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8143330

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

August 05, 2021

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: *62/784,114*
FILING DATE: *December 21, 2018*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/784,114*



Certified by

Anders Iversen

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

Provisional Application for Patent Cover Sheet This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)					
Inventor(s)					
Inventor 1					Remove
Given Name	Middle Name	Family Name	City	State	Country ;
Ajit		NIMBALKER	Fremont	CA	US
Inventor 2					Remove
Given Name	Middle Name	Family Name	City	State	Country ;
Sina		MALEKI	Malmö		SE
Inventor 3					Remove
Given Name	Middle Name	Family Name	City	State	Country ;
Pramod	Jacob	MATHECKEN	LUND		SE
Inventor 4					Remove
Given Name	Middle Name	Family Name	City	State	Country ;
Ali		NADER	MALMÖ		SE
Inventor 5					Remove
Given Name	Middle Name	Family Name	City	State	Country ;
Ravikiran		NORY	San Jose	CA	US
Inventor 6					Remove
Given Name	Middle Name	Family Name	City	State	Country ;
Andres		REIAL	MALMÖ		SE
All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the Add button.					Add
Title of Invention		Conditional Wake-Up Signal Configuration for New Radio			
Attorney Docket Number (if applicable)		017997.1838			
Correspondence Address					
Direct all correspondence to (select one):					
☒ The address corresponding to Customer Number			☐ Firm or Individual Name		

Doc Code: **TR.PROV**

Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (02-18)

Approved for use through 11/30/2020. OMB 0651-0032

U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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Customer Number	05073
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.	
☒	No.
☐	Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:
☐	Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Entity Status**Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29**

- ☐ Applicant asserts small entity status under 37 CFR 1.27
- ☐ Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ☒ No

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 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.

Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Kathryn A. Juffa/			Date (YYYY-MM-DD)	2018-12-21
First Name	Kathryn A.	Last Name	Juffa	Registration Number (If appropriate)	65688

This collection of information is required by 37 CFR 1.51. 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 8 hours 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. **This form can only be used when in conjunction with EFS-Web. If this form is mailed to the USPTO, it may cause delays in handling the provisional application.**

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.

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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	017997.1838
		Application Number	
Title of Invention	Conditional Wake-Up Signal Configuration for New Radio		
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.)
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Inventor Information:

Inventor 1					Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Ajit		NIMBALKER			
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service						
City	Fremont	State/Province	CA	Country of Residence	US	
Mailing Address of Inventor:						
Address 1		4241 Stanley Ave				
Address 2						
City	Fremont	State/Province	CA			
Postal Code	94538	Country i	US			
Inventor 2					Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Sina		MALEKI			
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service						
City	Malmö	Country of Residence i	SE			
Mailing Address of Inventor:						
Address 1		Zenithgatan 56 LGH 1202				
Address 2						
City	Malmö	State/Province				
Postal Code	212 14	Country i	SE			
Inventor 3					Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Pramod	Jacob	MATHECKEN			

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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number		017997.1838	
		Application Number			
Title of Invention		Conditional Wake-Up Signal Configuration for New Radio			
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service					
City	LUND		Country of Residence ⁱ		SE
Mailing Address of Inventor:					
Address 1		Mariagatan 6			
Address 2					
City	LUND		State/Province		
Postal Code	SE-223 53		Country ⁱ	SE	
Inventor 4					Remove
Legal Name					
Prefix	Given Name	Middle Name		Family Name	Suffix
	Ali			NADER	
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service					
City	MALMÖ		Country of Residence ⁱ		SE
Mailing Address of Inventor:					
Address 1		Jaktvagnsgatan 13			
Address 2					
City	MALMÖ		State/Province		
Postal Code	SE-212 42		Country ⁱ	SE	
Inventor 5					Remove
Legal Name					
Prefix	Given Name	Middle Name		Family Name	Suffix
	Ravikiran			NORY	
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		60 Descanso Dr, Unit 2421			
Address 2					
City	San Jose		State/Province		CA
Postal Code	95134		Country ⁱ	US	
Inventor 6					Remove
Legal Name					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	017997.1838
		Application Number	
Title of Invention	Conditional Wake-Up Signal Configuration for New Radio		

Prefix	Given Name	Middle Name	Family Name	Suffix
	Andres		REIAL	
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service				
City	MALMÖ	Country of Residence ⁱ	SE	

Mailing Address of Inventor:				
Address 1		Barometergatan 44		
Address 2				
City	MALMÖ	State/Province		
Postal Code	SE-211 17	Country ⁱ	SE	
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).	
☐ An Address is being provided for the correspondence information of this application.	
Customer Number	05073
Email Address	ptomail1@bakerbotts.com Add Email Remove Email

Application Information:

Title of the Invention	Conditional Wake-Up Signal Configuration for New Radio		
Attorney Docket Number	017997.1838	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	4	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country ⁱ

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	017997.1838
	Application Number	
Title of Invention Conditional Wake-Up Signal Configuration for New Radio		

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	05073		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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. When referring to the current application, please leave the "Application Number" field blank.			
Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			

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. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) ¹ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(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).

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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	017997.1838
		Application Number	
Title of Invention	Conditional Wake-Up Signal Configuration for New Radio		

			Remove
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ^j (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

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.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	017997.1838
	Application Number	
Title of Invention	Conditional Wake-Up Signal Configuration for New Radio	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is 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 State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	017997.1838
	Application Number	
Title of Invention Conditional Wake-Up Signal Configuration for New Radio		

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			
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	
☐ 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		Telefonaktiebolaget LM Ericsson (publ)	
Mailing Address Information For Applicant:			
Address 1		SE-164 83	
Address 2			
City		Stockholm	State/Province
Country	SE	Postal Code	
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button.			

Assignee Information including Non-Applicant Assignee 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.

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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	017997.1838
		Application Number	
Title of Invention	Conditional Wake-Up Signal Configuration for New Radio		

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		State/Province	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet must be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, all joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of all joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Kathryn A. Juffa/		Date (YYYY-MM-DD)	2018-12-21
First Name	Kathryn A.	Last Name	Juffa	Registration Number
				65688

Additional Signature may be generated within this form by selecting the Add button.

