the small---cell or WiFi AP: The wireless SoC in the small---cell or WiFi AP continuously monitors the link quality for power adjustment and handover reasons. Such information could be exposed to the app developers to create cell---level analytics and reports without the need to have test--- drives or field testing of service quality	Management {gatherStatistics}, General Framework
69	Data Path Consolidation: An application on the fxDevice discovers identical data feeds from a cloud server to two or more users. The fxDeviceApp in the fxDevice can discover this potential duplicate flows at the session establishment (via a proxy function) and it would consolidate those sessions into one on the uplink towards the cloud server. A good example of this use case is the web---based desktop sharing where different many users in the same office site get the same feed from the cloud server.	FastPath {detectIdenticalFlows, aggregateFlows}

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[0117] The following references are herein specifically incorporated by reference in their entirety into this disclosure:

[1] 3GPP TS 23.002, “Network Architecture”;

[2] 3GPP TS 23.402, “Architecture enhancements for non-3GPP accesses”;

[3] 3GPP TS 23.401, “General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access”;

[4] Open Base Station Architecture Initiative (OBSAI); and

[5] SPDY Protocol (http://datatracker.ietf.org/doc/draft-mbelshe-httpbis-spdy/).

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CLAIMS

1. A plurality of network elements in a packet system, said network elements comprising:

a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp;

a flexible cloud platform having at least one fxCloudApp, wherein the at least one fxDeviceApp and at least one fxCloudApp are in secure communication to form a distributed application; and

an application management portal which manages life cycle of the distributed applications.

2. The system of claim 1, wherein each of the flexible network device, flexible cloud platform and application management portal include an access network interface unit configured to send and receive communications and a processor with a memory associated with the network interface unit.

3. The system of claim 1 further comprising:

an infrastructure application market place in communication with the application management portal, said infrastructure market place capable of providing tested and certified applications to the application management portal.

4. The system of claim 1, wherein the at least one fxDeviceApp is responsible for a plurality of functional capabilities of the flexible network device and is capable of at least one of the group consisting of: updating the firmware of the flexible network device; updating default communication protocols of the flexible network device; initializing flexible network device settings; boot loading the flexible network device; providing

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security digital certificates; providing OS and kernal upgrades; and upgrading and commissing agents for the fxDeviceApp upgrades and related procedures.

5. The system of claim 1, wherein the at least one fxCloudApp is responsible for a plurality of functional capabilities of the flexible cloud platform and is capable of at least one of the group consisting of: upgrading and commissioning agents for the fxCloudApp updates and related procedures; hypervisor upgrades; virtual machine and/or isolated execution environment lifecycle management; security digital certificate management; OS and kernel upgrades; and default communication protocols.

6. The system of claim 1, wherein the application management portal is capable of at least one of the group consisting of: receiving new applications from the infrastructure application market place; test said distributed application prior to deployment; provision said distributed application; and deprovision said distributed application.

7. The system of claim 1, wherein the flexible network device is an LTE eNB and the flexible cloud platform hosts an LTE core network functions in separate virtual machines from the group consisting of: MME, S-GW, and P-GW.

8. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:
a virtual fabric which provides a secure communication layer for said at least one fxDeviceApp and said at least one fxCloudApp.

9. The system of claim 1, further comprising:
a second flexible network device which includes at least one fxDeviceApp which is the same as the at least one fxDeviceApp in the first flexible network device and where each of the fxDeviceApps can communicate directly.

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10. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed resource service (DRS) which controls access to a plurality of resources upon receiving instructions from the application management portal.

11. The system of claim 10, wherein the resources include at least one of a group consisting of: firewall; data and statistics; storage; compute; load evaluator; general settings; routing engine; virtual machine master controller; power controller; and wireless engine.

12. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed resource service which is capable of providing at least one service from a group consisting of: exposing APIs to other applications; configuring and managing platform resources; policy enforcement and authorization of applications access to platform resource and other app's APIs; and policy conflict resolution.

13. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed content service wherein contents generated by the at least one fxDeviceApp may be shared with the at least one fxCloudApp.

14. The system of claim 1, wherein the flexible network device and flexible cloud platform further comprise:

a distributed notification service wherein notice of a particular event is sent from the at least one fxDeviceApp to the at least one fxCloudApp.

15. The system of claim 10, wherein the DRS further includes a load controller; and wherein the load controller is adapted to monitor loads on the at least one fxDeviceApp and at least one fxCloudApp and effect change in accordance with thresholds received from the application management portal.

16. The system of claim 1, wherein the fxDevice, at least one fxDeviceApp, flexible cloud platform, and the at least one fxCloudApp each have unique identities.

17. The system of claim 1, wherein the at least one fxDeviceApp and and at least one fxCloudApp are given an access level to determine which APIs can be accessed.

18. The system of claim 1, wherein the at least one flexible network device and flexible cloud platform are adapted to verify the authenticity and integrity of updates.

19. A plurality of network elements in a packet system, said network elements comprising:

a flexible cloud platform having a plurality of virtual machines, wherein each of the virtual machines has at least one fxCloudApp; and

a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

20. A plurality of network elements in a packet system, said network elements comprising:

a flexible cloud platform having a plurality of zones, wherein each of the plurality of zones has at least one fxCloudApp; and

a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

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ABSTRACT

The Distributed Software Defined Network (dSDN) disclosed herein is an end-to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/142,983

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	18 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	830		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/142,983	01/06/2021	2425	830	TAAG001CONT3	18	3

CONFIRMATION NO. 2943

112449
Roark IP
1438 Dahlia Loop
San Jose, CA 95126

FILING RECEIPT

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Date Mailed: 02/18/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Power of Attorney: The patent practitioners associated with Customer Number 112449

Domestic Priority data as claimed by applicant

This application is a CON of 16/900,963 06/14/2020 PAT 10893095
which is a CON of 15/836,824 12/09/2017 PAT 10686871
which is a CON of 14/295,331 06/04/2014 PAT 9843624
which claims benefit of 61/834,807 06/13/2013

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: No

Permission to Access Search Results: No

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 02/17/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/142,983**

Projected Publication Date: Request for Non-Publication Acknowledged

Non-Publication Request: Yes

Early Publication Request: No
**** SMALL ENTITY ****
Title

Distributed Software Defined Networking

Preliminary Class

725

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/142,983	01/06/2021	Pouya Taaghol	TAAG001CONT3

CONFIRMATION NO. 2943

112449
Roark IP
1438 Dahlia Loop
San Jose, CA 95126

FORMALITIES LETTER

OC000000123462715

Date Mailed: 02/18/2021

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given **TWO MONTHS** from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125, is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). The specification, claims, and/or abstract page(s) submitted is not acceptable and cannot be scanned or properly stored because:
  - The application papers (including any electronically submitted papers) are not in compliance with 37 CFR 1.52 because pages 54 contain text that is unreadable or of insufficient clarity.
    Application papers (including any electronically submitted papers) must be presented in a form having sufficient clarity and contrast between the background of the paper and the writing thereon to permit the Office to electronically reproduce the papers by use of digital imaging and optical character recognition. See 37 CFR 1.52(a)(1)(v).

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

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Sheet 1 of 4

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

U.S.PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 7114021	9-2006	Seshadri	
		US- 7630706	12-2009	Weigand	
		US- 8132166	3-2012	DeHaan	
		US- 8528108	9-2013	Ammer	
		US- 8650299	2-2014	Huang	
		US- 8756595	6-2014	Arcilla	
		US- 8843933	9-2014	Holler	
		US- 9226333	12-2015	Steiner	
		US- 20020016954	2-2002	Charisius	
		US- 20040107417	6-2004	Chia	
		US- 20040237081	11-2004	Homiller	
		US- 20050246703	11-2005	Ahonen	
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		US- 20110075611	3-2011	Choi	

FOREIGN PATENT DOCUMENTS

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		US- **20120300615**	**11-2012**	Kempf	
		US- **20130007254**	**01-2013**	Fries	
		US- **20130160147**	**06-2013**	**Draluk**	
		US- **20130263104**	**10-2013**	Basel	
		US- **20140052976**	**02-2014**	Marino	
		US- **20140241158**	**08-2014**	Anthony, Jr.	
		US- **20140254373**	**09-2014**	Varma	
		US- **20140259012**	**09-2014**	**Nandlall**	
		US- **20140317293**	**10-2014**	Shatzkamer	
		US- **20150173121**	**06-2015**	**Miklos**	
		US- **20110265077**	**10-2011**	Collison	
		US- **20120066665**	**03-2012**	Kunze	
		US- **20120096071**	**04-2012**	Murphey	
		US- **20130223442**	**08-2013**	Narayanan	
		US- **20150160877**	**06-2015**	Larkin	
		US- **20150242237**	**08-2015**	Spivak	
		US- **20160224460**	**08-2016**	**Bryant**	
		US- **20190165997**	**05-2019**	Shaikh	
		US- **8843933**	**09-2014**	**Holler**	

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Sheet 3 of 2

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First Named Inventor	Taaghol
Art Unit	
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Attorney Docket Number	TAAG001CONT3

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 8495611	07-2013	McCarthy	
		US- 20120266156	10-2012	Spivak	
		US- 20060271341	11-2016	Brown	
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Sheet 4 of 4

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Application Number	
Filing Date	
First Named Inventor	Taaghol
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		McKeown, et al. "OpenFlow: Enabling Innovation in Campus Networks", March 14, 2008.	
		Li et al. "Toward Software-Defined Cellular Networks", "2012 European Workshop on Software Defined Networking".	
		"Network Functions Virtualisation", "SDN and OpenFlow World Congress", Darmstadt-Germany, October 22-24, 2012.	
		Yap et al., "OpenRoads: Empowering Research in Mobile Networks", ACM SIGCOMM Computer Communication Review, 2010.	
		Bansal et al., "OpenRadio: A Programmable Wireless Dataplane", HotSDN'12, August 13, 2012, Helsinki, Finland.	
		Stallings et al., "Software-Defined Networks and OpenFlow", The Internet Protocol Journal, vol. 16, No. 1, March 2013.	
		Luo et al., "Software Defined Networking across Distributed Datacenters over Cloud", IEEE Int. Conference on Cloud Computing Tech, 2013	
		Chappell, David, "A Short Introduction to Cloud Platforms", Aug. 2008.	

Examiner Signature		Date Considered	

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Filer:	Christopher James Horgan
Attorney Docket Number:	TAAG001CONT3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	80	80
UTILITY SEARCH FEE	2111	1	350	350
UTILITY EXAMINATION FEE	2311	1	400	400
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**830**

Electronic Acknowledgement Receipt	
EFS ID:	41573796
Application Number:	17142983
International Application Number:	
Confirmation Number:	2943
Title of Invention:	Distributed Software Defined Networking
First Named Inventor/Applicant Name:	Pouya Taaghol
Customer Number:	112449
Filer:	Christopher James Horgan
Filer Authorized By:	
Attorney Docket Number:	TAAG001CONT3
Receipt Date:	06-JAN-2021
Filing Date:	
Time Stamp:	18:22:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$830
RAM confirmation Number	E202116I24496049
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The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	TAAG001CONT3_ADSv4.pdf	125468 c26ba63e7b8347ef9122411e4770e77b3f9a4f98	no	7
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
2	Power of Attorney	TAAG001CONT3_POA.pdf	213764 85c4f45ed9214d76b6c65bc872ddca03cd49b013	no	2
Warnings:					
Information:					
3	Assignee showing of ownership per 37 CFR 3.73	TAAG001CONT3_CERT.pdf	123719 2f7f54060add117eac94a2dc9694fd928e25ecf1	no	2
Warnings:					
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4	Nonpublication request from applicant	TAAG001CONT3_NONPUB.pdf	124790 42a62dc9be0f661f347edc2bcffc0246d7670592	no	1
Warnings:					
Information:					
5	Internet Communications Authorized	TAAG001CONT3_INT_COMM.pdf	69887 2d524d271ba0293765a37e702f211ee32f88701d	no	1
Warnings:					
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6	Drawings-only black and white line drawings	TAAG001CONT3_DRAWINGS_.pdf	907811 abcccd864b4c6997eb89e14f696bcb2e0a5f0bd3	no	18
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7	Specification	TAAG001CONT3_SPECIFICATION_v3.pdf	661870 167217d059a5331c194106481c0fcaa9e16391de	no	61
Warnings:					
Information:					
8	Oath or Declaration filed	TAAG001CONT3_DEC.pdf	328696 1cf9d3cd80c1b0e68ab30b96d6cfc378143b43ed	no	2
Warnings:					
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9	Information Disclosure Statement (IDS) Form (SB08)	TAAG001CONT3_IDSv3.pdf	254641 c132ccd05d78c6eb148efa342dbd206432ff8e01	no	4
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10	Non Patent Literature	NONPATLIT__LUO.pdf	852818 c9b78214cc0e2155c2e3383fd1740cb0450e3a05	no	8
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12	Non Patent Literature	NONPATLIT__YAP.pdf	264023 f25648fc789a6ab17de81ad0c50fde586fd8d1a7	no	2
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13	Non Patent Literature	NONPATLIT__BANSAL.pdf	692740 50119452c442a40f36be929599991991176c2498	no	6

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14	Non Patent Literature	NONPATLIT__LI.pdf	924070 888b121a29ca83c98742829c788e1f2e006a44ce	no	6
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16	Non Patent Literature	NONPATLIT__NFV.pdf	883145 339ff411e0988b66d095517cf5ca34f81eef04be	no	16
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18	Fee Worksheet (SB06)	fee-info.pdf	35203 74df611717aedd66fdd44a11e31bca8ef30ff14c	no	2
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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	TAAG001CONT3
	Application Number	
Title of Invention	Distributed Software Defined Networking	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Pouya		Taaghol	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	San Jose	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	1260 Trestlewood Lane		
Address 2			
City	San Jose	State/Province	CA
Postal Code	95138	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Vivek		Ramanna	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	San Jose	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	549 Manhattan Place		
Address 2			
City	San Jose	State/Province	CA
Postal Code	95126	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

PTO/AIA/14 (03-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	TAAG001CONT3
	Application Number	
Title of Invention	Distributed Software Defined Networking	

☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	112449		
Email Address	chris.horgan@roarkip.com	Add Email	Remove Email

Application Information:

Title of the Invention	Distributed Software Defined Networking		
Attorney Docket Number	TAAG001CONT3	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	18	**Suggested Figure for Publication (if any)**	3

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☒ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	112449		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	Pending		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	
	Continuation of	16900963	2020-06-14	
Prior Application Status	Pending		Remove	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	TAAG001CONT3
	Application Number	
Title of Invention	Distributed Software Defined Networking	

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
16900963	Continuation of	15836824	2017-12-09
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
15836824	Continuation of	14295331	2014-06-04
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
14295331	non provisional of	61834807	2013-06-13

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	TAAG001CONT3
	Application Number	
Title of Invention	Distributed Software Defined Networking	

Authorization to Permit Access:

☐ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :	
If the Applicant is an Organization check here. ☒	
Organization Name	Big Data Federation, Inc.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	TAAG001CONT3
	Application Number	
Title of Invention	Distributed Software Defined Networking	

Mailing Address Information For Applicant:			
Address 1	990 Linden Drive, #220		
Address 2			
City	Santa Clara	**State/Province**	CA
Country i	US	Postal Code	95050
Phone Number	408-623-8529	Fax Number	
Email Address	pouya@bigdatafeed.com		

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest), as the patent application publication will include the name of the applicant(s).

Remove

If the Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Non-Applicant Assignee:			
Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the Add button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	TAAG001CONT3
	Application Number	
Title of Invention	Distributed Software Defined Networking	

Signature:

Remove

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.					
Signature	/Christopher J. Horgan/			Date (YYYY-MM-DD)	2021-01-06
First Name	Christopher	Last Name	Horgan	Registration Number	40394
Additional Signature may be generated within this form by selecting the Add button. Add					

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: PA..
Document Description: Power of Attorney

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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	
First Named Inventor	Taaghol
Title	Distributed Software Defined Network
Art Unit	
Examiner Name	
Attorney Docket Number	TAAG001CONT3

SIGNATURE of Applicant or Patent Practitioner

Signature	/Christopher J. Horgan/	Date (Optional)	January 6, 2021
Name	Christopher J. Horgan	Registration Number	40394
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)	Big Data Federation, Inc.		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date
15/836,824	12/9/2017

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 112449

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Big Data Federation, Inc.

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	1/26/2020
Name	Pouya Taaghol		
Title	CEO, Big Data Federation, Inc.		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Big Data Federation, Inc.

Application No./Patent No.: _____ Filed/Issue Date: _____

Titled: Distributed Software Defined Networking

Big Data Federation, Inc., a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Pouya Taaghol To: Big Data Federation, Inc.

   The document was recorded in the United States Patent and Trademark Office at
   Reel 050963, Frame 0054, or for which a copy thereof is attached.

2. From: Vivek Ramanna To: Pouya Taaghol

   The document was recorded in the United States Patent and Trademark Office at
   Reel 035569, Frame 0334, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Christopher J. Horgan/	January 6, 2021
Signature	Date
Christopher J. Horgan	40394
Printed or Typed Name	Title or Registration Number

PTO/SB/35 (07-09)
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U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

NONPUBLICATION REQUEST UNDER 35 U.S.C. 122(b)(2)(B)(i)

First Named Inventor	Taaghol
Title	Distributed Software Defined Networking
Attorney Docket Number	TAAG001CONT3

I hereby certify that the invention disclosed in the attached application **has not and will not be** the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

I hereby request that the attached application not be published under 35 U.S.C. 122(b).

/Christopher J. Horgan/ — January 6, 2020

Signature — Date

Christopher J. Horgan — 40493

Typed or printed name — Registration Number, if applicable

408-687-8306

Telephone Number

This request must be signed in compliance with 37 CFR 1.33(b) and submitted with the application **upon filing.**

Applicant may rescind this nonpublication request at any time. If applicant rescinds a request that an application not be published under 35 U.S.C. 122(b), the application will be scheduled for publication at eighteen months from the earliest claimed filing date for which a benefit is claimed.

If applicant subsequently files an application directed to the invention disclosed in the attached application in another country, or under a multilateral international agreement, that requires publication of applications eighteen months after filing, the applicant **must** notify the United States Patent and Trademark Office of such filing within forty-five (45) days after the date of the filing of such foreign or international application. **Failure to do so will result in abandonment of this application (35 U.S.C. 122(b)(2)(B)(iii)).**

This collection of information is required by 37 CFR 1.213(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Doc Code: ECOMM.AUTH/ECOMM.WTDW
Doc Description: Internet Communications Authorized/Internet Communications Authorization Withdrawn

PTO/SB/439 (11-15)

AUTHORIZATION FOR INTERNET COMMUNICATIONS IN A PATENT APPLICATION OR REQUEST TO WITHDRAW AUTHORIZATION FOR INTERNET COMMUNICATIONS		
	Application No.	
	Filing Date	
	First Named Inventor	Taaghol
	Art Unit	
	Examiner Name	
	Practitioner Docket No.	TAAG001CONT3

To: Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I. To authorize permission for Internet Communications.

☑ Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with the undersigned and practitioners in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via video conferencing, instant messaging, or electronic mail. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03)

II. To withdraw authorization for Internet Communications.

☐ The authorization given on _____, to the USPTO to communicate with the undersigned and any practitioner in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via Internet communications such as video conferencing, instant messaging, or electronic mail is hereby withdrawn. I understand that the withdrawal is effective when approved rather than when received.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 40394.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Christopher J. Horgan/ — Signature

January 6, 2021 — Date

Christopher J. Horgan — Typed or printed name

408-687-8306 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Juristic entities must be represented by a patent practitioner (see 37 CFR 1.31, which is applicable to any paper filed on or after September 16, 2012, that is presented on behalf of a juristic entity, regardless of application filing date). Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

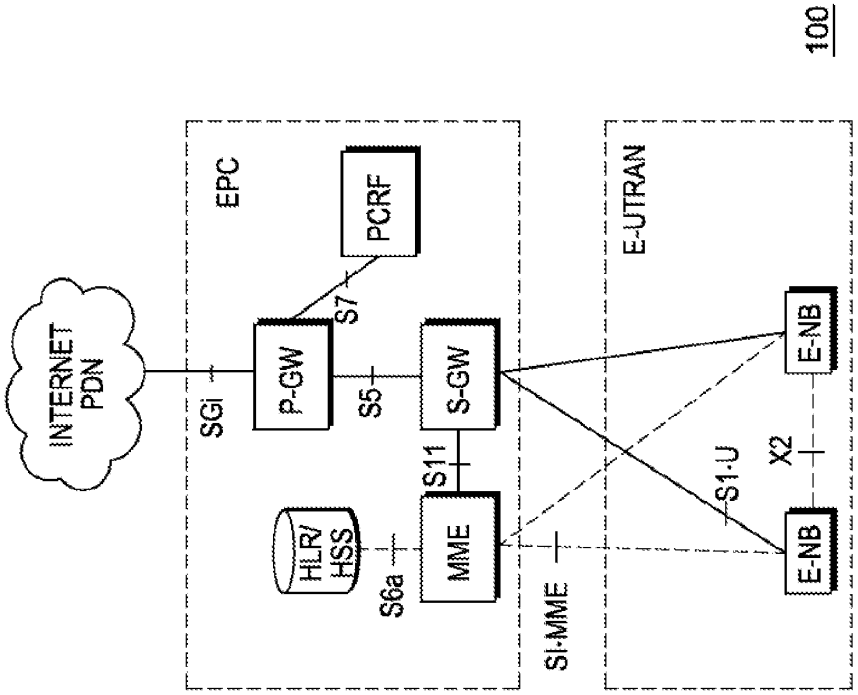

100
INTERNET PDN
EPC
PCRF
S7
P-GW
SGi
S5
S-GW
S11
HLR/ HSS
S6a
MME
S1-MME
E-UTRAN
E-NB
E-NB
S1-U
X2
LTE-Uu

FIG. 1

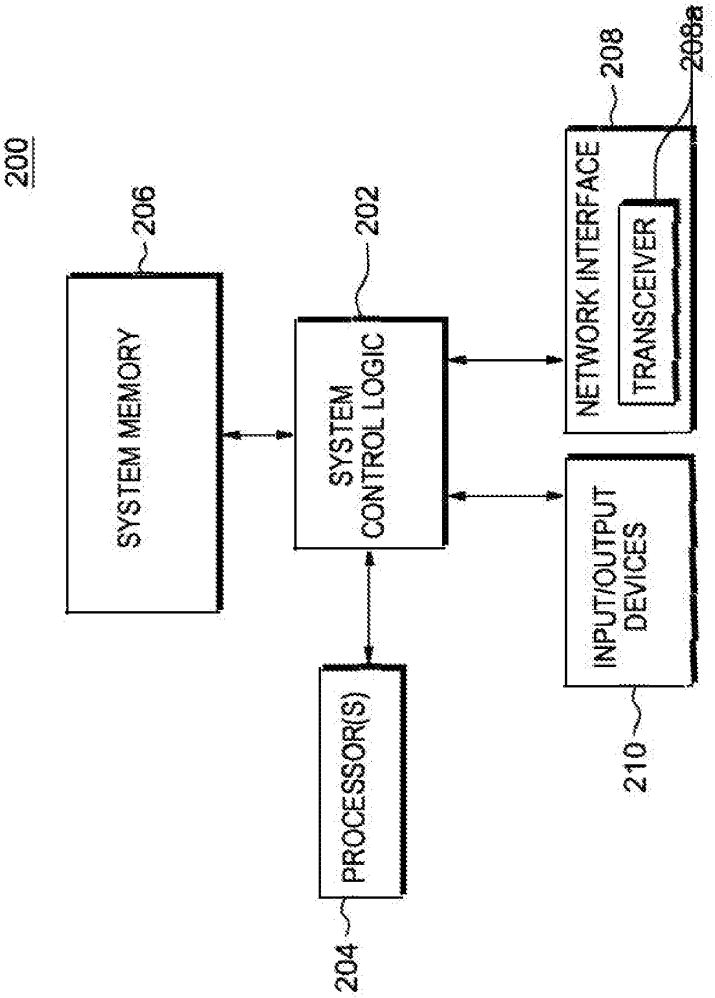

200
206
SYSTEM MEMORY
202
SYSTEM CONTROL LOGIC
208
NETWORK INTERFACE
208a
TRANSCEIVER
INPUT/OUTPUT DEVICES
210
PROCESSOR(S)
204