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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	017997.1838
		Application Number	
Title of Invention	Conditional Wake-Up Signal Configuration for New Radio		

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.

Conditional Wake-Up Signal Configuration for New Radio

INTRODUCTION

Generally, all terms used herein are to be interpreted according to their ordinary meaning in the relevant technical field, unless a different meaning is clearly given and/or is implied from the context in which it is used. All references to a/an/the element, apparatus, component, means, step, etc. are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any methods disclosed herein do not have to be performed in the exact order disclosed, unless a step is explicitly described as following or preceding another step and/or where it is implicit that a step must follow or precede another step. Any feature of any of the embodiments disclosed herein may be applied to any other embodiment, wherever appropriate. Likewise, any advantage of any of the embodiments may apply to any other embodiments, and vice versa. Other objectives, features and advantages of the enclosed embodiments will be apparent from the following description.

A New radio (NR) standard in 3GPP is being designed to provide service for multiple use cases such as enhanced mobile broadband (eMBB), ultra-reliable and low latency communication (URLLC), and machine type communication (MTC). Each of these services has different technical requirements. For example, the general requirement for eMBB is a high data rate with moderate latency and moderate coverage, while URLLC service requires a low latency and high reliability transmission but perhaps for moderate data rates.

One of the solutions to provide low latency data transmissions is to use shorter transmission time intervals. In NR, in addition to transmissions in a slot, a mini-slot transmission is also allowed to reduce latency. A mini-slot may consist of any number of 1 to 14 OFDM symbols. It should be noted that the concepts of slot and mini-slot are not specific to a specific service. For example, a mini-slot may be used for either eMBB, URLLC, or other services.

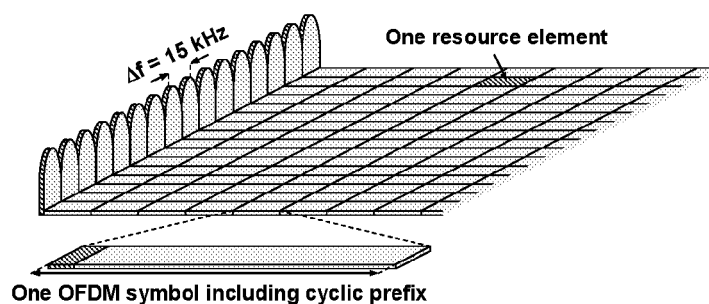


Figure 1 Exemplary radio resource in NR

UE Power consumption

UE power consumption is another important metric and it is desired to continue to reduce power consumption while providing better latency, reliability, coverage, and data rates. In general, significant power can be spent on monitoring the Physical Downlink Control Channel (PDCCH) in Long-term Evolution (LTE) based on

a discontinuous reception (DRX) setting from LTE field logs. A similar problem may also exist in NR if similar DRX settings with traffic modelling are utilized. For example, the UE may need to perform blind detection in its configured control resource sets (CORESETs) to identify whether there is a PDCCH sent to it, and act accordingly. Techniques that can reduce unnecessary PDCCH monitoring or allow the UE to go to sleep or wake-up only when required can be beneficial and reduce power consumption.

There currently exist certain challenge(s). Existing approaches for transmitting and monitoring for wakeup signals (WUS) may exhibit robustness issues. For example, if network node sends a wakeup signal to a UE and UE misses it, e.g., due to bad coverage, and remains in sleep state for extended periods of time, network node resources are wasted. Additionally, latency is increased because network node must wait until the next opportunity to transmit a WUS transmission before having the chance to transmit information to the UE. Moreover, if the WUS resource configuration is not appropriate for the channel condition for the UE, the UE may miss the WUS on multiple occasions, compounding the increased latency problem and degrading the overall user experience unless the network node can suitably reconfigure the WUS (e.g. by having higher aggregation levels, etc).

Certain aspects of the present disclosure and their embodiments may provide solutions to these or other challenges. For example, certain embodiments disclose a conditional WUS operation, wherein if a UE does not detect the WUS in a WUS monitoring occasion, it determines whether to monitor PDCCH or not based on an additional condition, e.g., a RSRP condition or a WUS decoder reliability metric, thereby providing additional robustness when reliable detection of WUS cannot be ensured. As another example, certain embodiments provide the UE skipping monitoring the WUS in a WUS occasion (or in one or more future WUS occasions), e.g., when the UE is in active time or inactivity timer is running. As yet another example, a network node configured parameter (such as WUS Monitoring occasion counter value) may be used so that the network can confidently configure a low aggregation level without risking losing the UE when it moves out of coverage of the WUS.

Certain embodiments include conditions on top of the conventional WUS operation to ensure recovery from unnecessary delays/robustness issues in WUS monitoring. For example, with the 'successful/unsuccessful WUS detection' criterion, the UE may use another reliability condition (e.g. whether RSRP measured by the UE is above/below a certain threshold, or whether WUS-PDCCH decoder's internal information suggests a presence of a compatibly encoded PDCCH) to determine whether to monitor/skip monitoring PDCCH in PDCCH monitoring occasion(s) corresponding to the WUS monitoring occasion. As another example, if a WUS monitoring occasion overlaps with a time slot where the UE is monitoring PDCCH (e.g UE is in active time), the UE may skip WUS monitoring in that WUS monitoring occasion and network node skips WUS transmission in that WUS monitoring occasion.

There are, proposed herein, various embodiments which address one or more of the issues disclosed herein.

Certain embodiments may provide one or more of the following technical advantage(s). For example, certain embodiments enable conditional WUS operation, which may reduce power consumption and latency. As another example, certain embodiments improve robustness when the WUS is missed at the UE due to bad

coverage or insufficient WUS resources in certain scenarios (e.g., if the link quality is degraded such that the configured WUS resources are inadequate to maintain good WUS detection performance). Certain embodiments may avoid unnecessary interruption/delays in PDCCH monitoring in case of missed detection of WUS at the UE. Additionally, certain embodiments also reduce resource wastage in WUS reconfiguration.