FIG. 2

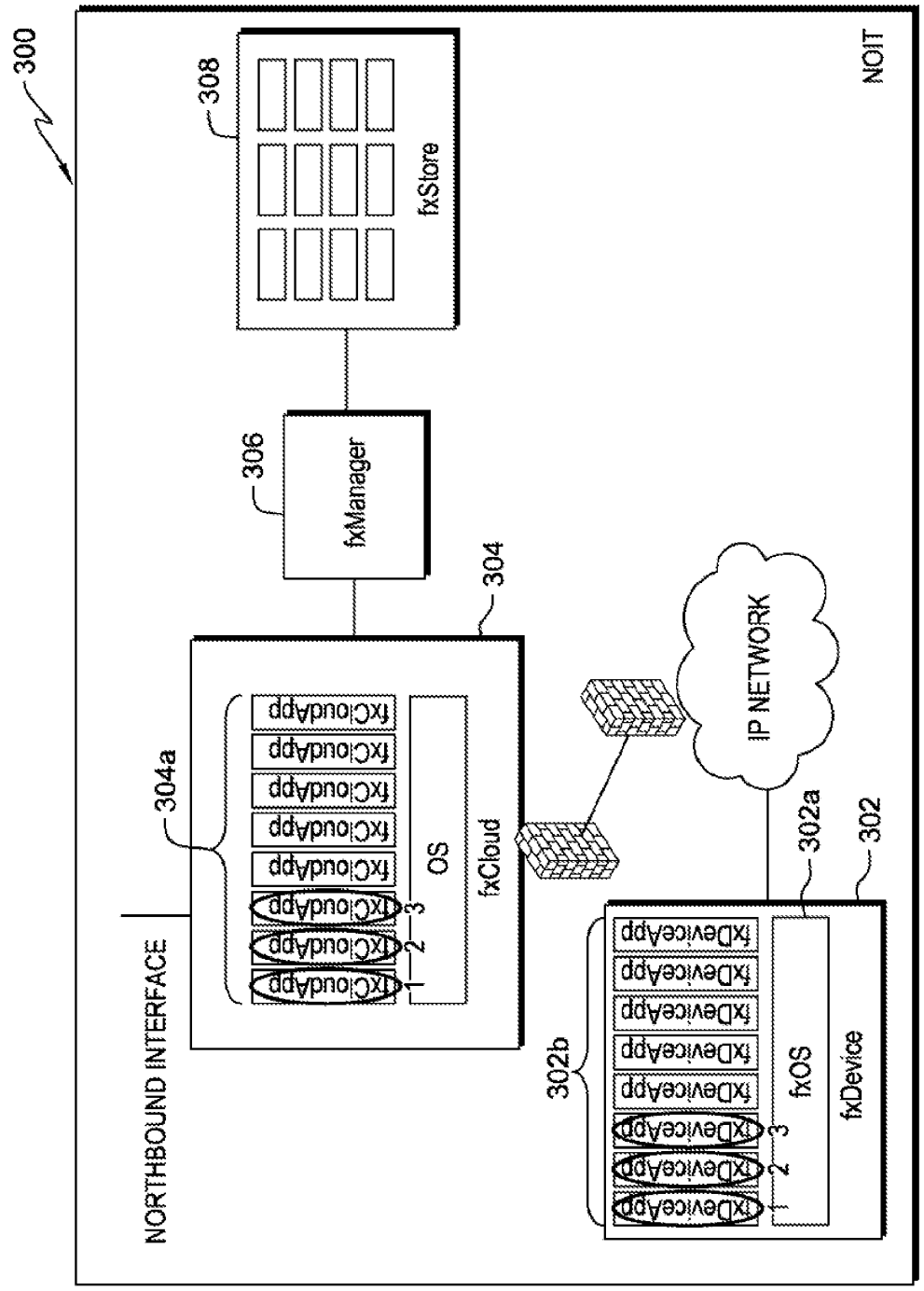

300
NOIT
308
fxStore
306
fxManager
304
304a
fxCloudApp
OS
fxCloud
IP NETWORK
NORTHBOUND INTERFACE
302a
302
302b
fxDeviceApp
fxOS
fxDevice
1
2
3

FIG. 3

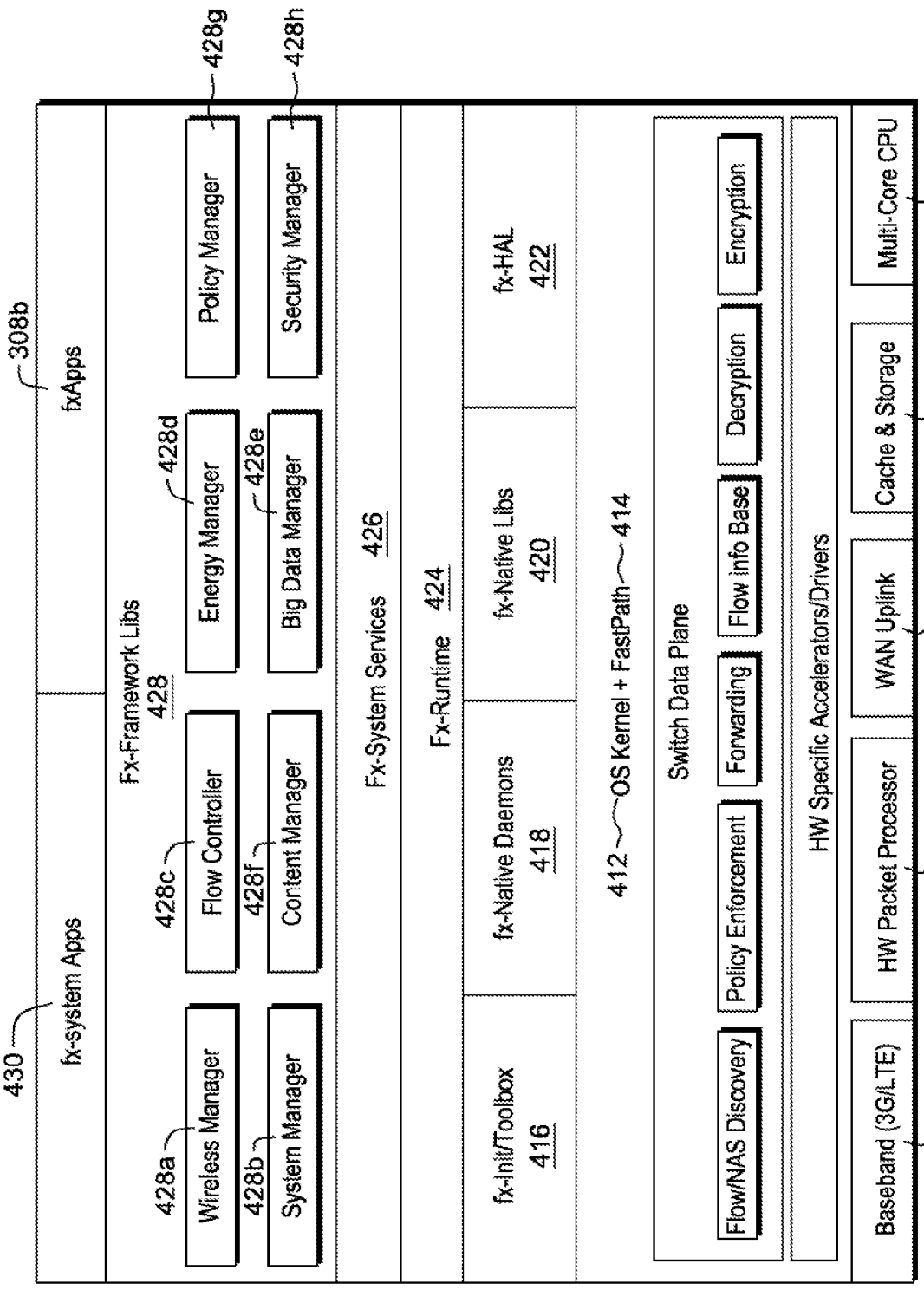

430
fx-system Apps
308b
fxApps
Fx-Framework Libs
428
428a
Wireless Manager
428b
System Manager
428c
Flow Controller
428f
Content Manager
428d
Energy Manager
428e
Big Data Manager
428g
Policy Manager
428h
Security Manager
Fx-System Services 426
Fx-Runtime 424
fx-Init/Toolbox
416
fx-Native Daemons
418
fx-Native Libs
420
fx-HAL
422
412
OS Kernel + FastPath
414
Switch Data Plane
Flow/NAS Discovery
Policy Enforcement
Forwarding
Flow info Base
Decryption
Encryption
HW Specific Accelerators/Drivers
Baseband (3G/LTE)
402
HW Packet Processor
404
WAN Uplink
406
Cache & Storage
408
Multi-Core CPU
410

FIG. 4

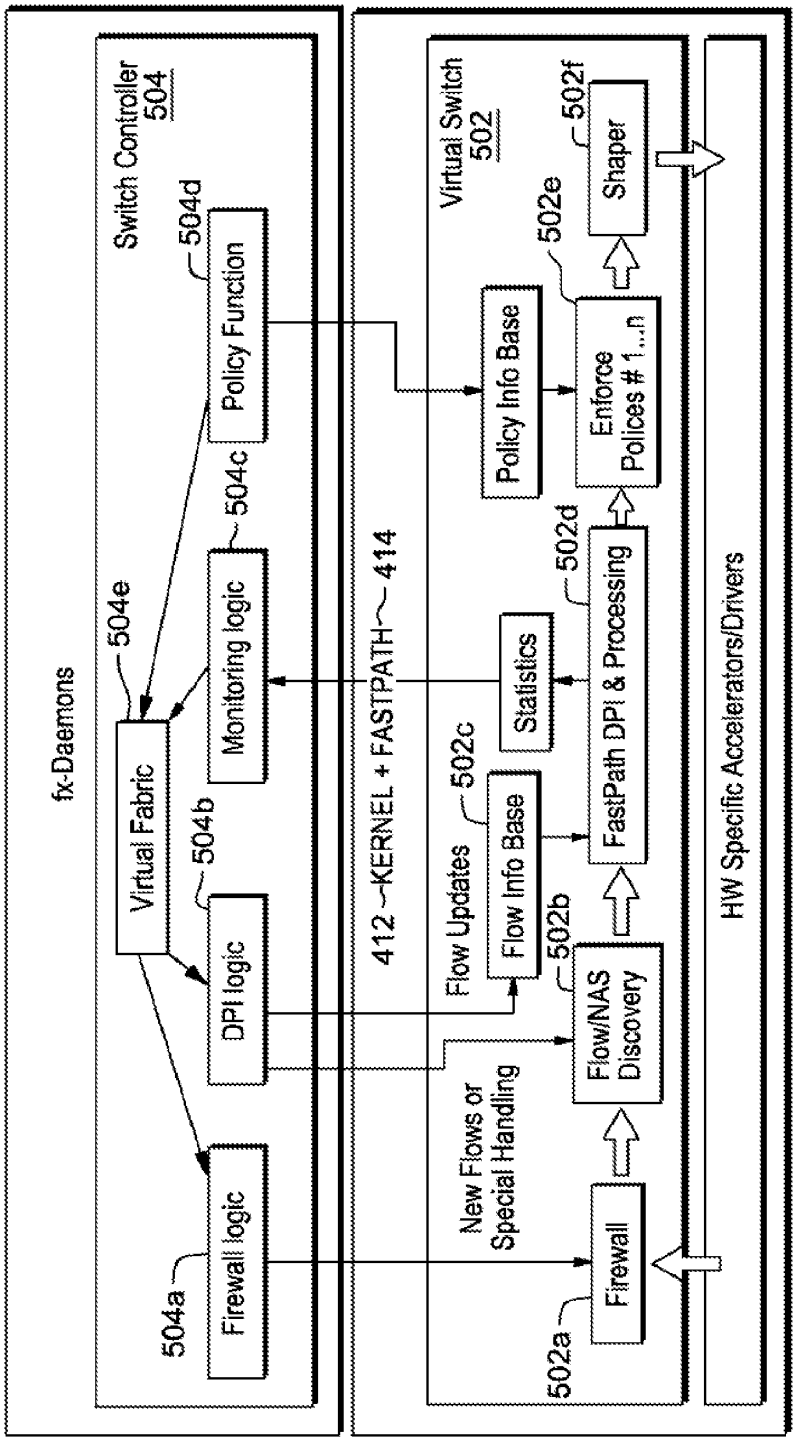

fx-Daemons
Switch Controller
504
504a
Firewall logic
504b
DPI logic
504c
Monitoring logic
504d
Policy Function
504e
Virtual Fabric
412 ~KERNEL + FASTPATH~ 414
Virtual Switch
502
502a
Firewall
New Flows or
Special Handling
502b
Flow/NAS
Discovery
Flow Updates
502c
Flow Info Base
Statistics
502d
FastPath DPI & Processing
Policy Info Base
502e
Enforce
Polices # 1...n
502f
Shaper
HW Specific Accelerators/Drivers
Control
Data

FIG. 5

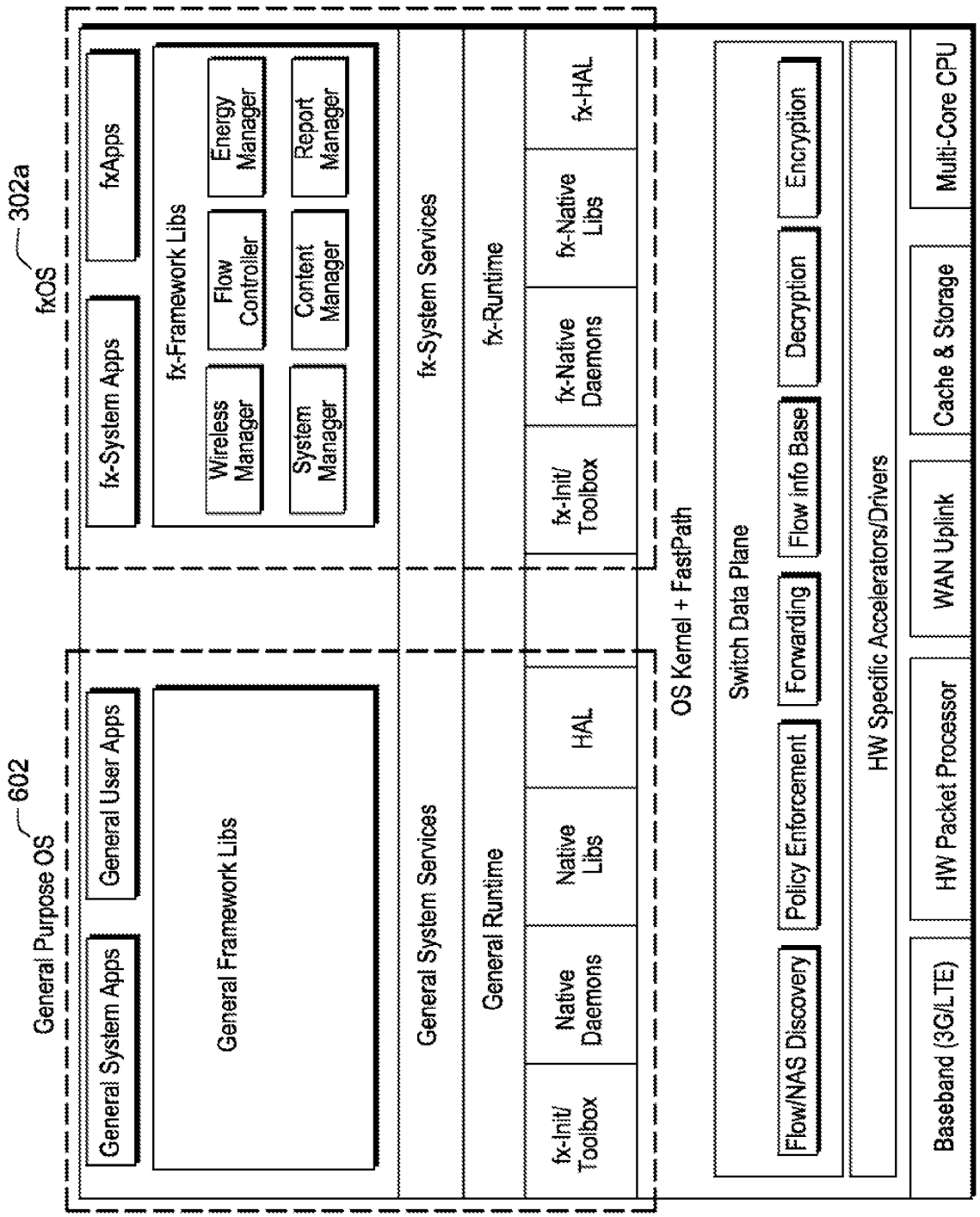

602
General Purpose OS
General System Apps
General User Apps
General Framework Libs
General System Services
fx-Init/ Toolbox
Native Daemons
Native Libs
HAL
General Runtime
302a
fxOS
fx-System Apps
fxApps
fx-Framework Libs
Wireless Manager
Flow Controller
Energy Manager
System Manager
Content Manager
Report Manager
fx-System Services
fx-Init/ Toolbox
fx-Native Daemons
fx-Native Libs
fx-HAL
fx-Runtime
OS Kernel + FastPath
Switch Data Plane
Flow/NAS Discovery
Policy Enforcement
Forwarding
Flow info Base
Decryption
Encryption
HW Specific Accelerators/Drivers
Baseband (3G/LTE)
HW Packet Processor
WAN Uplink
Cache & Storage
Multi-Core CPU

FIG. 6

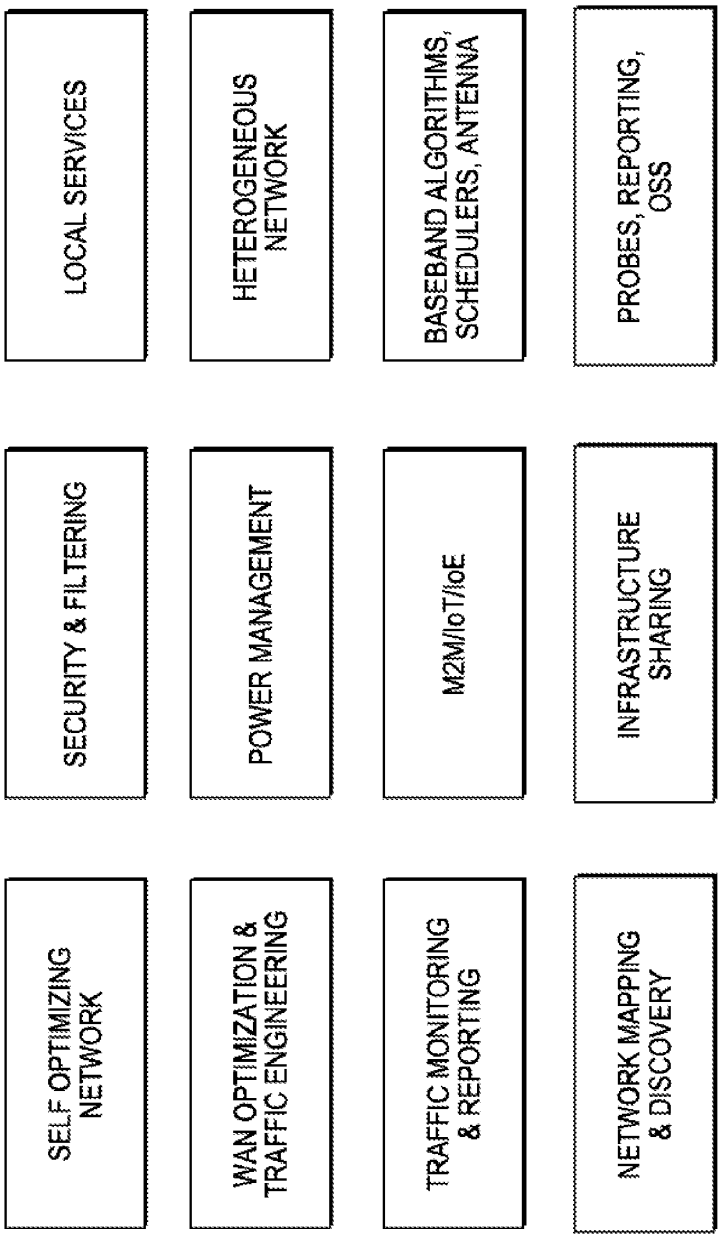

LOCAL SERVICES
HETEROGENEOUS NETWORK
BASEBAND ALGORITHMS, SCHEDULERS, ANTENNA
PROBES, REPORTING, OSS
SECURITY & FILTERING
POWER MANAGEMENT
M2M/IoT/IoE
INFRASTRUCTURE SHARING
SELF OPTIMIZING NETWORK
WAN OPTIMIZATION & TRAFFIC ENGINEERING
TRAFFIC MONITORING & REPORTING
NETWORK MAPPING & DISCOVERY

FIG. 7

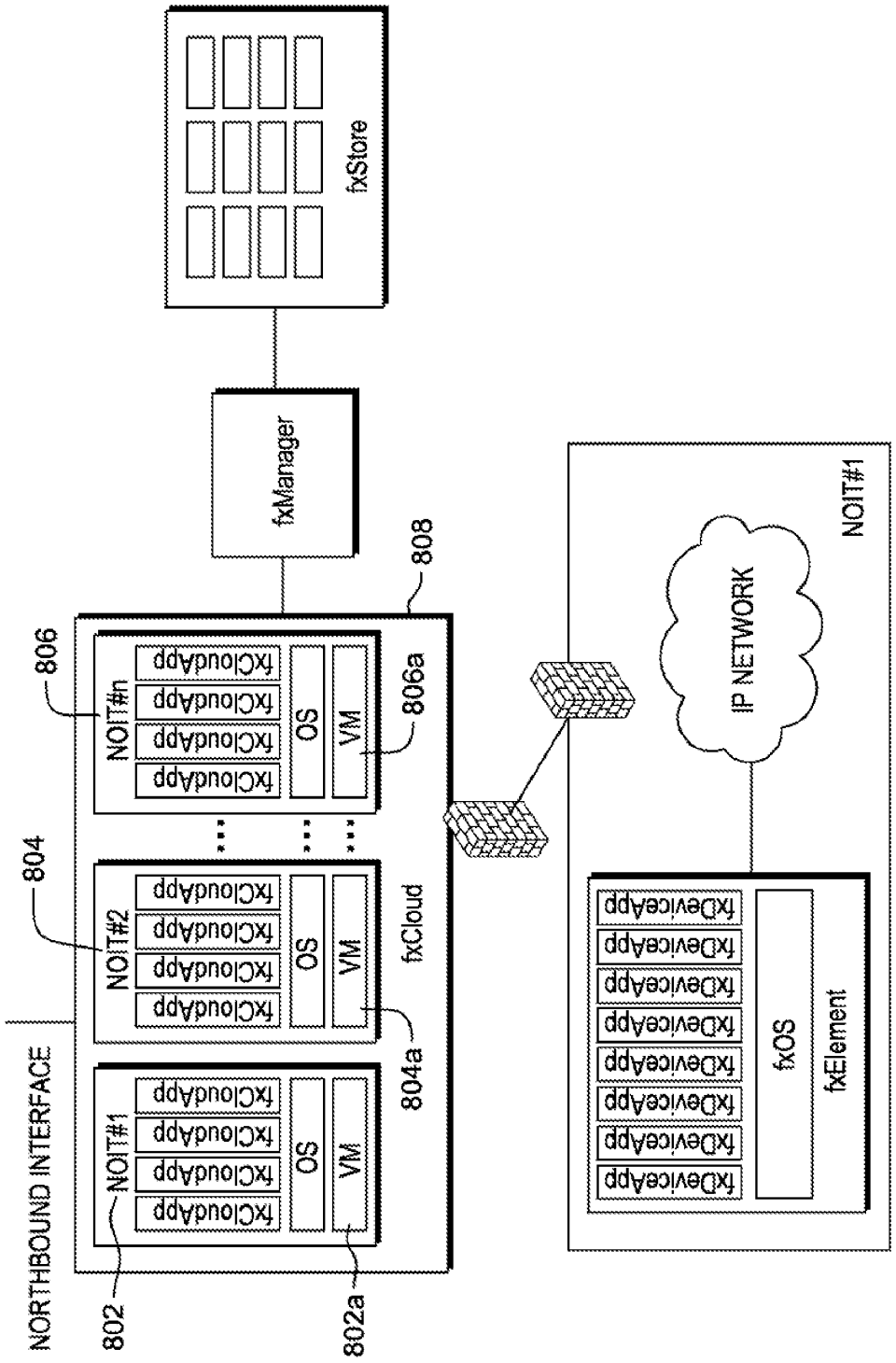

fxStore
fxManager
808
806
NOIT#n
fxCloudApp
OS
VM
806a
804
NOIT#2
fxCloud
804a
NOIT#1
802
802a
NORTHBOUND INTERFACE
IP NETWORK
NOIT#1
fxDeviceApp
fxOS
fxElement

FIG. 8

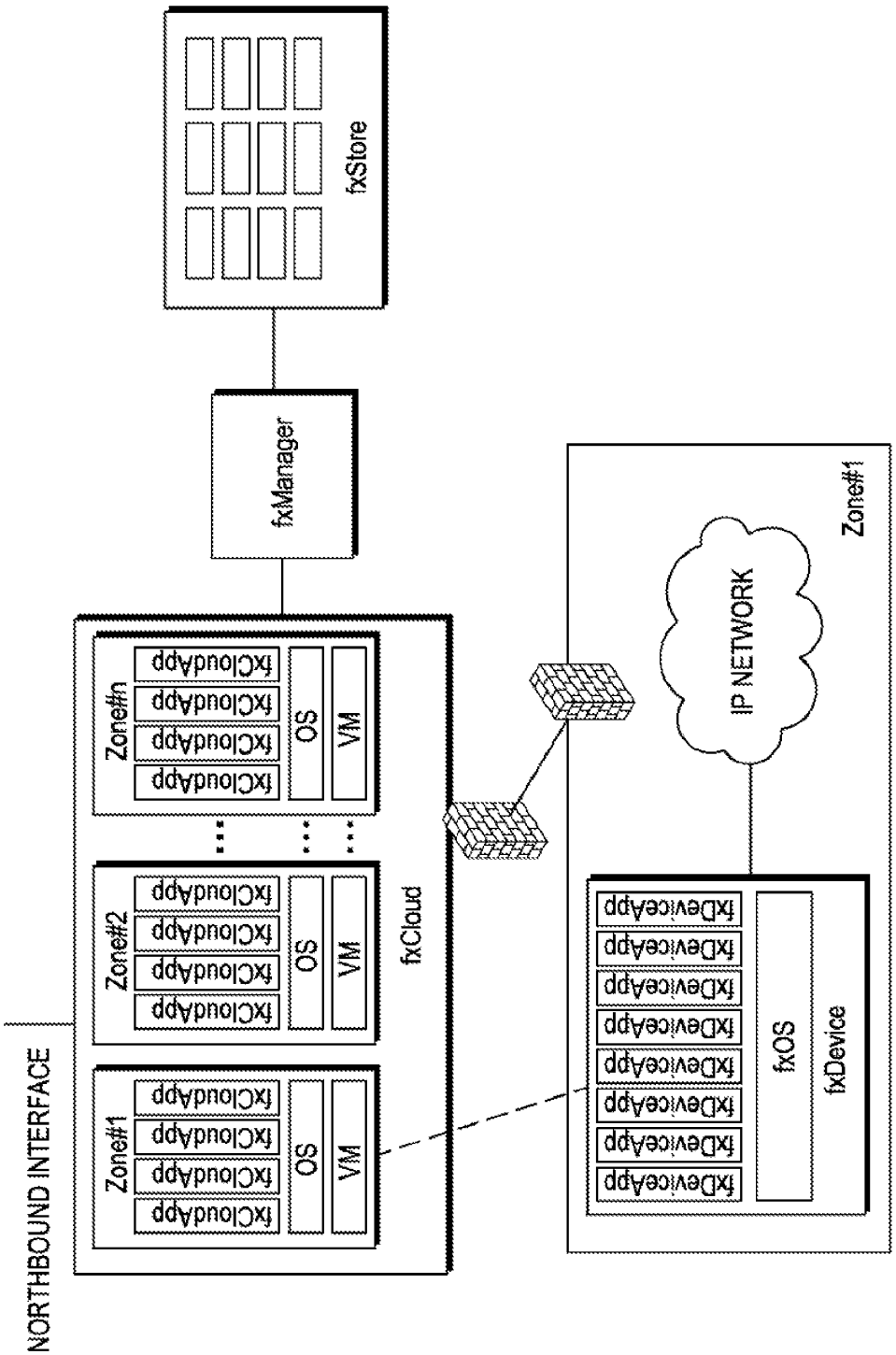

fxStore
fxManager
fxCloud
Zone#n
Zone#2
Zone#1
fxCloudApp
OS
VM
NORTHBOUND INTERFACE
IP NETWORK
Zone#1
fxDeviceApp
fxOS
fxDevice

FIG. 9

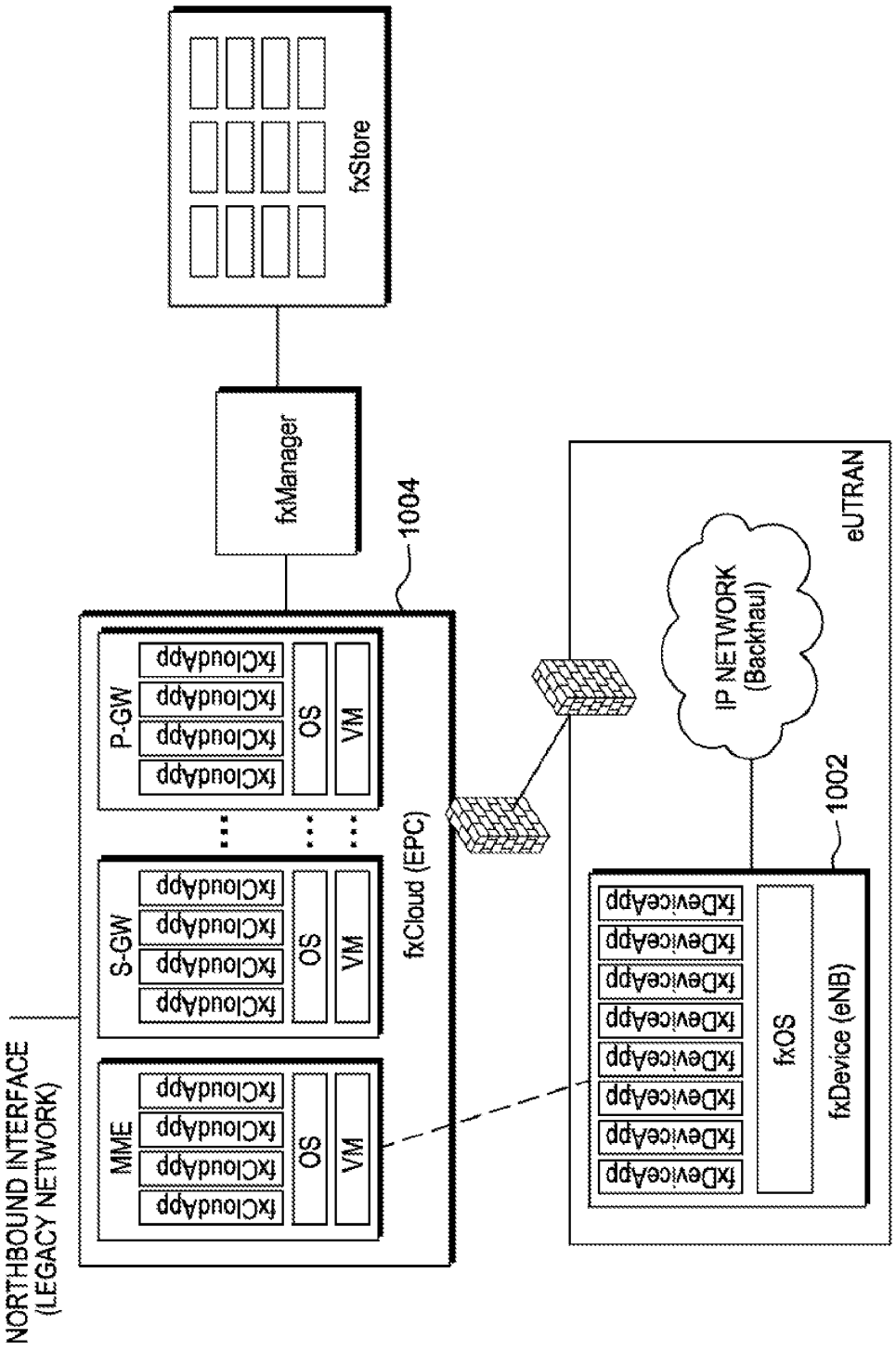

fxStore
fxManager
1004
P-GW
S-GW
MME
fxCloudApp
OS
VM
fxCloud (EPC)
NORTHBOUND INTERFACE
(LEGACY NETWORK)
IP NETWORK
(Backhaul)
eUTRAN
1002
fxDeviceApp
fxOS
fxDevice (eNB)

FIG. 10

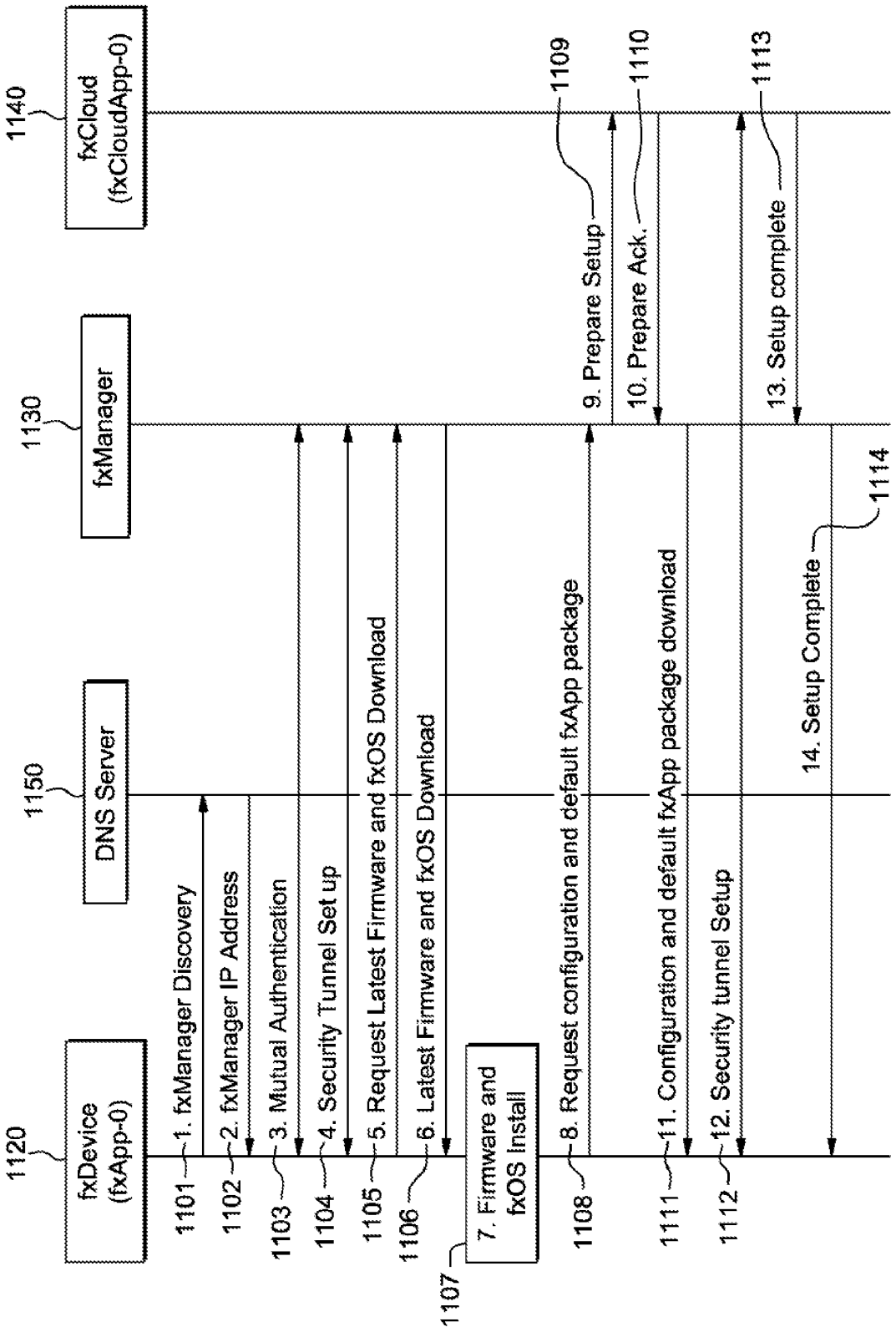

1120
fxDevice (fxApp-0)
1150
DNS Server
1130
fxManager
1140
fxCloud (fxCloudApp-0)
1101
1. fxManager Discovery
1102
2. fxManager IP Address
1103
3. Mutual Authentication
1104
4. Security Tunnel Set up
1105
5. Request Latest Firmware and fxOS Download
1106
6. Latest Firmware and fxOS Download
1107
7. Firmware and fxOS Install
1108
8. Request configuration and default fxApp package
1109
9. Prepare Setup
1110
10. Prepare Ack.
1111
11. Configuration and default fxApp package download
1112
12. Security tunnel Setup
1113
13. Setup complete
1114
14. Setup Complete

FIG. 11

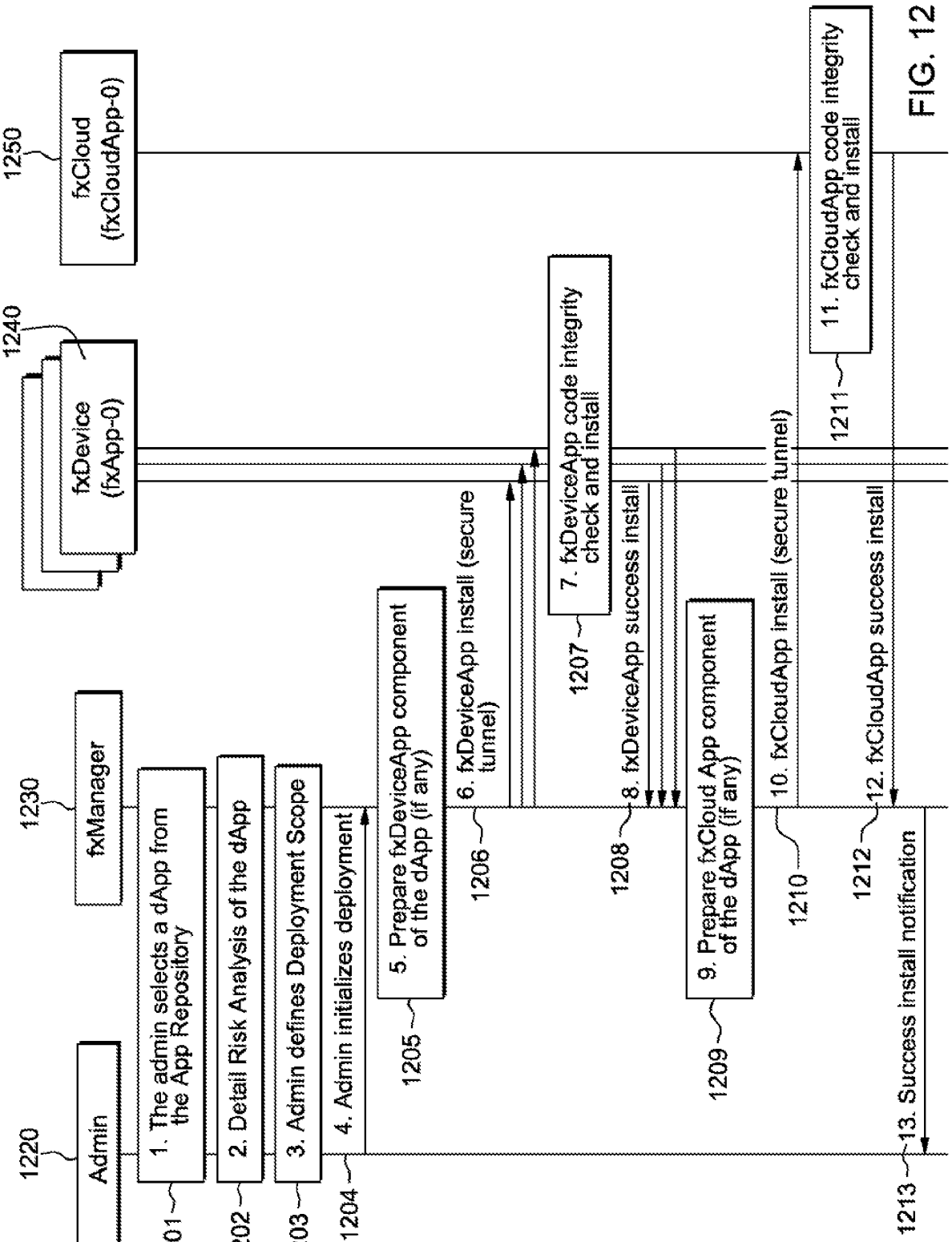

1220
Admin
1230
fxManager
1240
fxDevice
(fxApp-0)
1250
fxCloud
(fxCloudApp-0)
1201
1. The admin selects a dApp from the App Repository
1202
2. Detail Risk Analysis of the dApp
1203
3. Admin defines Deployment Scope
1204
4. Admin initializes deployment
1205
5. Prepare fxDeviceApp component of the dApp (if any)
1206
6. fxDeviceApp install (secure tunnel)
1207
7. fxDeviceApp code integrity check and install
1208
8. fxDeviceApp success install
1209
9. Prepare fxCloud App component of the dApp (if any)
1210
10. fxCloudApp install (secure tunnel)
1211
11. fxCloudApp code integrity check and install
1212
12. fxCloudApp success install
1213
13. Success install notification

FIG. 12

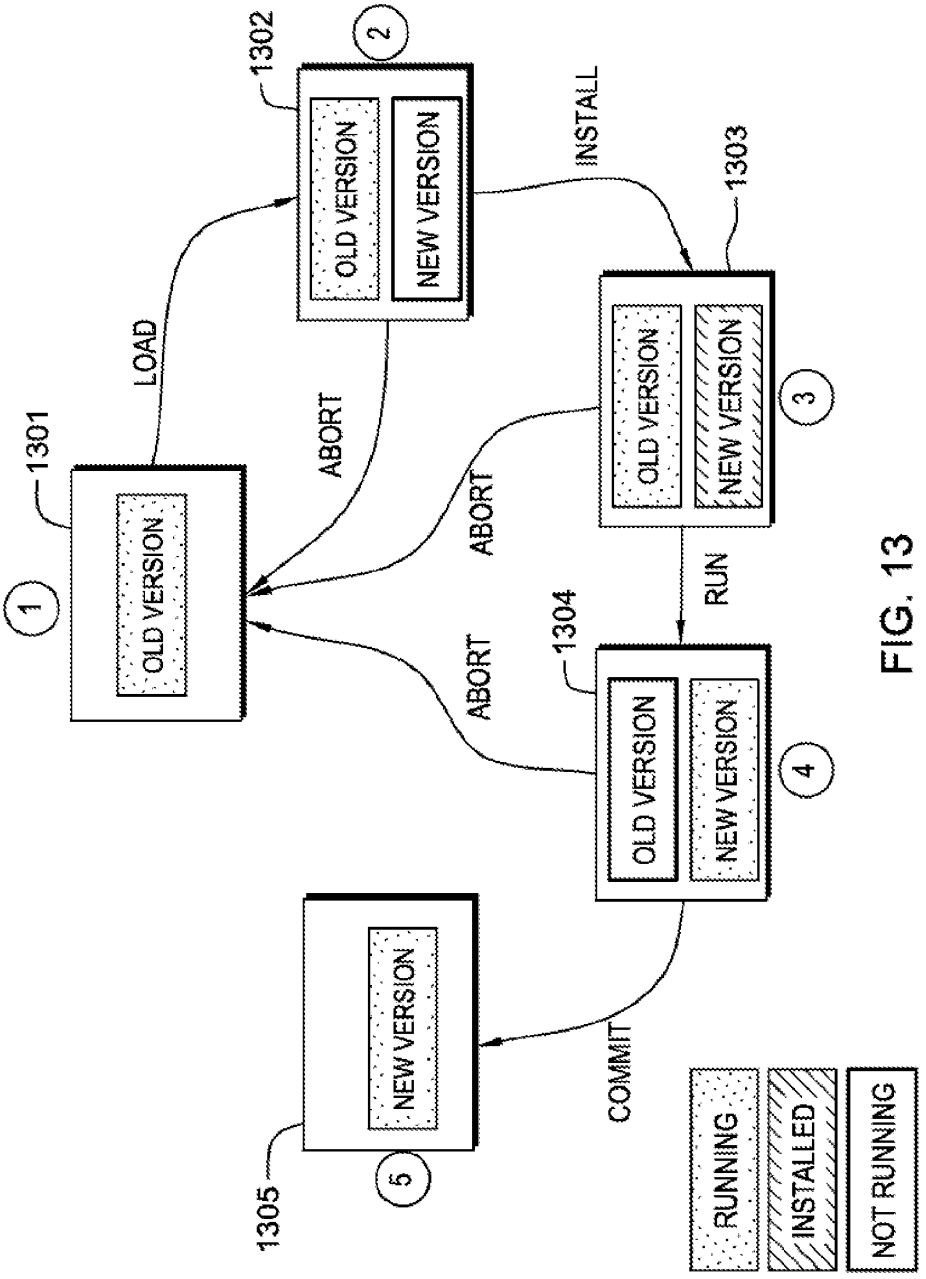

1301
OLD VERSION
1
LOAD
1302
OLD VERSION
NEW VERSION
2
ABORT
INSTALL
1303
OLD VERSION
NEW VERSION
3
ABORT
RUN
1304
OLD VERSION
NEW VERSION
4
ABORT
COMMIT
1305
NEW VERSION
5
RUNNING
INSTALLED
NOT RUNNING