ADDITIONAL EXPLANATION

Some of the embodiments contemplated herein will now be described more fully with reference to the accompanying drawings. Other embodiments, however, are contained within the scope of the subject matter disclosed herein, the disclosed subject matter should not be construed as limited to only the embodiments set forth herein; rather, these embodiments are provided by way of example to convey the scope of the subject matter to those skilled in the art.

Several embodiments of WUS configurations and monitoring techniques for improved WUS operation are described in detail below. For the purposes of this disclosure, the term "wakeup signal" may be any suitable signal, such as a power saving signal or signal for saving power. Additionally, references herein to a User Equipment (UE) are merely exemplary and any suitable wireless device may be configured to implement the various embodiments discussed herein.

In certain embodiments, the UE can receive information in PDCCH Downlink Control Indicator (DCI) (e.g. in PDCCH scheduling UL/DL data for the UE) or a MAC Control Element, indicating whether the UE needs to monitor WUS in subsequent WUS monitoring occasions, e.g., dynamic/semi-dynamic enabling/disabling of WUS monitoring. The network node may determine when the UE needs to monitor the WUS based on its own assessment of propagation conditions of the UE (e.g., based on CQI reports, RSRP/RSRQ measurement reports etc.) or in coordination with capabilities reported by the UE (e.g., UE has indicated that it supports WUS and furthermore benefits from it).

If UE exits the WUS monitoring state for any reason (e.g., the RSRP falls below a threshold previously configured by the network node via dedicated/broadcast signalling), the UE can inform the network that it has exited WUS monitoring state, according to certain embodiments. For example, when UE exits the WUS monitoring state, the UE may follow the PDCCH monitoring procedure as if WUS is not configured for that UE. Additionally, or instead of, the network node can reconfigure new WUS resources for the UE. Such reconfiguration may either be based on channel condition report from UE upon exiting WUS monitoring state, and/or based on network node's own assessment of the channel conditions upon later communications.

WUS resource configuration can include one or more relative time offsets (e.g., X symbols/slots before or relative to an ON duration). In some embodiments, X can be 0. In TDD, X may be the latest DL slot or a DL symbol in a slot that is X slots/symbols before ON duration. The relative time offset can be used to determine time offset from the time of WUS reception to the time when UE is required to start monitoring PDCCH in an ON duration corresponding to WUS monitoring occasion where WUS is detected. In certain embodiments, there may be one or more sets of latent WUS resources configured in the UE, in addition to the active WUS resource. The

network node may then via short commands such as MAC-CEs or DCIs order UE to shift its configuration, e.g., to one of the latent WUS resources.

First Set of Embodiments: Baseline WUS Operation

According to a first set of embodiments, a UE can be configured with DRX and WUS resources. The UE may determine whether to attempt to detect WUS in a monitoring occasion based on a condition. Figure 2 illustrates a particular example, which will be described in further detail below.

If the UE is configured with WUS resources, UE can monitor (i.e., attempt to detect) WUS in a WUS monitoring occasion. The WUS monitoring occasion can be at the beginning of a DRX ON duration, or before a DRX ON duration (e.g., offset relative to ON duration is configured indicating where the WUS monitoring occasion can be relative to DRX ON duration).

If the UE detects WUS in a WUS monitoring occasion, the UE may monitor PDCCH during the PDCCH monitoring occasion(s) associated with the WUS monitoring occasion. If the UE detects a PDCCH during the PDCCH monitoring occasion (e.g. within a DRX ON duration) associated with the WUS monitoring occasion, UE may continue to monitor PDCCH, e.g., until end of active time or until expiration of Inactivity timer (IAT). The UE "monitoring" may include decoding PDCCH candidates to detect a PDCCH intended for the UE.

In one example, an association between a WUS monitoring occasion and a PDCCH monitoring occasion may be preconfigured by the network or a network node (network node herein refers to any interface between the wireless device and the wireless network, such as an evolved NodeB, a gNB, or any other base station) or, in some cases, be dynamically configured using information from the WUS of when the UE should monitor the first PDCCH (e.g., after N slots or the end of a time counter).

In another approach, the WUS or one of the scheduling PDCCH occasions can indicate when the UE can stop monitoring PDCCH.

UE need not monitor WUS during WUS monitoring occasions overlapping the slots where UE is monitoring PDCCH (e.g., during "active time"). On the network node side, the network node does not need send WUS in a WUS monitoring occasion if it knows the UE is already monitoring PDCCH in a time slot overlapping that monitoring occasion.

Furthermore, the UE need not monitor WUS during occasions reserved for other activities. For example, the UE may not monitor WUS during measurement gaps, UL slots, etc. In some embodiments, the network node may provide a specific configuration to the UE that informs the UE that WUS monitoring is cancelled in certain occasions (slot/symbols). As mentioned further below, such cancelled occasions may imply, in some instances, that normal PDCCH monitoring shall apply for the UE.

After the end of the PDCCH monitoring duration (e.g., end of "active time"), the UE may resume monitoring WUS at WUS monitoring occasion(s) corresponding to subsequent PDCCH monitoring duration(s) (e.g., subsequent ON duration(s)).

If UE does not detect WUS in a WUS monitoring occasion, UE may skip PDCCH monitoring during the PDCCH monitoring occasion (e.g., an occasion during the DRX ON-duration) associated with the WUS monitoring occasion and continue to monitor WUS in subsequent WUS monitoring occasion(s).

In some embodiments, a single WUS occasion is associated with multiple PDCCH monitoring occasions (e.g., multiple DRX ON-durations). In such cases, the above behavior may be applied to all the DRX ON-durations associated to the single WUS monitoring occasion.

In some embodiments, if the IAT expires before an ON duration (or the “active time”) expires, but at or after a WUS occasion or slot within the WUS occasion, the UE can monitor PDCCH in the ON duration.

In some embodiments, if UE is not monitoring WUS in a WUS monitoring occasion, it monitors PDCCH in the associated PDCCH monitoring occasions.