FIG. 13

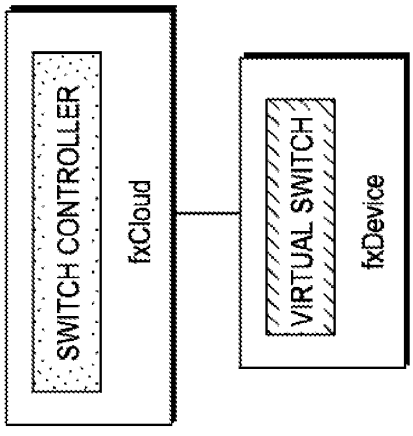


FIG. 14A

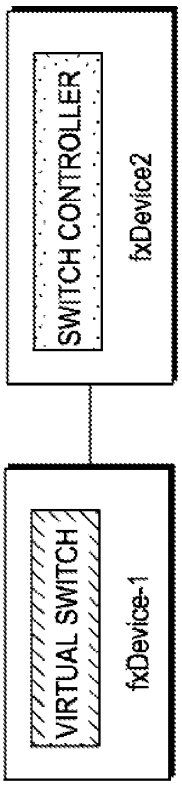


FIG. 14B

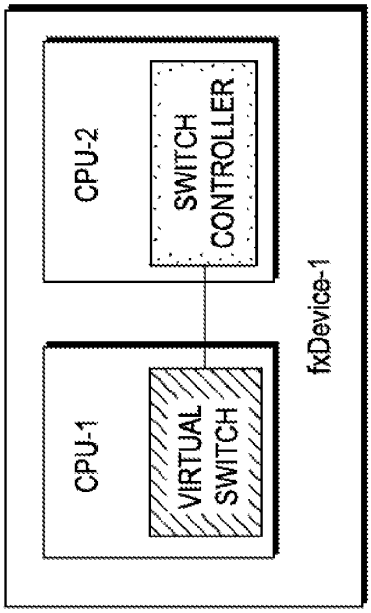


FIG. 14C

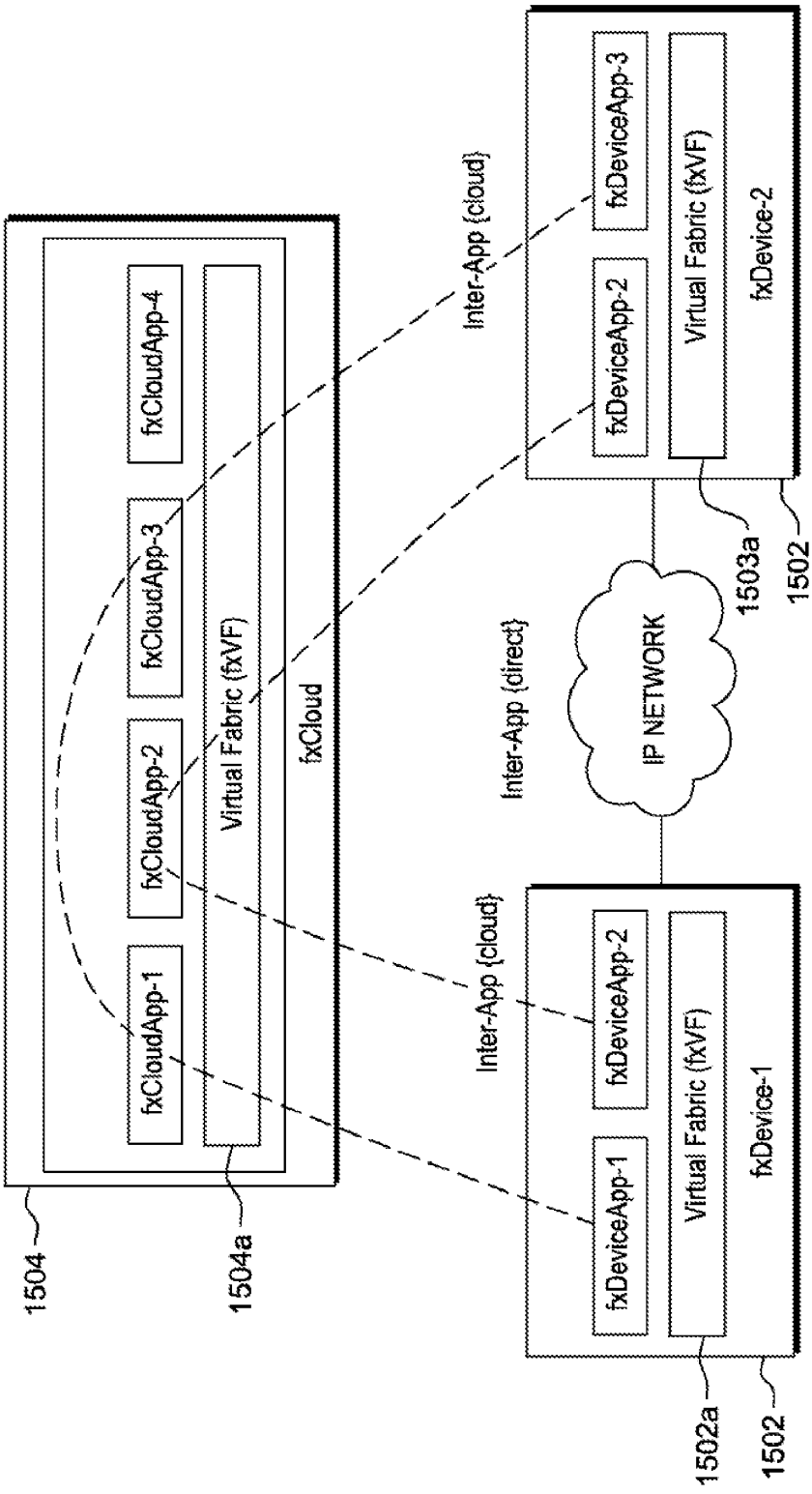

fxCloudApp-1
fxCloudApp-2
fxCloudApp-3
fxCloudApp-4
Virtual Fabric (fxVF)
fxCloud
1504
1504a
Inter-App {cloud}
Inter-App {direct}
IP NETWORK
fxDeviceApp-1
fxDeviceApp-2
Virtual Fabric (fxVF)
fxDevice-1
fxDeviceApp-2
fxDeviceApp-3
Virtual Fabric (fxVF)
fxDevice-2
1502a
1502
1503a
1502

FIG. 15

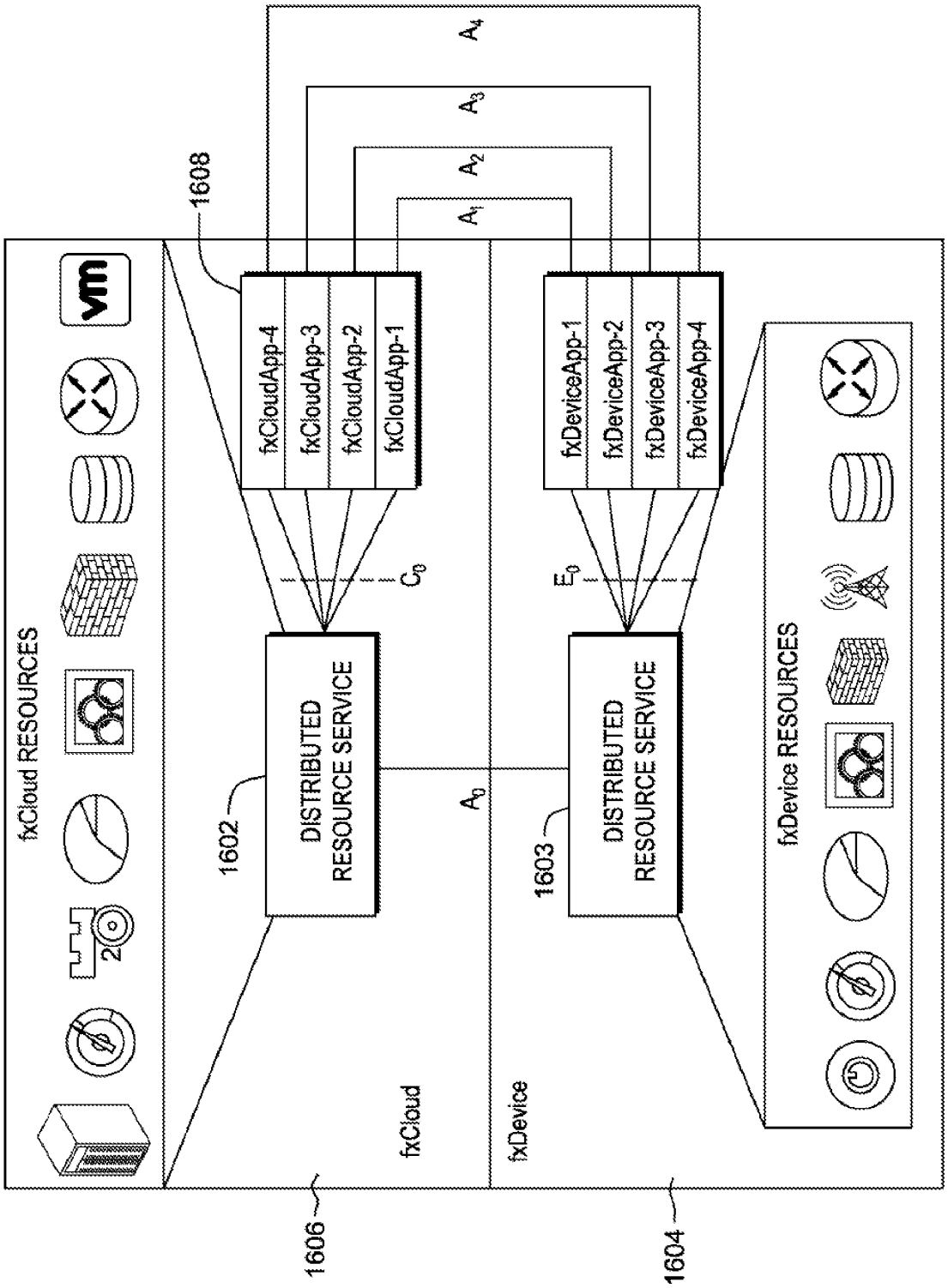

fxCloud RESOURCES
1608
fxCloudApp-4
fxCloudApp-3
fxCloudApp-2
fxCloudApp-1
fxDeviceApp-1
fxDeviceApp-2
fxDeviceApp-3
fxDeviceApp-4
A4
A3
A2
A1
A0
C0
E0
1602
DISTRIBUTED RESOURCE SERVICE
1603
DISTRIBUTED RESOURCE SERVICE
fxDevice RESOURCES
fxCloud
fxDevice
1606
1604

FIG. 16

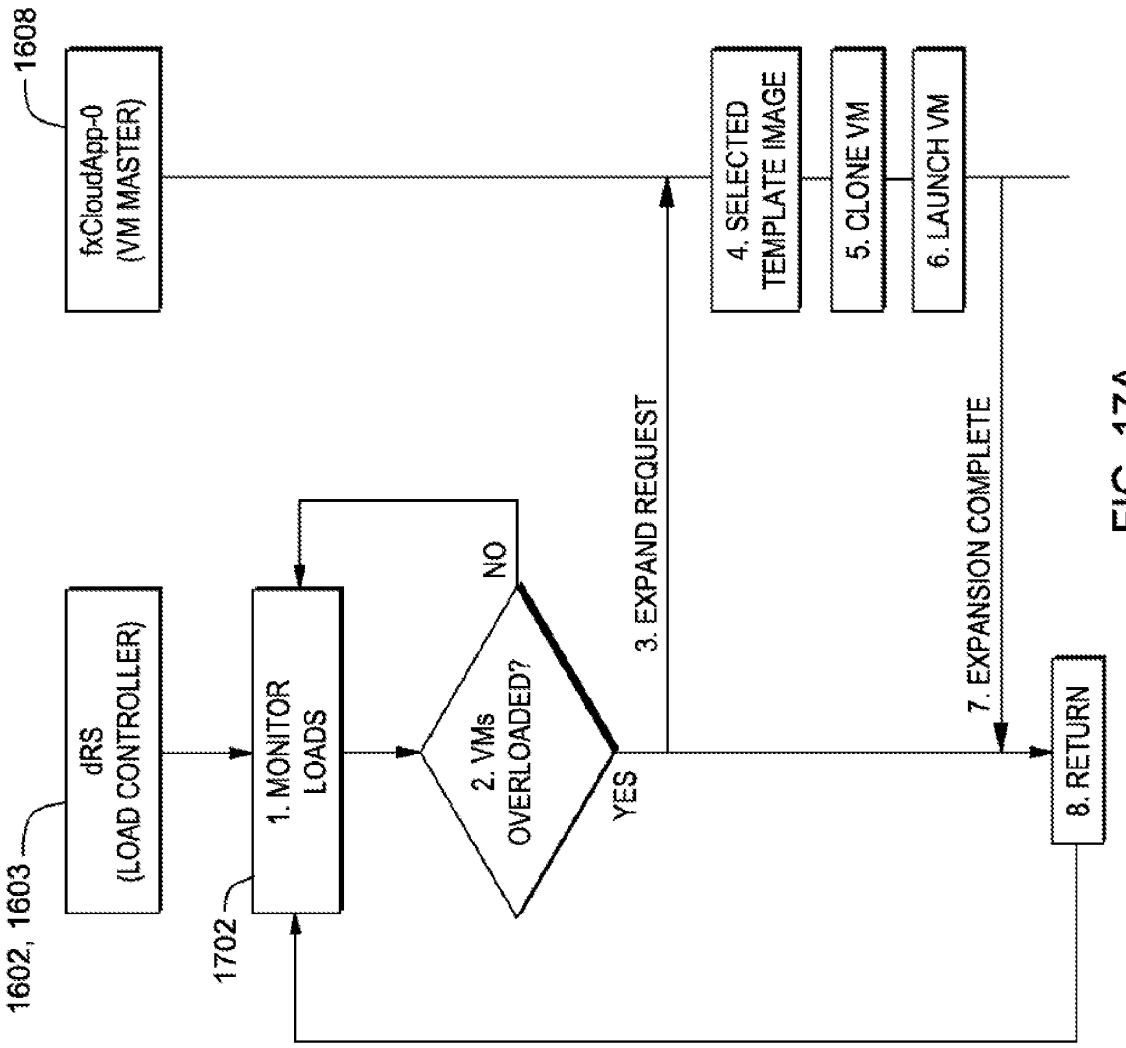

1608
fxCloudApp-0
(VM MASTER)
4. SELECTED
TEMPLATE IMAGE
5. CLONE VM
6. LAUNCH VM
3. EXPAND REQUEST
7. EXPANSION COMPLETE
dRS
(LOAD CONTROLLER)
1602, 1603
1. MONITOR
LOADS
1702
2. VMs
OVERLOADED?
NO
YES
8. RETURN

FIG. 17A

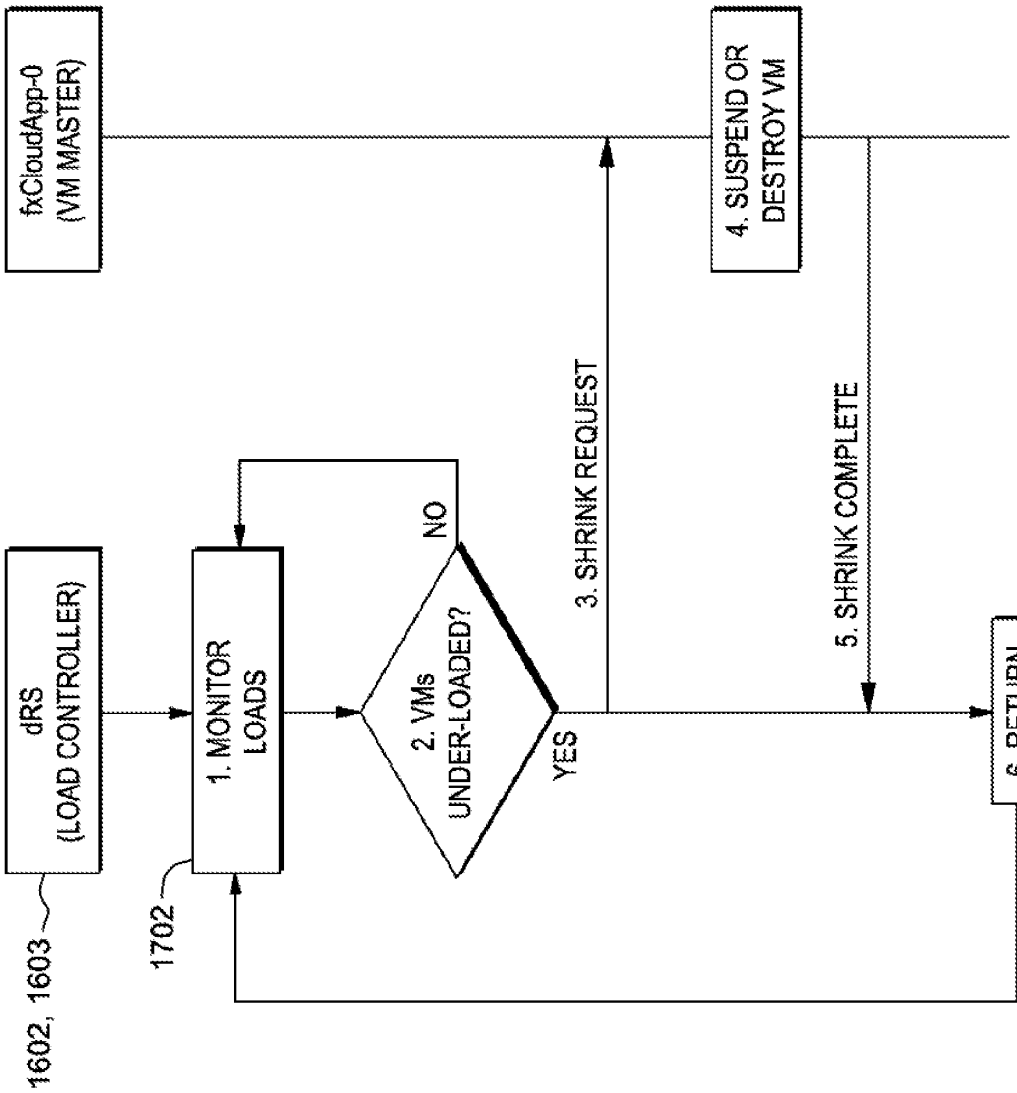

fxCloudApp-0
(VM MASTER)
4. SUSPEND OR
DESTROY VM
dRS
(LOAD CONTROLLER)
1. MONITOR
LOADS
2. VMs
UNDER-LOADED?
NO
YES
3. SHRINK REQUEST
5. SHRINK COMPLETE
6. RETURN
1602, 1603
1702

FIG. 17B

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Distributed Software Defined Networking

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Vivek Ramanna Date (Optional): June 2, 2014

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Distributed Software Defined Networking

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Pouya Taaghol Date (Optional): June 2, 2014

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

DISTRIBUTED SOFTWARE DEFINED NETWORKING

[0001] The present invention claims priority from U.S. Patent Appln. No. 16/900,963, filed on June 14, 2020; which claims priority to U.S. Patent Appln. No. 15/836,824, filed on 12/9/2017; which claims priority from U.S. Patent Application Ser. **No.** 14/295,331, filed June 4, 2014; which claims priority from U.S. Provisional Patent Application Serial No. 61/834,807, filed June 13, 2013; both of these disclosures are herein specifically incorporated by reference in their entirety.

FIELD OF THE **INVENTION**

[0002] This invention relates to a network architecture that facilitates secure and flexible programmability between a user device and across a network with full lifecycle management of services and infrastructure applications.

BACKGROUND

[0003] Existing network solutions are built on proprietary hardware and software. Network Operators & Information Technology (NOIT) can only configure the proprietary network infrastructure provided by vendors and are unable to add new and customized features or capabilities. As a result, the NOIT can only add new desired features by making such requests to their infrastructure vendors or pursuing standardization processes. But these existing approaches are time consuming and resourceintensive.

SUMMARY OF THE INVENTION

[0004] An aspect of the disclosure herein is a plurality of network elements in a packet system, said network elements comprising: a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp; a flexible cloud platform having at least one fxCloudApp, wherein the at least one fxDeviceApp and at least one fxCloudApp are in secure communication to form a distributed application; and an application management portal which manages life cycle of the distributed applications.

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[0005] Another aspect of the disclosure is a plurality of network elements in a packet system, said network elements comprising: a flexible cloud platform having a plurality of virtual machines, wherein each of the virtual machines has at least one fxCloudApp; and a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

[0006] Another aspect of the disclosure is a plurality of network elements in a packet system, said network elements comprising: a flexible cloud platform having a plurality of zones, wherein each of the plurality of zones has at least one fxCloudApp; and a flexible network device adapted to process data flows in the packet system having at least one fxDeviceApp, wherein the at least one fxDeviceApp and fxCloudApp are in secure communication to form a distributed application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 demonstrates the network architecture of a 4G system.

[0008] Figure 2 illustrates a network element (or system) upon which the Distributed Software Defined Network operates.

[0009] Figure 3 illustrates a Distributed Software Defined Network in accordance with the present disclosure.

[001O] Figure 4 is an exemplary view of the software layers in the Flexible Operation System (fxOS) Architecture.

[0011] Figure 5 illustrates the FastPath architecture.

[0012] Figure 6 presents a potential software layer of the fxOS co-existing alongside a general purpose OS.

[0013] Figure 7 is an exemplary view of the fxStore Portal.

[0014] Figure 8 demonstrates a shared fxCloud deployment.

[0015] Figure 9 demonstrates a Zoned Deployment.

[0016] Figure 10 demonstrates another deployment option as applied to cellular networks (especially Long Term Evolution (LTE)).

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[0017] Figure 11 shows an example of a signaling flow chart for thefxDevice Commissioning Procedure.

[0018] Figure 12 shows an example procedure for Application Provisioning.

[0019] Figure 13 presents the state machine for the application upgrade process.

[0020] Figures 14A-14C are examples of the Distributed Switch Controller during Upgrade.

[0021] Figure 15 shows how fxVF in the fxCloud and fxDevice.

[0022] Figure 16 demonstrates the logical interfaces between the platform resources and applications.

[0023] Figures 17A and 17B demonstrate example procedures for cloud breathing procedures.

DETAILED DESCRIPTION

[0024] The Distributed Software Defined Network (dSDN) disclosed herein is an architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

DEFINITIONS, ACRONYMS & ABBREVIATIONS

[0025] The following terms, acronyms, abbreviations and descriptions are explained below and are used throughout the detailed description of the dSDN:

TERM	DESCRIPTION
2G	2nd Generation Cellular Technology
3G	3rd Generation Cellular Technology
4G	4th Generation Cellular Technology
AP	WiFi Access Point
API	Application Programming Interface

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AR	Application Repository
ASIC	Application Specification Integrated Circuit
AuC	Authentication Center
BS	Base Station
BSC	Base Station Controller
BTS	Base Station
CON	Content Distribution Network
CN	Core Network
CNIE	Core Network Internet Edge
CPU	Central Processing Unit
dAP	Distributed Application Package
dApp	Distributed App
dCP	Distributed Content Service
dNS	Distributed Notification Service
DNS	Domain Name System
DPDK	Data Plane Development Kit
DPI	Deep Packet Inspection
dRS	Distributed Resource Service
DSCP	Differentiated Service Code Point (QoS)
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
EIR	Equipment Identity Register
eNB	Enhanced Node B (4G)
FIB	Flow Information Base
FQDN	Fully Qualified Domain Name
fxApp	FleXible Application, which has a fxDeviceApp and fxCloudApp component. fxDeviceApp and fxCloudApp of one application represent fxApp.
fxDeviceApp	FleXible Application which runs on fxDevice
fxBS	FleXible Base Station that is a BS that is powered by fxOS (an example of an fxDevice)

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fxCloud	FleXible Cloud that interacts with fxDevice and on other network elements on the northbound Interface
fxCloudApp	FleXible Cloud Application that is the application that runs on fxCloud and can be associated to one or more fxDeviceApp in fxDevice
fxManager	FleXible Manager that manager the fxOS lifecycle (provisioning, usage, de-provisioning)
fxOS	FleXible Operation System which run on the fxDevice as the OS and firmware
fxSDK:	FleXible Software Development Kit
fxSimulator	FleXible Simulator
fxStore	FleXible Store that presents fxApp to the network
administratorsGERAN	GPRS Edge Radio Access Network
GGSN	Gateway GPRS Support Node (used in core network of 2G/3G systems)uhu
GMSC	Gateway Mobile Switching Center
GPRS	General Packet Radio Service
GPS	Global Positioning System
GTP	GPRS Tunneling Protocol
GW	Gateway
HAL	Hardware Abstraction Layer
HD	High Definition
HLR	Home Location Register
HSS	Home Subscriber Server
IAC	Inter Application Communication

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IMS	IP Multimedia Sub-system
IMSI	International Mobile Subscriber Identifier
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
JVM	Java Virtual Machine
LA	Location Area
LAN	Local Area Network
LSP	Label Switching Protocol
M2M	Machine to Machine
MAC	Medium Access Control
MCP	Multi Chip Packaging
MIMO	Multi Input Multi Output
MME	Mobility Management Entity (used in core network of LTE)
MNO	Mobile Operator Network
MPLS	Multi Protocol Label Switching
MSC	Mobile Switching Center
MSISDN	Mobile Station
NAS	Non-Access Stratum
NB	Node B (3G)
NFC	Near Field Communication
NFV	Network Function Virtualization
NOIT	Network Operations & Information Technology; this term network broadly includes carriers, service providers, enterprise networks, and designated/contacted 3rd party administrators.

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OS	Operating System
OTT	Over the Top
P-GW	Packet Gateway
PaaS	Platform-as-a-Service
PBX	Private Branch exchange (telephony)
PDG	Packet Data Gateway
PON	Packet Data Network
PHY	Physical Layer
PLMN	Public Land Mobile Network
PnP	Plug and Play
pp	Packet Processor
PR	Platform Resources
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RA	Routing Area
RAN	Radio Access Network of cellular networks
RAPI	Resources API
RFID	Radio Frequency Identifier
RNC	Radio Network Controller
S-GW	Serving Gateway
S1-AP	S1 Interface Application Protocol (an LTE protocol between MME and eNodeB)
Saas	Software-as-a-Software
SOK	Software Development Kit
SON	Software Defined Network
SGSN	Serving GPRS Support Node (used in core

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	network of 2G/3G systems)
SIM	Subscriber Identity Module
SiP	System in a Package
SMS	Short Message Service
SoC	System on a Chip
SON	Self-Optimizing Network
SSDP	Simple Service Discovery Protocol
TA	Target Area
TNE	Test Network Environment
TTM	Time to Market
UMTS	Universal Mobile Telecommunication System
UPnP	Universal Plug and Play
URA	UMTS Routing Area
URI	Uniform Resource Identifier
UTRAN	UMTS Terrestrial Radio Access Network
VLR	Visitor Location Register
VM	Virtual Machine
VPN	Virtual Private Network
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WLAN	Wireless Local Area Network
XMPP	Extensible Messaging and Presence Protocol

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[0026] Database. One or more large structured sets of persistent datamaintained upon a computer system organized and structured according to a software system defining rules for organization as well as responding to queries to read, write, or modify data as well as provide statistical information regarding the contained data. As used in this disclosure in describing the dSDN, a database may be either a single unified system or a distributed system wherein certain database elements are located upon different systems or servers which may be in different physical locations, acting in harmony to appear as one unified database. Where databases are described, it will be understood by one of ordinary skill in the art that (i) alternative database structures to those described may be readily employed, and (ii) other memory structures besides databases may be readily employed. Any illustrations or descriptions of any sample databases presented herein are illustrative arrangements for stored representations of information. The database formats may include relational databases, object-based models and/or distributed databases which could be used to store and manipulate the data types described herein. Likewise, object methods or behaviors of a database can be used to implement various processes, such as the described herein. In addition, the databases may, in a known manner, be stored locally or remotely from a device which accesses data in such a database.

[0027] The term "determining" and grammatical variants thereof (e.g., to determine a price, determining a value, determine an object which meets a certain criterion) is used in an extremely broad sense. The term "determining" encompasses a wide variety of actions and therefore "determining" can include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" can include resolving, selecting, choosing, establishing, and the like. The term "determining" does not imply certainty or absolute precision, and therefore "determining" can include estimating, extrapolating, predicting, guessing and the like. The term "determining" does not imply that mathematical processing must be performed, and does not imply that numerical methods must be used, and does not imply that an algorithm or process is used.

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[0028] The functionality and/or the features of a single device that is described may be alternatively embodied by one or more other devices which are described but are not explicitly described as having such functionality/features. Thus, other embodiments need not include the described device itself, but rather can include the one or more other devices which would, in those other embodiments, have such functionality/features.

[0029] Devices that are described as in "communication" with each other or "coupled" to each other need not be in continuous communication with each other or in direct physical contact, unless expressly specified otherwise. On the contrary, such devices need only transmit to each other as necessary or desirable, and may actually refrain from exchanging data most of the time. For example, a machine in communication with or coupled with another machine via the Internet may not transmit data to the other machine for long period of time (e.g. weeks at a time). In addition, devices that are in communication with or coupled with each other may communicate directly or indirectly through one or more intermediaries.

[0030] Although process (or method) steps may be described or claimed in a particular sequential order, such processes may be configured to work in different orders. Further, some steps may be performed simultaneously despite being described or implied as occurring non-simultaneously (e.g., because one step is described after the other step) unless specifically indicated. Moreover, the illustration of a process by its depiction in a drawing does not imply that the illustrated process is exclusive of other variations and modifications thereto, does not imply that the illustrated process or any of its steps are necessary to the embodiment(s), and does not imply that the illustrated process is preferred. Where a process is described in an embodiment the process may operate without any user intervention.

[0031] It will be readily apparent to one of ordinary skill in the art that the various processes of the dSDN described herein may be implemented by, e.g., appropriately programmed general purpose computer(s), special purpose computer(s) and computing device(s). Typically a processor (e.g., one or more microprocessors, one or more microcontrollers, one or more digital signal processors) will receive instructions (e.g., from a memory or like device), and execute those instructions,

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thereby performing one or more processes defined by those instructions. Instructions may be embodied in, e.g., one or more computer programs, one or more scripts.

[0032] A "processor" means one or more microprocessors, central processingunits (CPUs), computing devices, controllers, microcontrollers, digital signal processors, or like devices or any combination thereof, regardless of the architecture (e.g., chip-level multiprocessing/multi-core, Reduced Instruction Set Computer (RISC), Complex Instruction Set Computer (CISC), Microprocessor without Interlocked Pipeline Stages, pipelining configuration, or simultaneous multithreading).

[0033] Further, programs that implement methods described herein may be stored and transmitted using a variety of media (e.g., computer readable media) in a number of manners. In some embodiments, hard-wired circuitry or custom hardware may be used in place of, or in combination with, some or all of the software instructions that can implement the processes of various embodiments. Thus, various combinations of hardware and software may be used instead of software only to implement the embodiments.

[0034] The term "non-transitory computer readable medium" in this disclosure refers to any medium, a plurality of the same, or a combination of different media, that participate in providing data (e.g., instructions, data structures) which may be read by a computer, a processor or a like device. Such a medium may take many forms, including but not limited to, non-volatile media, volatile media, and transmission media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include dynamic random access memory (DRAM), which typically constitutes the main memory. Transmission media may include coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to the processor. Transmission media may include or convey acoustic waves, light waves and electromagnetic emissions, such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of non-transitory computer-readable media in which the dSDN may be implemented include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper

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tape, any other physical medium with patterns of holes, a Random Access Memory (RAM), a programmable read only memory (PROM), an erasable programmable read only memory (EPROM), a flash electrically erasable programmable read only memory (FLASH-EEPROM), any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read.

[0035] Various forms of computer readable media in this disclosure may be involved in carrying data (e.g. sequences of instructions) to a processor. For example, data may be (i) delivered from RAM to a processor; (ii) carried over a wireless transmission medium; (iii) formatted and/or transmitted according to numerous formats, standards or protocols, such as Ethernet (or IEEE 802.3), Bluetooth, and Transmission Control Protocol/Internet Protocol ("TCP/IP"), Time Division Multiple Access (TOMA), Code Division Multiple Access (CDMA), and 2G/3G; and/or (iv) encrypted to ensure privacy or prevent fraud in any of a variety of ways well known in the art.

[0036] Thus in some embodiments in this disclosure a description of a process may be a description of a non-transitory computer-readable medium storing a program for performing the process. The computer readable medium may store (in any appropriate format) those program elements which are appropriate to perform the method.

[0037] In an embodiment, a server computer, network element orcentralized authority may not be necessary or desirable. For example, an embodiment may be practiced on one or more devices without a central authority. In such an embodiment, any functions described herein as performed by the server computer or data described as stored on the server computer may instead be performed by or stored on one or more such devices.

[0038] In interpreting the present application (which includes the claims), one of ordinary skill in the art shall refer to the prosecution history of the present application, but not to the prosecution history of any other patent or patent application, regardless of whether there are other patent applications that are considered related to the present application, and regardless of whether there are other patent applications that share a claim of priority with the present application.

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[0039] Numerous embodiments are described in the present application, and are presented for illustrative purposes only. The described embodiments are not, and are not intended to be, limiting in any sense. One of ordinary skill in the art will recognize that the disclosed embodiment(s) may be practiced with various modifications and alterations, such as structural, logical, software, and electrical modifications. Although particular features of the disclosed invention(s) may be described with reference to one or more particular embodiments and/or drawings, it should be understood that such features are not limited to usage in the one or more particular embodiments or drawings with reference to which they are described, unless expressly specified otherwise.

[0040] The present disclosure is not a literal description of all embodiments of the invention(s). Also, the present disclosure is not a listing of features of the invention(s) which must be present in all embodiments. A description of an embodiment with several components or features does not imply that all or even any of such components/features are required. On the contrary, a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention(s).

[0041] The following description has been presented for purposes of illustration and description and is not intended to be exhaustive or to limit the embodiments to the precise form disclosed. Many modifications and variations are possible in light of the teachings disclosed herein.

[0042] The embodiments were chosen and described to explain principles of operation and their practical applications. However, the scope of the invention is to be defined by the claims.

[0043] The major technical reason for inflexibility in network infrastructure has been related mostly to the proprietary hardware and rigid software architecture in the existing network elements (routers, switches, gateways, cellular base-stations, WiFi access points, etc.). With recent advancements in semiconductor device manufacturing, there is no longer a cost barrier to add computing power to many electronics in the market including networking infrastructure. The addition of such compute capabilities would open up new opportunities for programmable platforms in the network and ultimately creating more flexible network architecture

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and business models.

[0044] The Distributed Software Defined Network (dSDN) disclosed herein is an end-to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and applications (fxApp). The dSDN also harmonizes fxApp deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning. In this disclosure, the dSDN is applied to the wireless networks as an exemplary embodiment. However, the dSDN is not limited to wireless networks embodiments and it could be applied to many other network types including enterprise, wireline service providers, data centers, and Internet of Things (IoT).

[0045] Figure 1 demonstrates the network architecture of a 4G system 100. (In alternative embodiments, the system and method disclosed may also be implemented in a 2G/3G network as well). In a cellular network, the base station or BS (denoted as BTS in 2G, NodeB or NB in 3G, and eNodeB or eNB in 4G systems) is responsible for termination of a wireless link (air-interface) to the mobile device (also known as the User Equipment (UE)). The BS thentransports the user data to the core network and communicates control-signaling messages with the core network. In a typical cellular network, there are thousands of BS's covering nations. Each BS covers an area known as a cell. As the demand for mobile Internet expands, the mobile network operator (MNO) needs to deploy smaller cells so it can reuse the frequency more often.

[0046] A BS is made up of the following main functional blocks: 1) radio frequency (RF) front end; 2) clock; 3) baseband; 4) power manager; and 5) central processing unit (CPU). Some BS's also have a dedicated packet processor (PP) to accelerate packet processing in hardware. BS vendors may also use custom or merchant System-on-a-Chip (SoC) or Multi-Chip-Packaging (MCP) solutions to combine various functions into a single chip (e.g., PP, CPU, and baseband).

[0047] Even though there has been attempts to open up various interfaces in the BS (such as the Open BS Architecture Initiative that defines interfaces between these functional modules in the BS), there has been very little to no efforts to unify the

programmability of the BS itself. As a result, the MNOs suffer from the following difficulties. First, the core network Internet edge (CNIE), Packet Data Gateway (PDG) and the surrounding functions are becoming extremely complicated, non scalable, and expensive. Second, each MNO needs certain customization and feature sets. Currently, they depend on their vendors for these customizations, which could cost the MNO tremendously both financially and in regards to time-to-market (TTM); hence, hindering innovation. In addition, usually these features are put into standards or in the vendor's feature set, thus eliminating the MNO differentiation against the other MNOs. Third, if the MNO is multi-vendor in their CNIE, coordinating all the vendors to implement the same features is usually a difficult and a time-consuming effort. As a result, more add-on network appliances are introduced into the CNIE which adds to the network management complexity. Fourth, as a BS becomes Internet Protocol (IP) based, there is more visibility into the user traffic types and new innovative opportunities are missed for creative traffic shaping features, backhaul bandwidth optimization, prioritization at radio edge, power management algorithms, etc. Fifth, many features implemented in CNIE present suboptimal performance. For example, the filtering enforcement at CNIE is fundamentally inefficient since the packets have to travel all the way through the expensive air interface, the backhaul, various other core network elements and transport networks to get to the CNIE. Sixth, the Radio Access Network (RAN) deployments are a very expensive endeavor for MNOs. The current rigid BS designs limit innovation and force the MNOs to undergo major upgrades every few years.

[0048] The problems stated above apply to many different types of networks even though here they are presented in cellular networks as a focus. In the present disclosure, the dSDN exhibits a new paradigm in the software programmability of networks that would address the problems above and enable many more advanced features.

[0049] The dSDN may be located at a network element (or system) 200 which is shown in detail in Figure 2 or in alternative embodiments the functions of the dSDN may be divided among a plurality of network elements (or systems) which are similar in structure to network element 200. Each network element 200 may comprise one or

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more system control logic 202 coupled with at least one or a plurality of processor(s) 204, system memory 206, a network interface 208 (including a transceiver 208a), and input/output (1/0) devices 210. The processor(s) 204 may include one or more single core or multi-core processors. The processor(s) 204 may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, baseband processors, etc.). System control logic 202 for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) 204 and/or to any suitable device or component in a packet network in communication with system control logic 202. System control logic 202 for one embodiment may include one or more memory controller(s) to provide an interface to system memory 206. System memory 206 may be used to load and store data and/or instructions, for example, for network element 200. System memory 206 for one embodiment may include any suitable volatile memory, such as suitable dynamic random access memory (DRAM), for example. System memory 206 may also include non-volatile memory including one or more tangible, non-transitory computer-readable media used to store data and/or instructions, for example, such as the embodiments described herein with regard to the **dSDN.** The non-volatile memory may include flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disk (CD) drive(s), and/or one or more digital versatile disk (DVD) drive(s). The system memory 206 may include a storage resource physically part of a device on which the network element 200 is installed or it may be accessible by, but not necessarily a part of, the device. For example, the system memory 206 may be accessed over a network via the network interface 208 and/or over Input/Output (1/0) devices 210. Network interface 208 may include a transceiver 208a to provide a radio interface for network element 200 to communicate over one or more network(s) and/or with any other suitable device. Network interface 208 may include any suitable hardware and/or firmware. The network interface 208 may include a plurality of antennas to provide a multiple input, multiple output radio interface. Network interface 208 for one embodiment may include, for example, a wired network adapter, a wireless network adapter, a telephone modem, and/or a wireless modem. For one

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embodiment, at least one of the processor(s) 204 may be packaged together with logic for one or more controller(s) of system control logic 202. For one embodiment, at least one of the processor(s) 204 may be integrated on the same die with logic for one or more controller(s) of system control logic 202. In various embodiments, the 1/0 devices 210 may include user interfaces designed to enable user interaction with the network element or system 200, peripheral component interfaces designed to enable peripheral component interaction with the network element or system 200, and/or sensors designed to determine environmental conditions and/or location information related to the network element or system 200. In various embodiments, the peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface.

dSDN Architecture

[0050] In the dSDN architecture, the network features are virtualized and may be distributed across separate network elements that cooperate together to create an advanced, programmable, and scalable network. In an alternative embodiment, the network features may be located at a single network element. A high-level overview of a dSDN system 300 is depicted in Figure 3. The dSDN system 300 consists of a flexible network device (fxDevice) 302, a flexible cloud platform (fxCloud) 304, an application management portal (fxManager) 306, and an infrastructure application market place(fxStore) 308. The fxDevice 302 is a network device that is powered by a sandboxing operating system named flexible operating system (fxOS) 302a. The sandboxing operating system ensures each application runs as a dedicated process in sure isolation from the other applications. The fxOS 302a may be built based on an existing sandboxed operating system (OS) (e.g., Android®) by extending several aspects of such an OS with routing/networking layers and supports for operating as the wireless infrastructure. The fxDevice 302 may host several independent and securely isolated applications (on top of fxOS 302a) named here fxDeviceApp 302b.

[0051] In the dSDN system, fxDeviceApp 302b may have a sister app in the backend cloud infrastructure (i.e., flexible cloud platform 304) referenced here as fxCloudApp 304a. The fxCloudApp 304a in the cloud is paired with its fxDeviceApp 302b in the fxDevice 302. The fxCloudApp 304a and the fxDeviceApp 302b

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collectively form a distributed application (dApp or fxApp). In this description, when fxDeviceApp is referenced it shall mean any application that may have software components in the fxDevice, fxCloud, or both. In general, an fxApp package may include the following software components:

fxDeviceApp binary;

fxCloudApp binary;

Manifest files; and

Signatures.

[0052] It is important to note that the fxDeviceApp 302b and fxCloudApp 304a could use any protocol to communicate with each other and there is no need for standardizing this communication allowing for ultimate freedom for the developers. This allows for the system to operate in a loosely coupled autonomous fashion allowing for asynchronous communication in a distributed fashion.

[0053] The fxApps lifecycle is managed via fxManager 306. The fxManager 306 presents a user-friendly portal to the network administrator (admin) to discover, test prior to deployment, provision, and deprovision dApps. Using fxManager 306, the admin may discover new fxApps from the fxStore 308, which presents all the tested and certified vApps as well as showing the supported fxOS version, support hardware platforms, and other information such as reviews and number of commercial deployments by all NOIT customers.

fxOS

[0054] fxDevice 302 is defined as any networking equipment embedded with a special flexible operating system (fxOS) 302a. The purpose of fxOS 302a is to enable a carrier-class programmable platform. The fx:OS 302a is configured to do, but is not limited to, the following. First, since fxOS 302a is designed for network equipment, it allows for efficient execution and running all the time. A plurality of power save modes may be implemented to ensure energy saving schemes without hindering the functionality of the fxDevice 302. Second, it enables simultaneous execution of several flexible applications (fxDeviceApp 302b) on the fxDevice 302. Third, it allows for application of a legacy compiled binary or byte-code of another language (for example, Java or Android®) in addition to fxDeviceApps 302b. Fourth, it allows

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FastPath processing for data plane packets. The packet forwarding in this case separated from the control plane operations. The FastPath engine allows integration with specialized hardware accelerators or packet processors (PP). The packet forwarding may be implemented with software/kernel enhancements all in software. Another FastPath implementation may use both software/kernel enhancement and hardware packet processors (PP). Fifth, the fxOS 302a is capable of Deep Packet Inspection (DPI) and identifying all the flows and their related protocols, services and present this information in a format useful to application developers. The fxOS 302a can act on the data flows as the directed by the application developer. Sixth, applications are securely isolated from each other and to communicate with them is completely configurable by policies defined by the admin. Seventh, resource utilization of each application is policed such that an application may not be able to exceed its usage. For example, an application is pre-allocated the memory size, cache/storage space, and CPU cycles. Eighth, the applications may be signed with unique certificate security keys. The security keys and certificates may be allocated and/or signed by a certificate authority. The fx:Device 302 may be protected by validating signed applications to run or to install in the device. Ninth, it allows hot upgrade of the software and applications on the platform with little to no interruption to the operational aspect of the platform and its applications. Tenth, the fxOS 302a may boot by using the secure code from the network servers (cloud-booting). This would ensure tamper-proof software foundation for the fxDevice 302. Eleventh, there may be a secure and programmable firewall in the fxOS 302a. This embedded firewall protects against attacks to the fxDevice 302 and network attached to the network. The fx:OS 302a firewall may be configured by the developer and it does allow replacing of attack detection algorithms (e.g., man-in-the-middle detection algorithm). The fxOS 302a may allow secure caching of user data, web pages, and media files (video and audio) in the fxDevice 302. The secure connections to the cloud (fxCloud 304) can enable sharing and control of the caching between the fxCloud 304, fxDevice 302, or the rest of the network. Twelfth, the fxOS 302a can support multi-threading and multi-core CPUs. This feature may dynamically distribute the threads to various CPU core without developers assistance.

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[0055] The fxOS 302a allows secure connection to the fxCloud 304. This secure connection allows communication between fxDeviceApps 302b in the fxDevice 302 and fxCloudApp 304a in the fxCloud 304. The fxOS 302a controls the access of applications to platform APIs. An application is categorized into an Access Level (AL) based on which the fxOS 302a decides that the application does not exceed its AL and access APIs that it is not authorized. The fxCloud 304 and the fxOS 302a create a virtual fabric (fxVF) for messaging between applications. The actual message can travel directly between two fxDevices or it may traverse the fxCloud 304. The messaging complexity may be abstract for the developer.