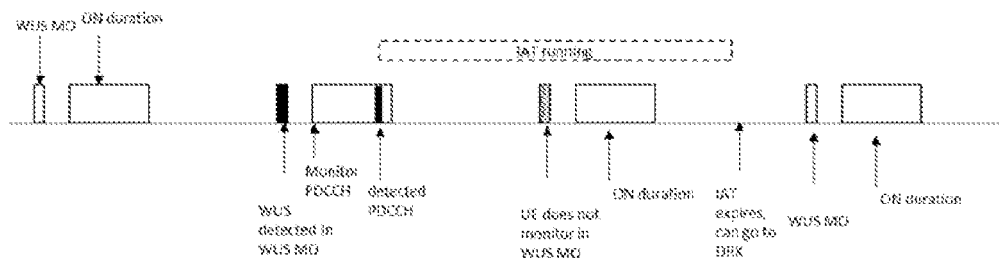


Figure 2: Example showing WUS operation including an example where UE does not monitor WUS in a WUS occasion based on a condition (IAT running).

Second Set of Embodiments: Conditional WUS Operation

The first set of embodiments describe a procedure in which the UE skips monitoring PDCCH in PDCCH monitoring occasion(s) (e.g. DRX ON duration(s)), corresponding to the WUS monitoring occasion if it does not detect WUS in a WUS monitoring occasion.

The reliability of WUS detection may depend on the UE propagation channel condition between the network node (e.g., a new radio network node, such as a gNB) that is transmitting the WUS and the UE and/or a detection threshold which may be fixed or adaptive for the corresponding WUS detector. In circumstances where WUS detection is less reliable, it may be desirable that the UE does not solely rely on a ‘unsuccessful WUS detection’ in a WUS monitoring occasion as the criterion for skipping PDCCH monitoring in PDCCH monitoring occasions(s) associated with that WUS monitoring occasion. A missed detection of a WUS may lead to increased latency and packet losses of data traffic that the UE is scheduled to receive. When WUS detection is reliable, the UE may rely on the WUS detection and achieve power savings.

In certain embodiments, if the conditions for reliable WUS detection are not present, the UE even though configured for WUS reception, may not skip PDCCH monitoring in a PDCCH monitoring occasion when a WUS is not detected in the WUS monitoring occasion(s) corresponding to that PDCCH monitoring occasion(s). This may result in the UE monitoring PDCCH even if a WUS was not sent to the UE.

From the network node perspective, including the above functionality may enable it to use a more aggressive link adaptation when transmitting WUS. In certain embodiments, if the network node uses a PDCCH structure to transmit WUS, instead of choosing the highest possible aggregation level for WUS to ensure reliable detection at the UE, the network node may send WUS using a lower aggregation level, and rely on the UE to not use the 'unsuccessful WUS detection' in a WUS monitoring occasion as a criterion for skipping PDCCH monitoring, if the UE determines that WUS detection is unreliable for that aggregation level.

Several techniques may be applied to determine the conditions on which the UE conditionally monitors the PDCCH based on the WUS, as detailed below.

In certain embodiments, a UE can be configured with DRX and WUS resources. The UE may be configured to use conditional WUS operation to determine whether to monitor the PDCCH. Figure 3 illustrates an example of conditional WUS.

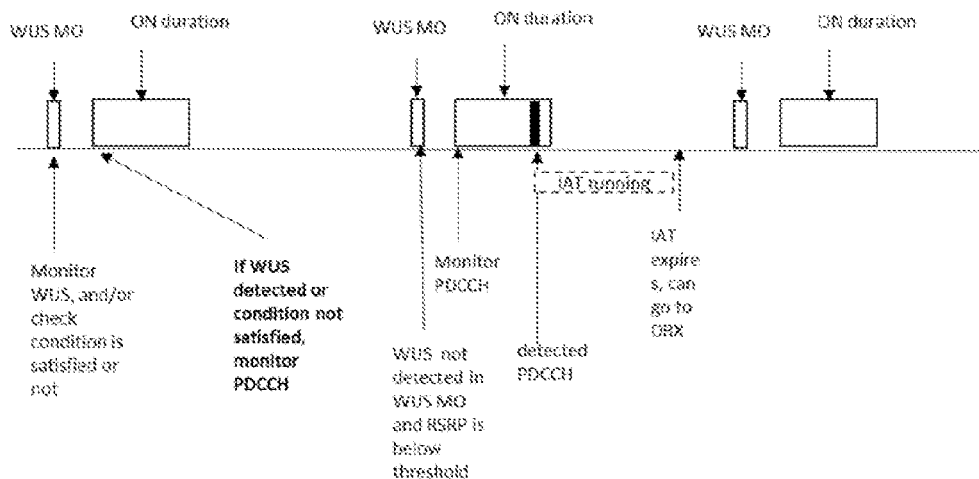


Figure 3: Example showing conditional WUS operation including an example where UE monitors PDCCH based on an additional condition).

In certain embodiments, the WUS configuration can include one or more of: an RSRP threshold X, RSRP measurement signal and/or resource. The RSRP measurement signal can be a SSB and/or periodic or aperiodic CSI-RS resource and/or a TRS. The RSRP measurement signal can also be a resource that is configured to provide the UE time/frequency synchronization information. Alternatively, in certain embodiments, instead of RSRP threshold, a RSRQ measurement signal and RSRQ threshold can also be used. In some embodiments, RSRP and RSRQ can be used together. A CSI threshold or a hypothetical WUS BLER threshold or in-sync or out-of-sync indications as part of RLM procedure can also be considered as a quality metric for evaluation conditions based a configured measurement signal such as a SSB or a CSI-RS resource and/or a TRS.

As used in this disclosure "RSRP" may be SS-RSRP and/or CSI-RSRP and/or RSRP on a specified signal. Also, "RSRQ" may be SS-RSRQ and/or CSI-RSRQ and/or RSRQ on a specified signal. Additionally, the RSRP and/or the RSRQ can be based on L1 RSRP or higher layer filtered RSRP or RSRQ (e.g., L3 filtered).

The CSI condition can be based on measurement on a periodic CSI-RS resource and/or an aperiodic CSI-RS resource. For example, an aperiodic CSI-RS resource may be transmitted in an aperiodic CSI-RS resource occasion associated with WUS monitoring occasion.