[0056] Figure 4 demonstrates an examplary view of the software layers in the fxOS 302a. Each layer of this software stack is modified and redefined to optimize for embedded networking equipment of wireless and wireline nature. Starting from the bottom of the stack, the kernel also connects to the hardware resources via the device drivers. Examples of such resources are wireless baseband SoC402, hardware packet processor 404, Wide Area Network (WAN) uplink interface 406, cache and storage 408, and multi-core CPU 410. The OS kernel 412 is enhanced with the FastPath function 414 to accelerate packet processing (by help of hardware features such as Intel's Data Plane Development Kit (DPDK) or pure software enhancements) and other related data path functions. The enhanced kernel with FastPath 412,414 would enable visibility into the data flows, sniffing the Non-Access Stratum (NAS) signaling (which is the signaling between the UE and the Core Network and the RAN is supposed to be transparent to), policy enforcements, regular packet forwarding functions, collection offlow statistics into Flow Information Base (FIB), and encryption/decryption functions.

[0057] Above the kernel, there are several tools 416, native daemons 418, native libraries 420 and Hardware Abstraction Layers (HAL) 422. These tools abstract out the hardware dependencies for the upper layers and programmers. The Runtime 424 is an embedded virtual machine capable of securely isolating and executing the applications. System Services 426 are a set of services always running and available to the developers (e.g., timing and messaging services).

[0058] fx-Framework Library 428 consists of several Frameworks. The new

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frameworks are the library extensions introduced explicitly for the dSDN framework. Each of these frameworks adds a set of methods of (functions) and data structures for the following examples:

Wireless Manager 428a: manipulation, monitoring, and configuration of the wireless interfaces;

System Manager 428b: configuration, provisioning, and changing major settings of the fxDevice 302;

Flow Controller 428c: allows for manipulation of data path, tunneling, switching, and optionally coordinate this activity with fxCloud 304;

Energy Management 428d: enables fine-grained control over various elements in the fx:Device 302 that could be moved into various power stares, for example: ON, OFF, SLEEP, SUSPEND;

Big Data Manager 428e: manipulation, processing, and organization ofdata collected from various elements. This framework could enable close coordination between the fx:Device 302 and thefxCloud 304;

Content Manager 428f: for data sharing (database sharing) between the applications within the fxDevice 302 or the fxCloud 304 and between applications in fxDevice 302 and fxCloud 304. The Content Manager 428f may use URI to address the contents to be shared. The Content Manager 428f allows access to the application data according to the policy settings and permissions;

Policy Manager 428g:_responsible for execution and implementation of polices set up by the admin. The application developers could use this framework to perform queries about the permissions, limitations, and rules;

Security Manager 428h: allows for access to the security protocol libraries and rewriting some of security algorithms such as the man-in-the-middle detection algorithm;

General Framework: general compute and logic building that may be

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inherited from existing general OS frameworks.

[0059] Using the frameworks, there are potentially at least two types of application types that are possible. First, the System Native Applications 430 that are provided as the initial application load into the platform. These applications could be used by other applications by links or API. Second, the fxDeviceApps 302b that are written by third party developers or the NOIT.

[0060] Figure 5 further details the FastPath 414 architecture. In this approach, the FastPath 414 is divided into the Virtual Switch (data-plane) 502 and the Switch Controller (control-plane) 504. Such separation makes possible flexible deployment wherein the function of the Switch Controller 504 could move to the fxCloud 304 by an admin decision or by the dSDN system intelligence for example in the case of failure, redundancy, stateful reboot, or Hot Upgrade. The Virtual Switch 502 may include several functions and may interact with the Switch Controller 504 in the following exemplary ways:

Firewall 502a: implements the policies given to it by the firewall logic 504a in the fxOS Daemons.

Flow/NAS Discover 502b: continuously monitors data packets and discovers new flows and NAS signaling. It would then report it to the DPI Logic 504b where the flow intelligence resides and matching to meta-data happens. DPI Logic 504b in turn updates the Flow Information Base Information (FIB) 502c of the Virtual Switch 502.

FastPath & DPI Processing 502d: forwards, routes packets, and performs DPI functions as instructed by the FIB 502c. It also collects statistics of packets and reports them to the Monitoring Logic 504c.

Policy Enforcement 502e: this function enforces various policies on the traffic such as QoS marking according to the policies received from the Policy Logic 504d.

Shaper 502f: this function could shape (queue) the traffic according to the available bandwidth on the uplink or WAN interface.

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Virtual Fabric (fxVF) 504e: enables transparent switching of application and system messages of a dApp between the fxCloud 304 and the fxDevice 302 and between different dApps. The fxVF 504e is an abstraction layer that hides most of the complexities of messaging from the developers. The fx:VF 504e uses the policies and firewall rules to enforce security and policies.

[0061] The fxOS 302a is mostly used for networking applications. There are some potential use cases where there is a need for a general purpose OS to run the legacy software applications with no need of recompilation. An example of a double OS situation may be where a digital signage (using a general purpose OS such as Android®) in a shopping mall also acts as a smart small-cell (using the fxOS 302a). In such a solution, any existing Android®application (for example) could be loaded in the fx:Device 302 and in parallel networking applications (fxDeviceApps 302b) could run on the same fxDevice302.

[0062] Figure 6 presents a potential software layer of the fxOS 302a co-existing alongside a General Purpose OS 602. Another implementation may be a standalone fxOS without the company of another general OS. It is important to note that the shown co-existence allows reuse of the kernel so there would be no need to re-port the drivers of hardware resources twice.

fxCloud

[0063] The fxCloud 304 is an integral part of the dSDN framework. The fxCloud 304 connects to various parts of the fxDevice 302 to form a single virtual view of the system. Examples of the main fx:Cloud 304 responsibilities include the following. First, it interacts and manages all applications, firmware, and fxOS 302a in the fxDevice 302. Second, it secures isolation environments for distributed apps. Third, it directs the Virtual Machine lifecycle management including load-linked VM creations and destruction (Cloud Breathing). Fourth, the fxCloud 304 executes instructions defined by the fxManager 306. Fifth, it implements uniform policy (including security) distribution and execution across dSDN 300 (including the fxDevice 302, fxDeviceApps 302b, fxCloudApps 304a, anddApps). Sixth, Plug-and-Play commissioning of thefxDevice 302 introduction

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and network expansion. Seventh, Distributed Resource Service (dRS) by which distributed applications can seamlessly communicate and message to each other using published APIs or proprietary methods within the pre-defined policies. Eighth, security violation discovery and alert system. Ninth, translation and/or exposure of Resources APIs (RAPI) to the systems outside the dSDN 300 within pre-defined policies. Tenth, fxCloud 304 in coordination with the fxDevice 302 creates a Distributed Notification Service (dNS) across the dSDN 300 by which the applications could be notified of an event to wakeup and/or respond to the event. Eleventh, fxCloud 304 in coordination with thefxDevice 302 creates a Distributed Content Management Service(dCMP)which provides a virtualized and distributed database system for applications to share application-specific or system-specific information with the pre-defined policies. Twelfth, the Switch Controller 504 function in the fxCloud 304 could take control of the controller function of the fxOS 302a in the fxDevice 302. This would allow controller switching from local to remote and back. Examples of such a configuration is a temporary reason where the fxOS Switch Controller 504 may not be available during reboot or software upgrade.

[0064] In the discussion below, these services and features are expanded upon.

fxDeviceApp-0 & fxCloudApp-0

[0065] The fxDevice 302 and fxCloud 304 have embedded System Applications categorized as fxDeviceApp-0 and fxCloudApp-0, respectively. ThefxDeviceApp-0 is responsible for all default and core functional capabilities of the fxDevice 302 as listed below:

Firmware of thefxDevice;

Default communication protocols (e.g. LTE S1-AP, baseband software, security protocols, GTP, DNS, tunneling protocols);

Message communication protocol between the fxDevice and fxCloud;

Initial fxDevice settings;

Boot Loader;

fxDevice X.509 digital certificate;

OS and Kernel upgrades;

Upgrade and commissioning agents for the fxDeviceApp-0 upgrades and related procedures;

Establishing and initiating the message communication protocol between the fxDevice and fxCloud;

General fxDeviceApp install and upgrades;

Access to fxDevice hardware and software information.

The fxCloudApp-0 is responsible for all default and core functional capabilities of the fx:Cloud 304 such as:

Upgrade and commissioning agents for the fxCloudApp-0 upgrades and related procedures;

Hypervisor upgrades;

Virtual Machine lifecycle management (e.g.creation, suspension, destruction);

fxCloud X.509 digital certificate management;

OS and kernel upgrades;

General fxCloudApp install and upgrades;

Default communication protocols (e.g. security protocols, DNS, tunneling protocols).

Each software component can be managed and updated individually. To simplify the management of these software components, each software components can be sub-numbered such as fxDeviceApp-0.1, fxDeviceApp-0.2, fxCloudApp-0.1, fxCloudApp-0.2, etc.

fxManager

[0066] The network administrator may use the fxManager 306 to control much of the dSDN system 300. The fxManager portal could use HTML5, for example, as

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a frontend technology. The major functions of the fx:Manager 306 may include the following.

fxDevice Management:

Commissioning (plug-and-play), de-commissioning, firmware/OS upgrading/downgrading;

Suspend/resume functions;

Unification of zones and partitions for example in case of network merger;

Detailed management of fxDevices (remote secure login) where the administrator may zoom into a particular or a group offxDevices to monitor and setmanagement alarms;

Security policy setting.

Application lifecycle management: fxManager 306 may work, coordinate, and/or perform these tasks in conjunctions with fxCloud 304 for:

Provisioning, de-provisioning, upgrade/downgrade applications. Some applications may only have a fxDevice component (Device Centric Apps), may only have fxCloud component (Cloud-Centric Apps), or may have both fxDevice and fxCloud components (Hybrid Apps);

Creating a Test Network Environment (TNE) where the administrator can test certain configuration and applications without impacting the production networks;

Uploading applications developed by the NOIT or their partners into the Application Repository (AR). The AR is placeholder where the application packages are downloaded and stored for testing and verification prior to installation into the live dSDN system. An application could have several components (e.g. fxDeviceApp binaries, fxCloudApp signatures, manifest files, signatures) bundled together to form the Distributed Application Package (dAP);

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Browsing through the certified applications in the fxStore and downloading them to theAR;

Application license accounting services by which a secure and accurate accounting of the installed applications are performed regularly. This inventory management function allows the administrator and the 3rd party ISV toaccount for live and active instants of the software in the network;

Application review tool where the network admin could use to review feedbacks and comments of other NOIT (maybe anonymous reviews) and could input his/her reviews for others (maybe anonymous reviews).

fxCloud Management:

Zoning and partitioning the network for administrative purposes. Zones and partitions could optionally put into different Virtual Machine (VM);

VM load management and Cloud Breathing policies;

The configuration conflict resolutions. Some configurations applied to the resources may conflict with each other (e.g., one firewall rule may state drop Netflix packets explicitly and another rule may state allowing Netflix explicitly). The fxCloud resource manager could monitor these configurations and discover the conflicts and signal those to the networkadministrator.

Security Management:

Security policy setting;

Inter-App communicationsetting;

Security of communication between fxDevice and fxCloud;

API Access Level (AL) definitions and (re-)assignment to the applications (permissions);

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Risk Analysis of the applications;

Certificate and signature verification of the applications;

Content sharing between applications and associated policies.

[0067] An fxManager Portal per the above description may have an "Account" button which can be used to create admin users and their privileges. The fxManager Portal could also include a geographical map illustrating locations of fxDevices and their status. The fx:Manager 306 functions could be integrated into other network management tools. The fxManager 306 could potentially build the inventory of the network devices (fxDevices) showing all the available devices and statistics. As described above, the network administrator could optionally procure the applications a third party hosted application store (fxStore). The fxStore 308 could potentially categorize the applications several groups (as shown in Figure 7 which is an example view of the fxStore portal). The fxStore 308 could also show the reviews of the advertised applications. In order to maintain quality, the third party fxStore 308 may perform rigorous testing of the applications and accompany those results with the advertised application.

fxSDK

[0068] The flexible Software Development Kit (fxSDK) may include a development environment and other tools to facilitate development, testing, debugging and verifications of applications for dSDN environments. The fxSDK is unique in several aspects exemplified as follows. First, since the dSDN applications may have a device component (fxDevice 302) and cloud component (fxCloud 304), the fxSDK allows the developer to develop the components together to simplify the development and testing. Second, the dRMS offers various system level APIs with remote accessibility. In other words, the APIs in the fxDevice 302 could be accessed via the applications in the fxCloud (fxCloudApps) and vice versa. The fxSDK simplifies the usage system created APIs and application created APIs. Third, it is essential for the dSDN to ensure quality and security of applications in the network. The fxSDK may be accompanied with an extensive Risk Analysis Utility (RAU) which verifies all the APIs that are being used by the application and based on its potential danger to the

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network, it would show the risk analysis and may make specific suggestions to reduce the risk. Once completed, the risk analysis result is included in the dAP for posting to the fxStore and consumed by the fxManager user (the admin). Fourth, the fxSDK would also ensure that the applications do not exceed their planned memory and resource usage. Fifth, the Integrated Development Environment (IDE) may provide various tools to actively demonstrate errors, defined APIs, security dangers, and excessive resource usage. Sixth, the IDE could also provide a flexible Simulator (fxSimulator) for the developer test the application in a network setup in presence of other network elements.

Deployment Examples

[0069] The dSDN 300 offers flexible deployment options. In this section, a few exemplary embodiments are presented.

[0070] Figure 8 demonstrates a shared cloud deployment where several NOITs (802,804,806) share an fxCloud 808. In order to ensure complete isolations, each NOIT may be assigned a separate Virtual Machine (VM) 802a, 804a, 806a. A good example of this deployment option may be when multiple service providers outsource their fxCloud deployment to a third party vendor that offers a SaaS/PaaS solution. It is important to note that in this option, each NOIT should have its own secure instance of the whole system. This option could potentially create a full outsourcing model for network operations including possibilities of seamless merging of networks of two or more NOITs.

[0071] Another deployment option may be a Zoned Deployment as shown in Figure 9. In this option, a large NOIT may partition their network into a plurality of zones (Zone #1, Zone#2,... Zone#n) for administrative, software compatibility grouping, or other reason. For example, it is possible that in a large network deployment, there would be different versions of fxOS with varying capabilities in the network (the older hardware may not support newer fxOS version). In this case, the service provider may decide to group the fxDevices per fxOS versions for management simplifications.

[0072] Figure 10 is another embodiment deployed in a Programmable & Virtualized Cellular Network. In this example, the dSDN is applied to the cellular

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networks (e.g., LTE). As shown, the fxDevice 1002 here is the LTE eNB (4G base-station) and the fxCloud 1004 hosts the LTE core network (EPC) functions such as MME, S-GW, and P-GW in separate VMs. Within each EPC function, new features could be added using the dSDN framework. For example, a new application to optimize signaling for Machine-2-Machine (M2M) devices could be loaded into the fxDevice 1002 and the MME function in the fxCloud 1004.

PRINCIPAL PROCEDURES & SERVICES

[0073] The dSDN framework could offer extensive services and capabilities that would simplify the programmability of the network. In this section below, a set of main procedures and services are presented as further exemplary embodiments.

fxDevice Commissioning Provisioning

[0074] Figure 11 illustrates a signaling flow chart fora fxDevice Plug-and-Play Commissioning Procedure. This procedure enablesfxDevice commissioning and initial setup to provide a seamless and Plug-and-Play (PnP) deployment. The fxDevice relies on the fxDeviceApp-0 and the fxCloudApp-0 to connect to the backend management system and perform the commissioning procedure. In step 1101, the fxDevice 1120 tries to discover the fxManager 1130 using the fxManager Fully Qualified Domain Name (FQDN). The fxDevice 1120 is configured to always look for the same FQDN. If the NOIT has a private cloud deployment, the DNS server in the NOIT will be configured to point to its own fxManager IP address. If the cloud is shared, the NOIT will configure their DNS server to point to the shared cloud IP address. In step 1102, the fxDevice 1120 receives the IP address of the fxManager 1130. In step 1103, the mutual authentication may be performed where the fxDevice 1120 authenticates the fxManager 1130 and vice versa. In step 1104, a secure tunnel may be created between the fxDevice 1120 and the fxManager 1130. In step 1105, the fxDevice 1120 may optionally request for the latest firmware/OS version. In this phase, the fxDevice 1120 informs the fxManager 1130 of its hardware information (e.g. vendor, model number, CPU model/speed, memory/cache size) and software information (e.g., current firmware version, current OS version, fxDeviceApp-0 version package statingversionsoffxDeviceApp-0 components). In step 1106, the fxManager 1120 may send the latest firmware/OS version (or point

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the fxDevice to the right URL to download the latest load). In step 1107, if a new firmware/OS load is downloaded and verified, the fxDevice 1120 installs it. In step 1108, the fxDevice 1120 requests the default settings and the default application package (the initial applications that the NOIT admin would like to install in fxDevice 1120 prior to other applications). In step 1109, the fxManager 1130 prepares the fxCloud 1140 for the new fxDevice 1120 integration into the network. In step 1110, once completed, the fxCloud 1140 informs the fxManager 1130 of its readiness. In step 1111, the fxManager 1120 sends all the default settings and the default application package to thefxDevice 1120. In step 1112, the fxDevice 1120 then sets up a secure connection to the fxCloud 1140 (more precisely the fxCloudApp-0). In step 1113, a commissioning completion message is set from the fxCloud 1140 to the fxManager 1130. In step 1114, the fxManager 1130 signal to the fxDevice 1120 the completion of the commissioning and starts th regular operation of the fxDevice 1120. At this phase, fxManager 1130 can optionally modify the settings in the security connections between fxDeviceApp-0 and fx-CloudApp-0 and between fxDeviceApp-0 and fxManager 1130.

Application Provisioning Procedure

[0075] The Application Provisioning Procedure enables provisioning and de provisioning of applications across the dSDN system. For simplicity, the term provisioning in this disclosure is used to present all similar procedures of provisioning and de-provisioning. The application provisioning procedures are usually triggered by the network administrator and are orchestrated by the fxManager, which works in collaboration with the fxDeviceApp-0 and fxCloudApp-0.

[0076] Figure 12 shows an example procedure for Application (dApp) Provisioning. In step 1201, the network admin identifies the applications that would need to be installed in the dSDN system. These applications are already downloaded (from the fxStore or other sources) into the Application Repository (AR). Prior to installation in the live network, the authorized network admin 1220 has probably performed rigorous testing of the application in the test network. In step 1202, the fxManager 1230 performs a detailed analysis on the potential risks that this application may

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create on various parts of the network and other applications. The analysis tool uses the secure manifest file and other information to discover, for example, all the APIs used by the application, the required access-level authorization level for each of those APIs, requirements on the fxVF (inter-app, intra-app communication needs), and usage of platform resources including conflict discovery and resolutions. In step 1203, the admin defines the deployment scope that the application would be applied. Examples of deployment scopes could be a given zip code, a city, an administrative domain (zone), a shopping mall, an office building, or manual handpicking of sites or fxDevices 1240. The fxManager 1230verifies compatibility ofthe OS version and resouces requirements of the application and the fxDevices 1240. If the fxManager 1230 discovers incompatibility, it informs the admin and request adjustment to the deployment scope or proposes upgrading incompatible fxDevice if possible. In step 1204, the admin 1220 initiates the installation process. In step 1205, the fxManager 1230 unpacks the dApp and if there is fxDeviceApp component, it would prepare it for submission to the fxDeviceApp-0 of fxDevices in the deployment scope. In step 1206, installation commands are sent to the fxDeviceApp-0s in a secure connection already set up as part of the fxDevice Commissioning. In step 1207, the fxDevice 1240 verifies the fxDeviceApp package and performs necessary integrity checks of the received software package. Once verified, the fxDeviceApp is installed and re verified. In step 1208, the completion of successful install is sent to the fxManager 1230 by the fxDevice 1240. In step 1209, the fxManager 1230 prepares the fxCloudApp component of the dApp (if any). In step 1210, installation commands are sent to the fxCloudApp-0s in a existing secure connection. In step 1211, the fxCloud 1250 verifies the fxCloudApp package and performs necessary integrity checks of the received software package. Once verified, the fxCloudApp is installed and re-verified. In step 1212, the completion of successful install is sent to the fxManager 1230 by the fxCloud 1250. In step 1213, the fxManager 1230 informsthe admin 1220 of the successful installation process.

Hot Upgrade Procedure

[0077] The Hot Upgrade refers to a procedure by which the software upgrades

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on the system have no or minimal implication on the functionalities offered by the software component subject to the upgrade process. Herein are presented two types of software upgrades. For simplicity, the use of the term upgraded in this disclosure represents both upgrade and downgrade since they both use identical processes. First, upgrade of applications on the fxDevice (i.e., fxDeviceApp) and fxCloud (i.e., fxCloudApp). Second, upgrade of core functions in the fxDevice (aka fxDeviceApp-0) or fxCloud (aka fxCloudApp-0).

[0078] The upgrade procedures for fxDevice and fxCloud are similar. Here, the focus is on the fx:Device upgrade process since it is technically more challenging due to stricter resource limitations in the fx:Device.

General Application Upgrade

[0079] The applications could be upgraded automatically or manually by the network admin. In either case, the installation of the upgrade follows a similar procedure as the Application Provisioning Procedure. Figure 13 presents the state of the machine for the application upgrade process. In state 1301, the old version of the application is still running. In Load state 1302: the new version of the application is downloaded in the local storage while the old version is still running. In Install state 1303: the new version is installed (in the memory) while the old version is still running. In Run state 1304: the new version is activated taking charge of all the related data and application state and the old version is deactivated while still remaining in the local storage. In Commit state 1305: the old version is fully removed after ensuring the new version is running properly as expected.

fxDeviceApp-0 Upgrade

[0080] The fxDeviceApp-0 is a collection of software components that perform the core functionalities of the fx:Device. As a result, this hot upgrade is quite challenging. The most important thing is to ensure that major functionalities of the fxDevice (such as packet forwarding) remain

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intact during the upgrade process. The fxDeviceApp-0 upgrades may be categorized as:

- No OS Kernel upgrade; or
- OS Kernel upgrade.

No Kernel Upgrade

[0081] As described earlier, the packet forwarding function could be broken into the Virtual Switch and the Switch Controller. In order to maintain, the packet forwarding function, the Switch Controller function could be performed by another device or a second processor in the same device while the fxDevice is being upgraded. Figures 14A-14C demonstrate a few examples of distributed Switch Controller function during the upgrade. In some cases, it may be possible for the fxCloud to take over the Switch Controller function (Figure 14A), or a neighboring fxDevice (Figure 14B), or second CPU in the same fxDevice (Figure 14C). The actual software upgrade procedure would be similar to Application Provisioning Procedure and the state machines are the same as the one shown in Figure 13.

Kernel Upgrade

[0082] In this case, the packet forwarding process is mostly unavailable. Therefore, one potential solution might be for the fxDevice to redirect the entire bit stream to a neighboring fxDevice. In other words, the fxDevice would have just a bare minimum routing function working and the rest of the function would be performed by a neighboring fxDevice.

[0083] All the other upgrade procedures and state machines are similar to the ones performed for the No Kernel Upgrade process.

Virtual Fabric Service

[0084] The Virtual Fabric (fxVF) provides an abstraction layer for application to communicate with each other whether they are in the fxDevice or fxCloud. Various frameworks and services may use the fx:VF service. Figure 15 illustrates fxVF 1502a, 1503a, 1504a in the fxDevices 1502 and 1503 and fxCloud 1504. The fxVF 1502a,

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1503a, 1504a may use Extensible Messaging and Presence Protocol (XMPP) for this messaging as the default protocol. It is important that the developers may use their own communication protocols between the fxDeviceApps 1502b, 1503b and the associated fxCloudApp 1504b. fxVF 1502a, 1503a, 1504a provide a secure routing mechanism.

Intra-App Messaging

[0085] This is an example of where one application in the fxDevice communicates with the same instance of the app in another instance of the same application in another fxDevice. The actual messages could go directly between the fxDevice or via the fxCloud. As an example, in the case of mobile networks, this messaging could be used to transfer user specific context from one eNB to another as a user hands off to a new eNB. In LTE, Private Messages on X2 interface could be used for messaging between the eNBs that act as the fxDevices.

Inter-App Messaging

[0086] In some cases, different applications may need to communicate with each other via their published APIs. In this case, the security policies set up by the network administrator determines which applications could communicate with each other for what purpose. The fxVF follows the security policies determined by the network administratorfor inter-application communications.

distributed Resources Service (dRS)

[0087] The resources could be platform resources or APIs offered by the applications. The fxCloud and fx:Device resources could include (as examples):

Firewall;
Data and statistics;
Storage (usually abundant at fxCloud);
Compute (usually abundant at fxCloud);
Load evaluator;
General settings;

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Routing engine (usually relevant to the fxDevice);

Virtual Machine master controller (usually relevant to the fxCloud);

Power controller (usually relevant to the fxDevice); and

Wireless engine (usually relevant to the fxDevice).

[0088] An app (fxDeviceApp or fxCloudApp) could expose APIs to be used by the other apps. The inter-app communication is enabled by the fxVF where the policy and security provisions are enforced. The APIs exposed may be RESTful (representational state transfer) and could travel across physical network elements. Since the fx:Managerdefines fxVF policies, the administrator could ultimately specify which APIs between which apps could communicate with each other. Figure 16 demonstrates the logical interfaces between the platform resources and applications. As shown in Figure 16, the distributed Resources Service (dRS) 1602, 1603 comprises software agents residing in the fxDevice 1604 and the fxCloud 1606. These dRS agents manage the access to the platform resolutions (including potential configuration conflict resolution) as well as facilitating inter-app APIs. The dRS 1602, 1603 allows or disallows access to platform resource or inter-app communication according to the policies defined by the network administrator using the fx:Manager. In summary, the dRS 1602, 1603 provides services to application developers for:

Exposing APIs to other applications;

Configuring and managing platform resource;

Policy enforcement and authorization of applications access to platform resource and otherapp's APIs; and

Policy conflict resolution.

distributed Content Service (dCS)

[0089] The distributed Content Service (dCS) allows the developers to seamlessly store and share the contents generated by one application with other applications and its associated application in the cloud. The dCS simplifies access to the data and brings in storage virtualization to the applications. In other words, the developers no longer would need to know where the data is actually stored (in

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the cloud or on the device) and would be able to access them easily. The dCS implementation may use Virtual Fabric (fxVF) and distributed Resources Service (dRS).

distributed Notification Service (dNS)

[0090] The distributed Notification Service (dNS) is another potential tool for developers that could wake or ping an application when a particular event has occurred. For example, a load monitoring application could be notified when the CPU load on a particular fxDevice (or a target area) exceeds a certain threshold. In turn, such an exemplary application could make smart decisions on reducing the load on the CPU by forcing handoffs of users to neighboring cells (i.e. fxDevices). The dCS implementation may use Virtual Fabric (fxVF), distributed Resources Service (dRS) and distributed Content Service (dCS).

Cloud Breathing Procedures

[0091] In general, resources (compute, storage) at the cloud are more abundant. However, software licensing costs and other limitation may require smart management of resources. The Cloud Breathing, here, is defined as a mechanism where the cloud resources are automatically expanded as load increases on the system or reduced as the load decreases. This creates an automatic elasticity in the cloud dimensions. Figures 17A and 17B demonstrate procedures for the cloud breathing. Figure 17A is expansion and Figure 17B is reduction. The Load Controller in the dRS 1602, 1603 could be used to monitor the load (step 1702) on the existing VMs (e.g. CPU or memory utilization loads). The VM Master of the fxCloudApp-0 1608 could effectively act on the decisions made by the dRS's Load Controller. Again, the network administrator via the fx:Managerdefines the policies and thresholds for such decisions.

Security Aspects

[0092] The security aspects of this solution are of outmost importance in order to ensure quality in the productnetworks.

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Identity

[0093] To create a security model, the dSDN network elements should have unique identities. The following identities may be defined:

fxDevice Identity (DID): this identity is unique globally and may be allocated at manufacturing and included in the X.509 digital certificate of the fxDevice;

fxCloud Identity (CID): this identity is unique to the NOIT domain and may be allocated by the network administrator and included in the X.509 digital certificate of the fxCloud;

fxDeviceApp Identity (DAID): this identity may be globally unique and may be allocated by the fxSDK at the point of code creation by a globally accessible server;

fxCloudApp Identity (CAID): this identity may be globally unique and may be allocated by the fxSDK at the point of code creation by a globally accessible server;

dApp Identity (AID): This identity may be globally unique and may be constructed by concatenation of DAID and CAID together;

Application Developer Identity (ADID): this is a globally unique identity allocated by a globally accessible server and may be included in the developer's X.509 digital certificate and is used to sign the final developed applications.

[0094] For addressability purposes, the identities may be presented in a URI format using the FQDN of the NOIT.

Access Level

[0095] The applications are given different access levels. The AL is used by the dRS to determine which APIs or class of APIs an application can access (e.g., a fxDeviceApp running on fxDevice should not be able normally to reboot the fxDevice). The required AL is generated by the fxSDK and included in the manifest files. It may also be published in the fxStore for that give application. A preset of ALs could be defined to categorize the applications security risks.

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Software Security Verification

[0096] It is important for the target network element to verify the authenticity and integrity loaded software prior to install. The uniquely defined security keys of the application developers sign the applications. The following rules may be followed to ensure software securityverification:

Only the verified OS/Firmware software can install on verified hardware;

Only the verified OS/Firmware software can run on verified hardware (continuous verification of essential parts of the software);

Only the verified fxDeviceApp software can install on verified hardware;

Only the verified fxDeviceApp software can run on verified hardware (continuous verification of essential parts of the software).

[0097] Each fxDeviceApp is accompanied by a manifest that is generated by the Integrated Device Electronics (IDE) at the time of compilation of the fxDeviceApp. The manifest file specifies which libraries and frameworks the fxDeviceApp uses. The fx:Manager uses this information to determine the security risk of the fxDeviceApp as well as the required Access Level (AL) to run this fxDeviceApp. In order to ensure that manifest file is actually genuine manifestation of the fxDeviceApp and its integrity remains intact, a hashing algorithm could be used to generate a signature. An example is shown below:

Signature= HMAC-SHA256(K, Message);

where

Message= fxDeviceApp + Manifest

K = shared secret key between fxStore and fxManager.

[0098] The signature is generated by the IDE/fxSDK at the compile/build phase and is packaged with application binary and the manifest file. Once the distributed application package (dAP) is downloaded into the fxManager (Application Repository), the components of the signature, application binary, and manifest file are unpackaged. The fxManager then uses the same hashing algorithm to calculate

the signature as above using the pre-shared key (K). If the calculated signature and the unpackaged signature match, it would prove the authenticity of the manifest file and the integrity of both manifest file and the fxDeviceApp.

[0099] Code Generation Process (Compilation):

fxDeviceApp compiled Manifest file generation Signature

calculation Create fxDeviceApp Package

[0100] Install Process(Consumption):

Un-package fxDeviceApp Signature calculation Signature comparison [0101] This model works if the key K can be shared with two trusted parties (fxManager and fxStore). The manifest file that is generated by thefxSDK shall be secured by integrity checks to ensure it remains intact throughout the transaction (i.e. from compilation to consumption).

Communication Security

[0102] Security mechanisms built into the fxDeviceApp-0 and fxCloudApp-0 forces the fxDevice to only use the configured fxCloud servers for Software Security Verification, fxDeviceApp downloads, and fxDeviceApp-fxCloud communication. Optionally, the fxDeviceApp-fxCloud communication can be customized per application requirements. One implementation of this interface could use SPDY Protocol or per-application VPN.

[0103] For the purpose of inter-App communication, an Inter-App Communication (IAC) policy template is applied to an fxDeviceApp that defied the communication policies between the fxDeviceApps and fxCloudApps. The network administrator may use one of the pre-configured IAC policy templates (exemplified below):

Isolated: this type of applications cannot communicate with any other application in the same fxDevice and does not have any associated fxCloudApp;

Isolated-Extended: this type offxDeviceApps cannot communicate with any other fxDeviceApps in the same fxDevice but could communicate with its associated fxCloudApp;

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Private: a private fxDeviceApp in one fxDevice could communicate with same private fxDeviceApps in other fxDevice but does not have any associated fxCloudApp;

Private-Extended: a Private fxDeviceApps in one fxDevice could communicate with same private fxDeviceApp in other fxDevice and has its associated fxCloudApp;

Community: a group offxDeviceApps that belong to the same community can communicate with each other;

Promiscuous: a Promiscuous app could communicate with any other Promiscuous application and Community application;

Custom: the network administrator could create custom IAC Policy templates and could include (as examples):

Template name;

Inherited pre-configured template if any;

The protocols allowed to use for communication;

The maximum data rate allowed for inter-app communication between a pair of fxDeviceApps or between an fxDeviceApps and an fxCloudApp;

Policies related to the other fxDeviceApps in the same fxDevice, in other fxDevice, associated fxCloudApp and unassociated fxCloudApps;
Policies related to direct fxDeviceApp to fxDeviceApp communication or relayed via fxCloud communication.

Secure Boot

[0104] The secure boot refers to a capability where the main boot code is in the fxCloud with the following exemplary procedure:

The Boot Loader (BL) in the fxDeviceApp-0 of the fxDevice looks for a particular DNS (DNSSEC) name of the fxCloud. The network administrator should define the DNS entry in their network. If there is a private fxCloud, the resolved domain name points to the fxCloud. If using shared cloud, the resolved

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domain name points to the cloud point of presence;

A secure tunnel (TLS) is created between the BL in fxDevice and the fxCloud using pre-burned X.509certificate;

BL identify itself to the fxCloud and include System Information;

fxCloud determines the appropriate boot file and points the BL to the exact address of the boot file in thefxCloud;

BL downloads the correct boot file;

BL runs Software Security Verification;

BL reboots the fxDevice and the system will be ready for operation.

Frameworks

[0105] The following describes an example of the API Framework for the dSDN. Some APIs are purely local to the fxDevice or the fxCloud and some may be extended from the fxDevice all the way to the fxCloud using dRS.

General Framework

[0106] This framework refers to general libraries and APIs inherited from the legacy OS. An example of the legacy OS may be Embedded Android®. This framework allows for general processing and may be used for algorithmic applications.

Wireless Framework

[0107] The Wireless Framework adds a set up functions related to managing and controlling the wireless module. Table 1 highlights some examples of methods/functions that may be available in the Wireless Framework.

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Table 1: Wireless Framework	
1v1emoa	uescnpt1on
discoverNeighbors	Discovers wireless neighbors and returns their identities
retrieveNeighborInfo	Retrieves detail information of neighboring BS/AP information. This method may transparently call cloud servers to gather more information
measureInterference	Measures wireless interference observed on a frequency or a set of frequency channels
setWirelessConfig	Sets various parameters in the wireless module such as power, frequency channels, Multiple Input/Multiple Output (MIMO) antenna configuration, etc.
definePHYReceiverAlgorithm	Defines the physical layer receiver algorithm
connectedDevice	Returns details about the connected mobile devices (length of connection, data tx/rx) to a given wireless interface (channel, band, sector)
forceOffload	Offloads connected mobile devices to other access technologies (e.g. from cellular to WiFi)
homeAreaNetworking	Control of home automation wireless technologies such as ZigBee or Z-Wave
setNeighborCells	Sets neighboring cellsinformation
forceHandoff	Handoffs connected mobile devices to the same access technology but different channel or frequency
topMovers	Identifies the mobile devices with highest degree of mobility

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positionDevice	Accurate positioning of mobile devices which may include geo-fencing data
borrowSpectrum	Allows one BS to borrow spectrum from another
configureMACScheduler	Configures the MAC scheduler (for example prioritize a particular user)
loadBalance	Enables load balancing across radio channels
defineMACScheduler	Defines the MAC scheduler algorithm

Security Framework

[0108] The Security Framework allows the developers to use a specialized security functions/methods. Some of these new methods may use the legacy OS frameworks. Table 2 highlights some examples of methods/functions that may be available in the Security Framework.

Table 2: Security Framework

Method	Description
setDOSDetect	Detects DOS attacks on user plane as requested
configureFirewall	Provides firewall functions such as traffic filtering, permissions (this may use dRS)
defineDOSDetectAlgorithm	Allows replacing and redefining the DOS algorithm
encryptTraffic	Encrypts the content of a message or a class of traffic as requested
aumentIcateuser	Authenticate users asrequestea
integrityCheckContent	Verifies authenticity of a message using its checksum information
configuresIPS	Configures IPS functions on the user plane

FastPath Framework

[0109] The FastPath Framework allows the developers to identify and manipulate the data path with a DPI capability. Table 3 highlights some

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examples of methods/functions that may be available in the FastPath framework.

Table 3: FastPath Framework	
Method	Description
matchTraffic	Identifies and matches the traffic type requested by the developer
aeiecn..,ongesuon	Detects if there is congestion on the data path
identifyTopURLs	Identifies the most visited URLs by the users
detectlocalConversation	Detect conversations and packet routing between the end user on the same fxDevice
detectDevice	Detects traffic of a given mobile user device
redirectTraffic	Redirect data traffic to a given network element. The traffic may be identified with a user or a class of traffic
connectedDevices	Returns all the connected mobile devices to a given fxDevice
assIgnAddress	Allocates a particular IP address to the mobile device
setPriority	Set traffic priority to a class of traffic
markTraffic	Marks the user traffic with the desired QoS tags
setupTunnel	ets up data tunnel from fxDevice to a destination
Adscript	Adds a JavaScript to an active transiting web page
detectIdenticalFlows	Identifies the identical flows coming from the WAN/uplink interface on the fxDevice
aggregateFlows	Enables aggregation of flows to save WAN/uplink utilization
routeTunnel	Routes a packet or a class of traffic onto an established tunnel
identifyTopDevices	Identifies users that generate most traffic load

Messaging Framework

[011O] The Messaging Framework allows the developers to send messaging between the applications residing in the fxDevice and fxCloud. Table 4 highlights some examples of methods/functions that may be available in the Messaging Framework.

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Table 4: Messaging Framework	
Method	Description
sendIntraApp	Sends an Intra-App message from one fxDevice to another
sendInterApp	Sends an InterApp message from one application to another
sendfxCloud	Sends a message to the fxCloud
sendSMS	Sends an SMS to the user of choice

Caching Framework

[0111] The Caching Framework allows the developers to cache particular contents or files that are accessed frequently in the caching engine. The caching can be done locally in the fxDevice, clustered cache (shared amongst a few fxDevice), or cloud caching. Table 5 highlights some examples of methods/functions that may be available in the Caching Framework.

Table 5: Caching Framework

Method	**Description**
storeForward	**Enables Store and forward model for a target class of traffic where the target traffic is matched and stored upon a condition and forwarded the condition is relieved**
cacheWebSite	**Caches the most visited web sites**
cacheVideo	**Caches the most viewed videos**
cacheCloud	**Caches the requested content or traffic type in the cloud storage in fxCloud**

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Management Framework

[0112] The Management Framework enables the developers to manage the BS platforms and perform administrative procedures. Table 6 highlights some examples of methods/functions that may be available in the Management Framework.

Table 6: Management Framework

Method	Description
upgradeFirmware	Started and executes the firmware upgrade procedure on the fxDevice
upgradeOS	Started and executes the operating system upgrade procedure on the fxDevice
remoteBootup	Performs remote boot up process where the fxDevice works closely with the fxCloud to perform the bootup
remotePower	Allows fxCloudApps to remotely turn on and off a fxDevice or elements in the fxDevice (e.g. the wireless)
gatherStatistics	Instructs fxDevice to gather specific statistics. Various commands may be consolidated for gathering statistics. Number of active users Stats of time spent by users in the cell Stats of quality perceived by the users Neighboring cell info Overall traffic passed through the system Total number of connected devices per frequency, per carrier, per site, per location Handover failure statistics Cloud aggregated data processing and full report Total traffic passed Applications used (meta-data correlated) Bandwidth consumed User's mobility pattern

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setIvIorntonng	Allows the developer to get reports and statistics of the fxDevice traffics, errors, and neighboring environment. The reporting criteria could be set up as: 1) Period, 2) Event based (reports only if a threshold is passed; a threshold could be based on absolute numbers or deltas), 3) One-time (i.e. the information is pulled once). The exact parameters to get report on may use the same data structures used by the method "getStatistics".

getSystemInfo	Retrieves static and dynamic system info such as: Hardware info: vendor, model number, capability profile. GPS, Cellular, WAN interfaces, RFID/NFC Heat temperature • Vendor Specific Information • Software info: OS version, firmware information • CPU load, per-application load (CPU, memory, accelerators) Loaded apps and status Memory utilization • Storage utilization Interface status & utilization (RF, backhaul, management...)
getfxDeviceLocation	Retrieves location of the fxDevice Location would be presented in GPS coordinates and civil address Location enhancement: Cloud, map data, and neighbor discovery could help more accurate positioning
getPowerConsumption Rate	Retrieves current power consumption rate of the fxDevice
configureWAN	Configures the WAN settings
retrieveNeighborInfo	Retrieves neighbor information from the fxCloud
getRFIDInfo	Returns the RFID/NFC information of the fxDevice
setRFIDInfo	Sets the RFID/NFC information of the fxDevice

Extensible API Framework

[0113] This framework allows the developer to create custom APIs and make it accessible for other applications (in the fxDevice or in the fxCloud). In turn, the fxCloud could present these APIs using e.g. REST technologies (via the fxCloud

Northbound Interface) to the developer outside the dSND system. There might be limits put on the APIs exposed through the cloud to avoid potential misuse or security threats. The dRS enforces the security policies defined by the admin (via fxManager). The applications take a role of Client Application (CA) or Server Application Role (SA). The CA and SA could be distributed in the fxDevice or fxCloud. The CA makes requests and SA serves the requests.

[0114] The Extensible APIs could be categorized (as examples) into:

Read-Only Data: this type of APIs allows a CA to read data from SAs without the ability to change or request any particular action from the SAs

Read-Write Data: this type of APIs allows CA application to read data from SAs with the ability to change some of their data but no option for requesting any particular action fromSAs;

Procedural: this type of APIs allows CAs to execute a particular procedure in SAs. The rights to change any data still depends on whether the API allows Read-Only Data or Read-Write Data types.

Cloud Management Framework

[0115] The Cloud Management Framework presents a collection of methods enables management of the cloud services and resource. Table 7 highlights some examples of methods/functions that may be available in the Cloud Management Framework.

Table 7: Cloud Management Framework

Method	Description
detectCloudCongestion	Detects congestions on a particular VM
deleteVM	Deletes an active VM permanently
suspen	Suspends an active VM but doesn remove
activate	Activates an already created VM
createVM	Creates a new VM but doesn't activate it

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EXAMPLES OF DAPPS

[0116] The dSDN create an end-to-end programming platform and the possibilities of vApps are only limited by the developers' imagination. An example list of potential vApps are presented in Table 8 below.