In certain embodiments, the condition may be based on a synchronization condition such as an Out-of-Sync (OOS) or In-Sync event or a few In-Sync indications to upper layers (e.g., configured number X) and/or a few Out-of-Sync indications to upper layers (e.g., configured number Y) that may occur during RLM process.

The condition on which the conditional WUS operation may be based may include one or more of the above conditions.

For the sake of simplicity, and not to be construed as limiting the present invention, further descriptions of the various embodiments refer to using RSRP measurements and thresholds, but any of the other described conditions described above may be used, alone or in any suitable combination, for the conditional WUS operation.

Example Conditional WUS Operation

In one example, the UE is configured with WUS resources and monitors WUS in a WUS monitoring occasion corresponding to a PDCCH monitoring occasion such as a DRX ON duration (e.g. offset relative to ON duration is configured).

The UE may detect a WUS in a WUS monitoring occasion and then monitor PDCCH during the corresponding ON duration. Then, if UE detects PDCCH, the UE continues monitoring PDCCH until end of active time. The UE may not monitor WUS in any WUS monitoring occasions that occur during active time. If UE does not detect PDCCH during ON duration, UE may monitor for a WUS in next WUS monitoring occasion.

In some embodiments, the UE does not detect WUS in a WUS monitoring occasion before a DRX ON duration. Instead of only relying on the lack of detecting a WUS, the UE may further determine if the RSRP is larger than a RSRP threshold. If the RSRP exceeds the threshold, the UE may skip PDCCH monitoring for this ON duration and monitors WUS before next ON duration. If the RSRP is lower than the threshold, the UE monitors the PDCCH occasion during the ON duration, even if a WUS is not detected in the WUS monitoring occasion.

As shown in the example above, in certain embodiments, if the UE does not detect a WUS in a WUS monitoring occasion, UE applies a condition (e.g., the RSRP threshold determination, etc.) to determine whether to wake-up and monitor PDCCH or not monitor PDCCH during the PDCCH monitoring occasion(s) corresponding to the WUS monitoring occasion.

A WUS occasion that is right before (e.g., a configured offset relative to an ON duration) can be associated with that ON duration. In some embodiments, a single WUS occasion is associated with multiple PDCCH monitoring occasions (e.g., multiple DRX ON-durations). In such cases, the above behavior may be applied to all the DRX ON-durations associated to the single WUS monitoring occasion.

In some embodiments, if the IAT expires before an ON duration (or the “active time”) expires, but at or after a WUS occasion or slot within the WUS occasion, the UE can monitor PDCCH in the ON duration.

In some embodiments, if UE is not monitoring WUS in a WUS monitoring occasion, it monitors PDCCH in the associated PDCCH monitoring occasions.

In certain embodiments, multiple RSRP thresholds may be applied. More generally, the network node can configure different conditions for WUS reliability for different WUS monitoring occasions. As a specific example, different configurations may apply to different carrier bandwidth parts (BWPs).

As described above with respect to the first set of embodiments, WUS resource configuration can include one or more relative time offsets (e.g., X slots before On duration). In some embodiments, X can be 0. In TDD, X may be the latest DL slot that is X slots before On duration. In TDD, X can be the latest DL slot or a DL symbol in a slot that is X slots/symbols before ON duration. The relative time offset can be used to determine time offset from the time of WUS reception to the time when UE is required to start monitoring PDCCH in an ON duration corresponding to WUS monitoring occasion where WUS is detected.

In certain embodiments, the WUS and PDCCH frequency resources may be different. For example, the WUS resources might be configured in the same frequency location (or BWP) where the SSB resides, whereas the PDCCH might be configured in another frequency location.

In certain embodiments, based on RSRP reporting, network node can determine if the configured WUS resource for a UE is adequate or needs to be adapted. However, if UE detects the RSRP had fallen below a threshold, it can send an indication to the network node requesting configuration of a new WUS resource. For example, the triggered indication may be based on L1 measurement report, based on new RRC configured measurement event (e.g. WUS BLER exceeds certain level), based on network node assessment of channel, or explicitly indicated by the UE via UL control channel PUCCH or through a random-access procedure (e.g., optionally with predefined preamble).

Accordingly, various embodiments have been described that allow for conditional WUS operation.

Third Set of Embodiments: WUS-ACK Mechanism

According to a third set of embodiments, the WUS mechanism may be made more robust to avoid missing detection, by configuring the UE to send a feedback called WUS-ACK in response to successfully receiving a WUS. In some embodiments, the UE may abstain from sending feedback in case it has missed detection of WUS or has not received a WUS.

In certain embodiments, the WUS-ACK by the UE may help the network node to save resources when the UE has missed a WUS. For example, the network node may infer or determine that the UE is not awake and therefore, not send any subsequent PDCCH(s). Instead, the network node may send a WUS again in the next WUS monitoring occasion. In some embodiments, the frequency of monitoring occasions is increased, thereby allowing the lowering of the latency when a WUS has been missed. Moreover, even if the network node does not receive an ACK successfully or has received it because of a false alarm, it does not increase the resources used by the network node because the network node will simply abstain from sending a scheduling PDCCH.

In certain embodiments, a WUS-ACK may lead to a slight power consumption at the UE for one transmission. However, it may reduce the number of lost packets caused by missing the detection of the WUS. Furthermore, in embodiments where frequent WUS monitoring occasions are configured for the UE, the UE can save energy by not having to monitor the rest of the monitoring occasions, if a WUS is detected in a previous one.

In certain embodiments, the WUS-ACK mechanism (i.e., whether the UE shall send ACK or not upon WUS detection) is controlled by the network node, e.g., on a UE-basis. For example, for a UE within a certain range of the cell, the network node might want to invoke WUS-ACK reporting. The configuration may entail a conditional threshold as discussed above to be configured at the same time, or an offset to the previously-described thresholds. For example, in particular embodiments, a UE perceiving a RSRP below such threshold would start reporting WUS-ACKs. This may act as a warning to the network node that the UE is getting out of WUS coverage. In response, the network node may reconfigure WUS resources.

One example implementation of the WUS-ACK feature is to send the ACK over PUCCH, e.g. using PUCCH formats 0 or 1. The network node may preconfigure the UE to use specific resources for the ACK, e.g., configuring to use certain resources that have a specific offset from the WUS monitoring occasion. As another example, the network node can send a more detailed WUS indicating such resources and offset if it uses PDCCH based WUS, for example.

Figure 4 illustrates an example of WUS-ACK operation according to certain embodiments.

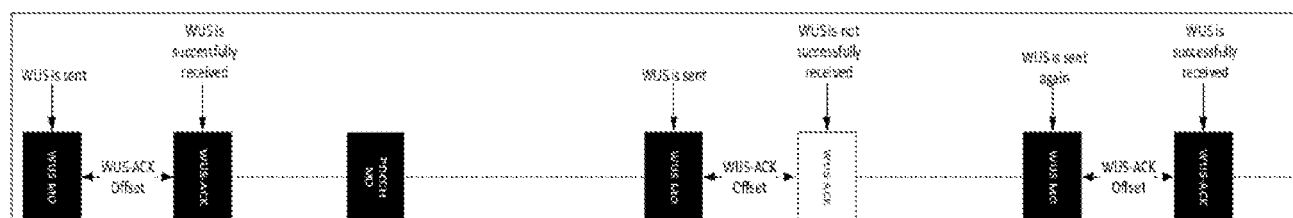


Figure 4: Example of WUS-ACK mechanism operation

Fourth Set of Embodiments: High/Low Aggregation Levels Mixing

In order to let the network confidently configure a low aggregation level without risking losing the UE in cases it moves out of coverage of the WUS, a network node configured parameter, e.g., a timer or a counter counting N number of successive WUS occasions may be introduced. In certain embodiments, the network node configures such counter and after N WUS monitoring occasions, regardless of WUS presence was detected or not by the UE, the UE exits WUS monitoring state and falls back to regular PDCCH monitoring CORESET, assumedly with higher aggregation level. As a result, the network node would have more leeway to configure the UE with a low aggregation level if the UE is configured with the fall-back mechanism if it moves out of WUS coverage. In some embodiments, an indication is sent from the UE to the network node indicating that the UE has left the WUS monitoring state. This may prevent the network node from wasting resources on sending WUSs that would not be decoded by the UE. In some embodiments, the indication could include channel conditions reports and based on such reports, if the quality is good enough, the network node could command the UE to

return to the WUS monitoring state. For example, the network node may command the UE to return to the WUS monitoring state with a different timer or counter value N' , where N' is greater than N if the reported quality is very high. In some embodiments, N could be set to zero meaning that timer is disabled.

An example is shown in Figure 5, where the command to monitor WUS includes a timer value N , which tells the UE to monitor WUS in N WUS monitoring occasions. Subsequently, the UE may not monitor WUS until it gets another command to monitor WUS with potential new WUS configuration and a timer value.



Figure 5: Example illustrating case of WUS monitoring based on N occasions.

According to certain embodiments, the UE may be configured with a first timer value N and a second timer value M . The UE monitors for a WUS in only M out of N possible WUS occasions (e.g., in a duty cycle for WUS monitoring). Accordingly, the network node could potentially always reach the UE (e.g., even if UE fails to detect WUS in M occasions, the UE could be reachable in the $N-M$ opportunities). Further, with this approach the command need not be re-sent/updated every N cycles since network node can re-configure WUS to the UE on an as-needed basis. Such a configuration may also allow the network to configure dedicated WUS CORESETs, whereby the search spaces in these CORESETs are configured with lower aggregation levels. As a result, the network may schedule more wake-up signals to multiple UEs, thereby, increasing its scheduling flexibility while at the same time allowing for a fall-back mechanism for handling UEs in bad coverage areas.

In certain embodiments, the regular PDCCH monitoring CORESET can have multiple search spaces which include search spaces configured for higher aggregation levels. Such a search space may ensure that a UE in bad coverage area is still reachable.

Fifth Set of Embodiments: WUS decoder metric to determine PDCCH monitoring

In previous embodiments, e.g., the second set of embodiments, the estimated channel quality (or other conditions) for the network node-UE link may be used to trigger PDCCH monitoring even if WUS is not detected. This may prevent performance degradation when a transmitted WUS is not successfully decoded by the UE. However, this may also result in unnecessary PDCCH monitoring and energy consumption by the UE. According to the fifth set of embodiments, the latter may be reduced by utilizing internal decoder metrics from the UE's channel decoder. In contrast to the RSRP or other quality metrics, these embodiments may determine the

PDCCH monitoring decision according to the instantaneous effective channel quality, instead of an average quality.

In certain embodiments, the UE uses its control channel decoder to obtain a soft metric characterizing the convergence to a received valid codeword. The decoder metric may be a S-metric in a soft Viterbi decoder, a mean extrinsic information magnitude in a Turbo decoder, another soft value quality metrics in a LDPC decoder, message reliabilities in a message-passing Polar decoder, a path metric in Polar list decoding, etc. If the input signal to the decoder is not a valid codeword, the decoder metric value does not typically increase significantly during an iterative or sequential decoding process, whereas in the presence of a valid codeword, a metric increase may be observed in scenarios of interest. If the coded bits' quality is insufficient for decoding, the increase of the decoder metric saturates at some level, e.g., depending on the received symbol SINR, while successful decoding is accompanied by the decoder metric reaching high values.

Recognizing a likely PDCCH decoding that was unsuccessful may thus be achieved by detecting that the decoder metric exceeds and remains above a threshold at some point in the decoding process. If the decoding was unsuccessful, it is not possible to ascertain the C-RNTI used to scramble the CRC of the PDCCH or its contents, and thus to determine whether the WUS or another PDCCH in the predetermined resources was directed to the given UE. However, detecting that a WUS-compatible PDCCH format was likely transmitted allows more reliable triggering of scheduling PDCCH monitoring, while avoiding PDCCH monitoring when no WUS-compatible PDCCH was transmitted.