Table 8 highlights examples of use cases possible by the Distributed Software Defined Network (dSDN)

use	Description	Framework Involved/used
1	Distributed SON: For example, the WiFi AP could search for the least crowded channel to minimize the interference.	Wireless {discoverNeighbor, retrieveNeighborInfo, measure nterference, setWirelessConfig, loadBalance}, General Framework, Messaging {sendIntraApp}
2	BS Hot Firmware Upgrade without impact to the basic functions of the BS.	Management (upgradeFirmware}
3	BS Hot infOS Upgrade without impact to the basic functions of the BS. For this function to support full hot upgrade without operational impact, the full platform should have dual processor.	Management (upgradeOS}
4	Secure network—based booting. This allows to keep the code securely in the cloud to avoid tampering by the ODM/CM or Man—in—the---Middle attacks.	Management {remoteBoot}
5	Turning on or off APs if nobody is in the office. Sensors in the building send information to fxCloudApp which in turn orders power control of the Aps.	Management {remotePower}
6	Store and forward model for low priority M2M applications where the target traffic is matched and stored in the case of network congestion and forwarded once the network congestion is relieved.	DataPath {matchTraffic, detectCongestion}, Cache {storeForward}
7	Replacing MAC Scheduler	Wireless {defineMacScheduler}
8	Replacing Receiver Algorithms	Wireless {definePHYReceiverAlgorithm}
9	Caching most visited website or video clip in the enterprise	DataPath {identify TopURL}, Cache {cacheWebSite}
10	The most viewed videos and webcasts are cached in the wireless edge.	DataPath {identifyTopVideos}, Cache {cacheVideo}
11	Local Routing: data and voice sessions between two parties on the same cell are routed within the same cell bypassing the core Network.	DataPath {detectLocalConversation, RouteLocal}
12	Local Routing: data and voice sessions between two parties on the nearby cells are routed locally bypassing the core network.	DataPath {detectConversationDetect, routeLocal}
13	Temporary redirection of a data flow for monitoring and security reasons. In this use case, a particular use(s traffic is tracked by redirection to a monitoring station. If user is mobile, such profile of tracking and associated redirection is transferred from fxDevice to fxDevice either directly or via the fxCloud.	DataPath {detectDevice, matchTraffic, redirectTraffic}
14	Power Calendar: On—demand coverage (triggered by passing traffic thresholds in certain cells or by calendaring): Operators need to design their network for peak usage rates at high costs, leaving their network underutilized most of the time.	DataPath {detectCongestion}, Management {remotePower}
15	DOS attack recognition and action could be blocking the user, the app, and/or notifying the user via an SMS message.	Security {setDOSDetect, configureFirewall}, Messaging {sendfxCloud}
16	Applying certain ACLs to the BS. For example, the students in the class can only access Facebook between the breaks and access to Facebook is blocked during the class.	Security {configureFirewall}
17	Forced offloading of some cellular users (users that have attached to the same cell for a while) to WiFi by changing "something" in the cellular connection to force WiFi connection (Heteroaeneous)	Wireless {identifyConnectedDevice, forceOffload}
18	Service continuity and anchoring at eNB for WiFi using the same LTE IP address (Heterogeneous).	DataPath {identifyConnectedDevices, assignAddress}
19	Graphic/general processing for special use cases such as City BS	General Frameworks
20	Application filtering/throttling (secondary conditions: time—based, location—based, subscriber—type, none).	DataPath {matchTraffic}, Security {configureFirewall}
21	Local Services: The enterprise user can discover Bonjour or UPnP devices and services (e.g. printer) even when connected to LTE/3G small—cell in the enterprise. In this case, the small cell or fxDevice pro—actively listens to Bonjour and UPnP discovery and advertisement messages (SSDP) and cache the available services until a device request for such information. In the case of Bonjour, fxDevice could listen to Multicast DNS (mDNS) messages sent over cellular connection (LTE/3G) and multicast them on the LAN or WLAN interfaces.	DataPath {matchTraffic, routeLocal}
22	Local Services: The premise—owner (e.g. airport, hotel} can provide ads under the browser for sponsored WiFi or cellular (3G/LTE) access over multi---mode small cell. The premise owner could use this service to advertise special offers or third party ads. This technique uses HTML <script> for example to add special content to the bottom of the page.	DataPath {matchTraffic, addScript)

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23	Distributed Content Distribution Network (CON). In this use case, the fxDevices function as CON that bring the contact closer to the end **users.**	DataPath {matchTraffic}, Cache {cacheVideo}
24	**In case of national security, the service provider may limit the access** to the network so only the law enforcement can use the cellular network. In this case, the admin defines a Target Area (TA) using an fxCloudApp in the fxCloud where the emergency lockdown needs to be applied. The IMSI/MSISDN number of law enforcement mobile devices are sent to the fxDevice in the TA which in turn enforce the policy. The policy may allow the public to just sent SMS while the law enforcement could have full access and priority to the system.	DataPath {matchTraffic, setPriority}, Security {configureFirewall}
25	Emails and web browsing monitored by the cloud services assisted by the agent in the dSDN network. In this case, the fxDevice detects certain traffic (email or web in this case) and redirects them to a **cloud service for security cleansing**.	DataPath {matchTraffic,redirectTraffic}
26	Analytics pre----analysis: The data collected from M2M devices could be processed (noise could be filtered out) and packaged (compressed) for consumption by cloud services.	DataPath {matchTraffic}, General Framework, Messaging {sendfxCloud}
27	Certain traffic could be marked with QoS DSCP codes for further processing in the network.	DataPath {matchTraffic,markTraffic}
28	Proprietary SP services and applications that run purely between the phone and the BS . For example, the SP may implement a certain application for the law enforcement to get direct feed of surveillance cameras in a target area (TA).	DataPath {matchTraffic}, Security {configureFirewall}, General Framework
29	IP—PBX implementation in the small---cell or WiFi AP for enterprise use. This would allow a simple out of a box solution. The VoIP phones connect to the fxDevice via the LAN connections. The WAN connection could connect to an fxCloudApp for PSTN calls.	DataPath {matchTraffic}, GeneralFramework
30	Network management system can add its own agent/probe to collect and consolidate data and transmit it to its cloud element using any protocol.	Management {gatherStatistics, getSystemInfo, control}, GeneralFramework
31	Application based performance monitoring on the wireless link (number of packets sent in idle mode, retransmit rate...). Such information could be shared with the app developer to optimize its application.	Management {gatherStatistics}, GeneralFramework
32	Seamless network sharing and mergers. This is the case where two Network Operators would like to share or merge their network. Using dSDN's infManager, the network administrators could merge the network administration control. This process may include setting up the desirable default fxApp packages of the network operator.	fxManager Portal Service
33	**Following a user to understand where it faces coverage issues or** call drops. Once discovered, the system could send a message to the user acknowledging an issue and that the SP is trying to fix this. The information is uploaded to the cloud for further analysis.	Management {gatherStatistics}, General Framework, Messaging {sendSMS}
34	Reporting: This allows the developer to get reports and statistics of the fxDevice traffics, errors, and neighboring environment. The reporting criteria could be set up as: 1) Period, 2) Event based r i'c, on i :r!h<i)£a J rE(is:ot' /i ,,,;'!ti)ed on	Management {setMonitoring}, GeneralFramework
35	Proprietary security protocol between the application in the mobile device and the BS in enterprise deployment. This would allow SP to create enterprise----class LTE for indoor using small cells.	Security {encryptContent, authenticateUser, Integrity, configureFirewall}, DataPath {RouteIocal}, General **Framework**
36	The femto cell at home that can't scan neighboring cells, gets a list of neighboring cells from the fxCloud or neighbors to broadcast to improve outbound handoffs.	Wireless {discoverNeighbors, retrieveNeighborInfo, setNeighborCells}, Management {retrieveNeighborInfo}
37	IMS---capable femto enabling various SP services to initiate or transferred between home network and mobile devices.	Messaging {sendfxCloud}, General Framework
38	Integrated smart home with multi---mode femto/WiFi router. For example, the application in the smart home router (fxDevice) allows for coordination of home physical security service (such as ADT services). With the fxCloudApp, the user could control the security status of his/her home and remotely control the setting.	Wireless {homeAreaNetworking}, Messaging {fxCloud}, General Framework
39	Home CCTV DVR implementation in an integrated home router. The **camera feeds are recorded on the same router caching engine.**	Cache {cacheVideo}, Messaging {sendfxCloud}, General Framework
40	Enterprise CCTV DVR implementation in an integrated router with cloud backup. The camera feeds are recorded in the cloud.	Cache {CacheVideo, CacheCloud}, Messaging {fxCloud}, General Framework
41	User traffic separation into various MPLS/LSP (integrating VPN and BS). In this case, users are classified into groups and each group is tunneled to the core network. For example, law enforcement use the encrypted tunnel while the other users use the defaulttunnel.	DataPath {Match, SetupTunnel, RouteTunnel}
42	**Dynamic spectrum allocation where a BS borrows unused spectrum** from the neighboring BS in case of temporary congestions.	DataPath {detectCongestion}, Wireless {discoverNeighbors, setWirelessConfig}, Management {retrieveNeighborInfo, borrowCarrier}, Messaging {fxCloud}

43	Proxy ANDSF (Access Network Discovery and Control Function) in the BS. When the UE tries to access the ANDSF, the Proxy ANDSF fxDeviceApp in the BS intercept the ANDSF messages and replies on behalf of the ANDSF. This would speed up the WiFi network discovery for example.	DataPath {matchTraffic}, General Framework, Messaging {sendfxCloud}
44	HD Audio calling: audio codecs in BS allows the phones with the right capabilities to communicate with HD Audio quality calling. If one of the mobile devices can't handle the HD quality audio, the BS performs the transcoding of the audio.	DataPath {matchTraffic}, General Framework
45	Enabling mobility on White Space Spectrum: The latest white space database will be downloaded. The mobile devices with special software applications make requests to the BS to retrieve the local available white space frequencies. This would allow the mobile device to handoff seamless between BS using the white space spectrum. The BS would advertise such a capability to the UEs. The **secure communication allows peer—to—•Peer communication** between the UE and the BS for certain applications such as White Space Channel lookup or site acquisition tools for field engineering and RF planning.	Messaging {sendfxCloud}, General Framework
46	**Site acquisition tool where the technician uses a software tool on his** mobile phone to interact with BSs to determine the best place to deploy the new BS. The phone app interests with fxDeviceApps in fesrf! d:.rJgiv e,,x J'iiiy:;ar\?.;' Rtr:[';fms air	Messaging {sendfxCloud}, General Framework. DataPath {matchTraffic, setPriority}
47	DNS caching at BS to accelerate DNS lookup for subsequent users. **This would improve the user experience by reducing response** delays.	DataPath {matchTraffic}, General Framework
48	Continuous SLA monitory for certain protocols, applications or general link quality for jitter, delays, bandwidth.	DataPath {matchTraffic}, Management {gatherStatistics}, General Framework
49	Enterprise users can use the small cell deployed in their enterprise free of charge. The DPI engine in fxDevice classifies the traffic and identifies the enterprise private data and they would be routed locally and charging records are generated by the BS (the SP decides how to bill the enterprise user and it may decide to make such usage.	DataPath {matchTraffic, routelocal}
50	On—premise small—cell aggregation where on fxDevice takes the responsibility of aggregating multiple small—cells on the premise and presenting them as a single BS/Node—B/eNodeB to the core network. In this case the aggregating fxDevice (AfxE) may take responsibility of local radio resource manager (RRM) or self—optimizing network (SON) server. AfxE can also implement and **enforce policies concerning local service access on the premise** (enterprise) as well as enable seamless handover between cellular technologies and on—premise (enterprise) local area network (LAN) for example using WiFi technology.	General Frameworks, Wireless {discoverNeighbors, retrieveNeighborInfo, setNeighborCells, setWirelessConfig}, Messaging {sendIntraApp}
51	Self adjusting fxCloud compute resources: The fxCloud creates and tears down virtual machines (VMs) based on the traffic load measured by itself or the packet processing and data plane engine. It is also possible that the VM adjustments are made based on the rush hour or pre—configured hours of the day or manually by the **administrator**.	CloudManagement {removeVM, createVM, detectCloudCongestion, actiavteVM, suspendVM}
52	Core Network Function Virtualization (cNFV) using distributed Software Defined Networking (dSDN): In the case, once an fxDevice is commissioned, its fxDeviceApp0 (i.e. firmware) uses predefined DNS names to discover the rest of the core network (e.g. MME, S—GW, etc.). The core network elements could be created.	General Frameworks, Messaging {sendInterApp, sendIntraApp), CloudManagement {deleteVM, suspendVM, createVM, activateVM, detectCloudCongestion}
53	Smart display and digital signage as wireless base stations: this use case allows combining the capabilities of a base station and the smart display in shopping malls, airports, and enterprises. There is a already electric power and connectivity for the smart display that the **base station function could use**.	**General Frameworks**
54	Tracking a mobile user at base station level even if the UE is in the idle mode. Currently in the idle mode, the MME, SGSN, or VLR/MSC can only know the location of the UE in with a accuracy of LA/RA/URA which is a very large area. The administrator uses the fxCloudApp and requests tracking of the user/UE (the admin may provide target area where the user/UE may be located; e.g. zip code or town name). The fxCloudApp contacts its fxDeviceApp in the fxDevices in the target area (TA) requesting information of a particular IMSI/MSISD/TMSI. Once an fxDevice responds indicating knowledge of the user location, the fxCloudApp directs that serving fxDevice to inform the fxDeviceApp in the next fxDevice of the instructions to track the user and contact fxCloudApp when they user hands off to due to its mobility. fxCloud could create user friendly interfaces and presentations to show for example the direction the **user is moving, predict next location of the user, and estimate arrival of the user to a certain location**.	DataPath {matchTraffic}, Messaging {sendIntraApp, sendfxCloud}
55	In case of emergency, fxDevices in a target area block all public traffic and only allow law enforcement sessions using specially encryption and authentication between the UE and the fxDevice or fxCloud (depending on the requirements).	DataPath {matchTraffic, setPriority}, Security {configureFirewall, encryptTraffic, authenticateUser}, **General Framework**

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56	SON triggered by the data traffic consumption. In this case, the mobile cell configuration is adjusted based on the current traffic of the cell. It could for example force handoff some users (high users or users moving fast) to neighboring cells.	DataPath {identifyTopDevices}, Wireless {forceHandoff}
57	Time based QoS and policy. In this use case, the infManager pushes certain policies in target area (TA). Such polices could be turning on extra capacity (frequency channels) or QoS policies and traffic prioritization on the WAN like.	DataPath {matchTraffic, setPriority}, Wireless {discoverNeighbors, setWirelessConfig}
58	Fast moving users detection: in this use case, the application in the BS measures the speed of the user (based on the time was handed off to this cell until it was handed over to the next cell). This information could be used by the fxDevice or fxCloud to force handoff the mobile user to a larger cell to reduce handoff rates.	General Frameworks, Wireless {identifyTopMovers, forceHandoff}
59	**Emergency broadcast of information and live camera feeds. In case** of emergency, the enterprise network administrator temporarily block all traffic and only allow emergency related traffic across the target area in the enterprise network. For example, the network admin broadcasts the camera feeds and alerts over the WiFiaccess points using multicast IP techniques. The client devices and digital sinages can listen to that particular multicast and show the camera feeds and emergency alerts.	DataPath {matchTraffic, setPriority}, Security {configureFirewall}, General Framework
60	Dynamic advertising in shopping malls. The shopper would use an app from the shopping mall. When the shopper brings up or refreshes the app, the dSDN allows the shopping mall to pinpoint the exact indoor/outdoor location of the user (e.g. the shop the shopper is in) and send special coupon and ads for that store to the shopper.	General Frameworks, Wireless (positionDevice}, Messaging {sendIntraApp, sendfxCloud}, Security {configureFirewall}, DataPath {matchTraffic, redirectTraffic}
61	Smart tour guide. The tourist would use an app from the tourism board or museum. Wihen the user brings up or refreshes the app, the dSDN allows to pinpoint the exact location of the tourist (e.g. the painting he/she is looking at) and send tour guide information (e.g. audio, video, hypertext). dSDN allows to localize the positioning.	General Frameworks, Wireless (positionDevice}, Messaging {sendIntraApp, sendfxCloud}, Security {configureFirewall}, DataPath {matchTraffic, redirectTraffic}
62	General hotspot landing page	DataPath {matchTraffic, redirect Traffic}, Security {authenticateUser}
63	Proprietary wireless mesh implementation	Wireless {discoverNeighbor, retrieveNeighborInfo, measureInterference, setWirelessConfig}, General Framework, Messaging {sendIntraApp}
64	Power and energy consumption map of the network. A real-—time fxCloudApp pulls the power consumption details from each fxDevice periodicaly or on demand. The pulled data then are combined with the location information and correlated into a map to present a **viewable consumption map**.	Management {getfxDeviceLocation, getPowerConsumptionRate}
65	Network deployment optimization. This application allows network operator to get advice for best optimal reconfiguration and/or redeployment of the network. For example, the network admin could get suggestion that based on the power consumptions and coverage perceived and spectrum utilization, it might be better to replace a particular group of smaller cells with a single macro-—-cell. This app could also pull information from larger OEMs based on the subject deployment scenario (the OEMs either provide this information statically to the tool or provide network APIs for use by this app e.g. using REST protocol).	Management {getfxDeviceLocation, getPowerConsumptionRate, gatherStatistics}
66	High availability. This app allows two or more fxDevice to form a redundancy cluster where they participate in statueful redundancy and load-—-balancing.	Messaging {sendIntraApp}, General Framework
67	Bandwidth Bursting. This feature enables the dynamic adjustment of backhaul or WAN link bandwidth as the demands change in the enterprise or public wireless deployments. In this case, the fxDeviceApp in the fxDevice monitors the WAN link utilization, once a preset threshold percentage has reached, it messages its sister fxCloudApp which in turn would send a request to the fxDeviceApp to increase or decrease the WAN bandwidth. If additional backend reconfiguration is needed, the fxCloudApp performs those additional changes prior to informing the fxDeviceApp of the bandwidth.	Management {getStatistics,configureWAN}
68	Wireless link quality measurement by the small-—cell or WiFi AP: The wireless Soc in the small-—-cell or WiFi AP continuously monitors the link quality for power adjustment and handover reasons. Such information could be exposed to the app developers to create cell-—-level analytics and reports without the need to have test-— drives or field testing of service quality.	Management {gatherStatistics}, GeneralFramework
69	Data Path Consolidation: An application on the fxDevice discovers **identical data feeds from a cloud server to two or more users. The** fxDeviceApp in the fxDevice can discover this potential duplicate flows at the session establishment (via a proxy function) and it would consolidate those sessions into one on the uplink towards the cloud server. A good example of this use case is the web—based desktop sharing where different many users in the same office site get the same feed from the cloud server.	FastPath {detectIdenticalFlows, aggregateFlows}

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[0117] The following references are herein specifically incorporated by reference in their entirety into this disclosure:

1 3GPP TS 23.002, "NetworkArchitecture";

2 3GPP TS 23.402, "Architecture enhancements for non-3GPP accesses";

33GPP TS 23.401, "Genera! Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access";

4 Open Base Station Architecture Initiative (OBSAI); and

[5] SPDY Protocol (b-Hp_Ifg_c1tc1_tn_cxtLi_E=1L999_Qqg r c1ftn1>_§_O_E=i:_U_t tp_1>i§_§>_dy().

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CLAIMS

1. A system for processing data packets in a network, the system comprising:

a programmable network device hosting a plurality of first network applications;

a programmable cloud device hosting a plurality of second network applications;

wherein at least one of the plurality of first network applications in the programmable network device and at least one of the plurality of second network applications in the programmable cloud device are in secure communication with each other to form a distributed application;

the programmable network device and programmable cloud device are each powered by a sandboxing operating system which facilitates deployment of the plurality of first and second network applications and facilitates upgrades of the first and second network applications with substantially no interruption to operation of the programmable network device and programmable cloud device;

wherein the programmable network device verifies authenticity of the upgrades to the plurality of first network applications and the programmable cloud device verifies authenticity of the upgrades to the plurality of second network applications and wherein the verification is based on unique security keys associated with each of the plurality of first and second network applications;

an application repository storing distributed applications which have been tested for installation in the programmable network device and programmable cloud device; and

an application management portal coupled to the programmable network device, programmable cloud device and the application repository, wherein the application management portal manages usage of the distributed applications on the programmable network device and programmable cloud device.

2.The system of claim 1, wherein each of the programmable network device and programmable cloud device include an access network interface unit to send and receive communications and a processor with a memory associated with the network interface unit.

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3.The system of claim 1, wherein the at least one of the first network applications is responsible for a plurality of functional capabilities of the programmable network device and is capable of at least one of the group consisting of: updating the firmware of the programmable network device; updating default communication protocols of the programmable network device; initializing programmable network device settings; boot loading the programmable network device; providing security digital certificates; providing operating system **(OS)** and kernel upgrades; and upgradin-g and commissioning agents for upgrades of the at least one of the first network applications.

4.The system of claim 1, wherein at least one of the second network applications is responsible for a plurality of functional capabilities of the programmable cloud device and is capable of at least one of the group consisting of: upgrading and commissioning agents for upgrades of the at least one of the second network applications and related procedures; hypervisor upgrades; virtual machine and isolated execution environment lifecycle management; security digital certificate management; operating system **(OS)** and kernel upgrades; and default communication protocols.

5.The system of claim 1, wherein the programmable network device is a Long Term Evolution (LTE) evolved NodeB (eNB) and the programmable cloud device hosts LTE core network functions in separate virtual machines, the network functions consisting of: Mobility Management Entity (MME), Serving Gateway (S-GW), and Packet Gateway f'-GW).

6.The system of claim 1, wherein the programmable network device and programmable cloud device further comprise:

a virtual fabric which provides a secure communication layer for at the least one of the plurality of first network applications and the at least one of the plurality of second network applications.

7. The system of claim 1, further comprising:

a second programmable network device which includes the at least one of the

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plurality of first network applications which is in the first programmable network device.

8.The system of claim 1, wherein the programmable network device and programmable cloud device further comprise:

a distributed resource service (DRS) which controls access to a plurality of resources by the plurality of first network applications and the plurality of the second network applications upon receiving instructions from the application management portal.

9.The system of claim 1, wherein the plurality of resources include at least one of a group consisting of: a firewall; data and statistics; storage; compute; load evaluator; general settings; routing engine; virtual machine master controller; power controller; and wireless engine.

10.The system of claim 1, wherein the programmable network device and programmable cloud device further comprise:

a distributed resource service (DRS) which is capable of providing at least one service from a group consisting of: exposing application programming interfaces (APIs) to other applications; configuring and managing platform resources; policy enforcement and authorization of applications access to platform resource and other application's APIs; and policy conflict resolution.

11.The system of claim 1, wherein the programmable network device and programmable cloud device further comprise:

a distributed content service wherein contents generated by the at least one of the plurality of first network applications may be shared with the at least one of a plurality of second network applications.

12.The system of claim 1, wherein the programmable network device and programmable cloud device further comprise:

a distributed notification service wherein notice of a particular event is sent from at least one of the plurality of first network applications to at least one of the plurality of

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second network applications.

13.The system of claim 10, wherein the DRS further includes a load controller; and wherein the load controller is adapted to monitor loads on at least one of the plurality of first network applications and at least one of the plurality of second network applications and effect change in accordance with thresholds received from the application management portal.

14.The system of claim 1, wherein the programmable network device, at least one of the plurality of first network applications, the programmable cloud device, and at least one of the plurality of second network applications each have unique identities.

15. A system for processing data packets, the system comprising:

a programmable network device processing data flows hosting at least one of a plurality of first network applications;

a programmable cloud device having a plurality of virtual machines wherein at least one of the virtual machines hosts at least one of a plurality of second network applications;

wherein the at least one of the plurality of first and the at least one of the plurality of second network applications are in secure communication to form a distributed application;

the programmable network device and programmable cloud device are each powered by a sandboxing operation system which facilitates deployment of the plurality of first and second network applications and facilitates upgrade of the plurality of first and second network applications with substantially no interruption to operation of the programmable network device and programmable cloud device;

wherein the programmable network device verifies authenticity of the upgrades to the plurality of first network applications and the programmable cloud device verifies the authenticity of the upgrades to the plurality of second network applications and wherein the verification is based on unique security keys associated with each of the plurality of first and second network applications;

an application repository storing distributed applications which have been tested

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for installation in the programmable network device and programmable cloud device; and

an application management portal coupled to the programmable network device, programmable cloud device and the application repository, wherein the application management portal manages provisioning, usage and de-provisioning of the distributed applications on the programmable network device and programmable cloud device.

16.The system of claim 15, wherein the programmable network device is a Long Term Evolution (LTE) evolved NodeB (eNB) and the programmable cloud device hosts LTE core network functions in separate virtual machines, the network functions consisting of: Mobility Management Entity (MME), Serving Gateway (S-GW), and Packet Gateway f'-GW).

17. A system for processing data packets in a network, the system comprising:-

a programmable network device processing data flows, hosting at least one of a plurality of first network applications;

a programmable cloud device partitioned into a plurality of zones, wherein at least one of the plurality of zones hosts at least one of a plurality of fi.fst second network applications;

wherein the at least one of the plurality of first network applications and at least one of the plurality of second network applications are in secure communication to form a distributed application;

the programmable network device and programmable cloud device are each powered by a sandboxing operation system which facilitates deployment of the plurality of first and second network applications and facilitates upgrade of the plurality of first and second network applications with substantially no interruption to operation of the programmable network device and programmable cloud device;

wherein the programmable network device verifies authenticity and integrity of upgrades to the plurality of first network applications and the programmable cloud device verifies the authenticity of the upgrades to the plurality of second network applications and wherein the verification is based on unique security keys associated with each of the plurality of first and second network applications;

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an application repository storing distributed applications which have been tested for installation in the programmable network device and programmable cloud device; and

an application management portal coupled to the programmable network device, programmable cloud device and the application repository, wherein the application management portal manages usage of the distributed applications on the programmable network device and programmable cloud device.

18. The system of claim 17, wherein the programmable network device is a Long Term Evolution (LTE) evolved NodeB (eNB) and the programmable cloud device hosts LTE core network functions in separate virtual machines, the network functions consisting of: Mobility Management Entity (MME), Serving Gateway (S-GW), and Packet Gateway f'-GW).

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ABSTRACT

The Distributed Software Defined Network (dSDN) disclosed herein is an end to-end architecture that enables secure and flexible programmability across a network with full lifecycle management of services and infrastructure applications (fxDeviceApp). The dSDN also harmonizes application deployment across the network independent of the hardware vendor. As a result, the dSDN simplifies the network deployment lifecycle from concept to design to implementation to decommissioning.

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