In certain embodiments, the decoder metric may be a demodulator output metric, e.g. the soft value distribution at the demodulator output, indicating a likely presence of QPSK symbols in the relevant REs in the WUS-PDCCH search space. While the RE contents may not be determined, the metric allows avoiding PDCCH monitoring if no QPSK signal contents were present in the search space.

According to certain embodiments, the UE may perform PDCCH monitoring if a WUS is successfully detected or if the decoder metric is above a predetermined threshold, indicating that a WUS may have been sent but the channel conditions have not permitted proper decoding. If the metric is below the threshold, indicating a lack of WUS transmission, no PDCCH monitoring is performed during the following period. In some embodiments, if the WUS SS contains multiple WUS-PDCCH formats or T/F locations, the largest of all performed tentative decoding metrics is used. In some embodiments, the threshold may be determined based on numerical evaluations made offline and stored, and the threshold value may a function of a channel quality metric, e.g., a metric described above in the second set of embodiments. Alternatively, in some embodiments, the threshold may be based on UE's online statistics about the decoder metric values encountered during WUS decoding, such as the decoder metric values for instances of successful decoding and decoding failures.

In some embodiments, the decoder metric may be combined with a channel quality metric to provide the conditional WUS operation. For example, when the channel quality metric is below a threshold, monitoring is performed regardless of the decoder metric result. But if the decoder metric result may be used if channel quality metric is above a threshold to determine when to perform monitoring. Furthermore, several types of metrics (decoder output metric, demodulator output metric, average channel quality metric, etc.) may be combined to

determine the monitoring decision. Different combinations of metrics and thresholds may be used at different channel quality conditions.

In some embodiments, the network node may have control over activating the use of decoder metric. The UE may indicate the capability or request the use of the feature and the network node may configure the UE to use it and/or specify signal quality, decoder metric, and other parameter value thresholds for the PDCCH monitoring decision.

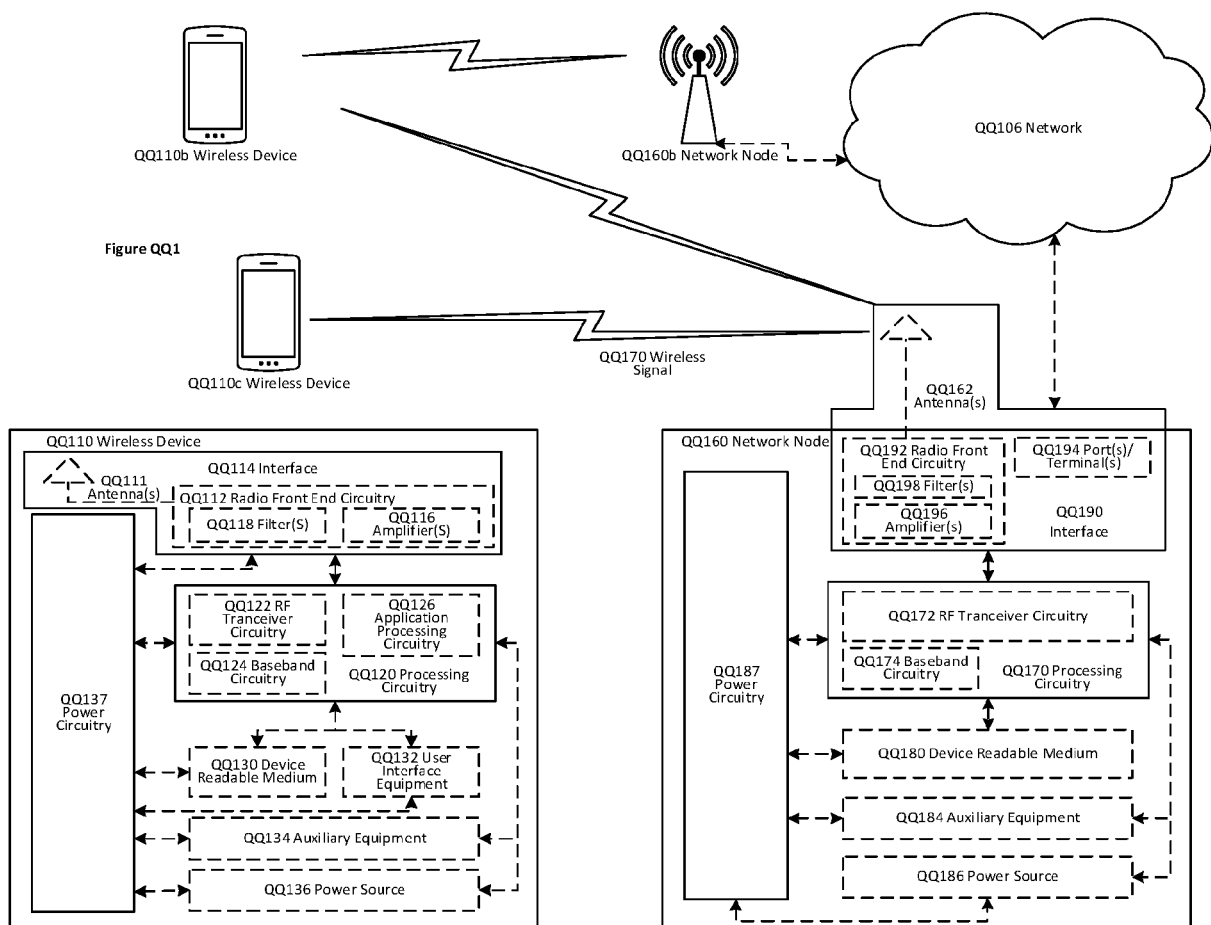


Figure QQ1: A wireless network in accordance with some embodiments.

Although the subject matter described herein may be implemented in any appropriate type of system using any suitable components, the embodiments disclosed herein are described in relation to a wireless network, such as the example wireless network illustrated in Figure QQ1. For simplicity, the wireless network of Figure QQ1 only depicts network QQ106, network nodes QQ160 and QQ160b, and WDs QQ110, QQ110b, and QQ110c. In practice, a wireless network may further include any additional elements suitable to support communication between wireless devices or between a wireless device and another communication device, such

as a landline telephone, a service provider, or any other network node or end device. Of the illustrated components, network node QQ160 and wireless device (WD) QQ110 are depicted with additional detail. The wireless network may provide communication and other types of services to one or more wireless devices to facilitate the wireless devices' access to and/or use of the services provided by, or via, the wireless network.

The wireless network may comprise and/or interface with any type of communication, telecommunication, data, cellular, and/or radio network or other similar type of system. In some embodiments, the wireless network may be configured to operate according to specific standards or other types of predefined rules or procedures. Thus, particular embodiments of the wireless network may implement communication standards, such as Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Long Term Evolution (LTE), and/or other suitable 2G, 3G, 4G, or 5G standards; wireless local area network (WLAN) standards, such as the IEEE 802.11 standards; and/or any other appropriate wireless communication standard, such as the Worldwide Interoperability for Microwave Access (WiMax), Bluetooth, Z-Wave and/or ZigBee standards.

Network QQ106 may comprise one or more backhaul networks, core networks, IP networks, public switched telephone networks (PSTNs), packet data networks, optical networks, wide-area networks (WANs), local area networks (LANs), wireless local area networks (WLANs), wired networks, wireless networks, metropolitan area networks, and other networks to enable communication between devices.

Network node QQ160 and WD QQ110 comprise various components described in more detail below. These components work together in order to provide network node and/or wireless device functionality, such as providing wireless connections in a wireless network. In different embodiments, the wireless network may comprise any number of wired or wireless networks, network nodes, base stations, controllers, wireless devices, relay stations, and/or any other components or systems that may facilitate or participate in the communication of data and/or signals whether via wired or wireless connections.

As used herein, network node refers to equipment capable, configured, arranged and/or operable to communicate directly or indirectly with a wireless device and/or with other network nodes or equipment in the wireless network to enable and/or provide wireless access to the wireless device and/or to perform other functions (e.g., administration) in the wireless network. Examples of network nodes include, but are not limited to, access points (APs) (e.g., radio access points), base stations (BSs) (e.g., radio base stations, Node Bs, evolved Node Bs (eNBs) and NR NodeBs (gNBs)). Base stations may be categorized based on the amount of coverage they provide (or, stated differently, their transmit power level) and may then also be referred to as femto base stations, pico base stations, micro base stations, or macro base stations. A base station may be a relay node or a relay donor node controlling a relay. A network node may also include one or more (or all) parts of a distributed radio base station such as centralized digital units and/or remote radio units (RRUs), sometimes referred to as Remote Radio Heads (RRHs). Such remote radio units may or may not be integrated with an antenna as an antenna integrated radio. Parts of a distributed radio base station may also be referred to as nodes in a distributed antenna system (DAS). Yet further examples of network nodes include multi-standard radio (MSR) equipment such as MSR BSs, network controllers such as radio network controllers (RNCs) or base station

controllers (BSCs), base transceiver stations (BTSs), transmission points, transmission nodes, multi-cell/multicast coordination entities (MCEs), core network nodes (e.g., MSCs, MMEs), O&M nodes, OSS nodes, SON nodes, positioning nodes (e.g., E-SMLCs), and/or MDTs. As another example, a network node may be a virtual network node as described in more detail below. More generally, however, network nodes may represent any suitable device (or group of devices) capable, configured, arranged, and/or operable to enable and/or provide a wireless device with access to the wireless network or to provide some service to a wireless device that has accessed the wireless network.

In Figure QQ1, network node QQ160 includes processing circuitry QQ170, device readable medium QQ180, interface QQ190, auxiliary equipment QQ184, power source QQ186, power circuitry QQ187, and antenna QQ162. Although network node QQ160 illustrated in the example wireless network of Figure QQ1 may represent a device that includes the illustrated combination of hardware components, other embodiments may comprise network nodes with different combinations of components. It is to be understood that a network node comprises any suitable combination of hardware and/or software needed to perform the tasks, features, functions and methods disclosed herein. Moreover, while the components of network node QQ160 are depicted as single boxes located within a larger box, or nested within multiple boxes, in practice, a network node may comprise multiple different physical components that make up a single illustrated component (e.g., device readable medium QQ180 may comprise multiple separate hard drives as well as multiple RAM modules).

Similarly, network node QQ160 may be composed of multiple physically separate components (e.g., a NodeB component and a RNC component, or a BTS component and a BSC component, etc.), which may each have their own respective components. In certain scenarios in which network node QQ160 comprises multiple separate components (e.g., BTS and BSC components), one or more of the separate components may be shared among several network nodes. For example, a single RNC may control multiple NodeB's. In such a scenario, each unique NodeB and RNC pair, may in some instances be considered a single separate network node. In some embodiments, network node QQ160 may be configured to support multiple radio access technologies (RATs). In such embodiments, some components may be duplicated (e.g., separate device readable medium QQ180 for the different RATs) and some components may be reused (e.g., the same antenna QQ162 may be shared by the RATs). Network node QQ160 may also include multiple sets of the various illustrated components for different wireless technologies integrated into network node QQ160, such as, for example, GSM, WCDMA, LTE, NR, WiFi, or Bluetooth wireless technologies. These wireless technologies may be integrated into the same or different chip or set of chips and other components within network node QQ160.

Processing circuitry QQ170 is configured to perform any determining, calculating, or similar operations (e.g., certain obtaining operations) described herein as being provided by a network node. These operations performed by processing circuitry QQ170 may include processing information obtained by processing circuitry QQ170 by, for example, converting the obtained information into other information, comparing the obtained information or converted information to information stored in the network node, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination.

Processing circuitry QQ170 may comprise a combination of one or more of a microprocessor, controller, microcontroller, central processing unit, digital signal processor, application-specific integrated circuit, field programmable gate array, or any other suitable computing device, resource, or combination of hardware, software and/or encoded logic operable to provide, either alone or in conjunction with other network node QQ160 components, such as device readable medium QQ180, network node QQ160 functionality. For example, processing circuitry QQ170 may execute instructions stored in device readable medium QQ180 or in memory within processing circuitry QQ170. Such functionality may include providing any of the various wireless features, functions, or benefits discussed herein. In some embodiments, processing circuitry QQ170 may include a system on a chip (SOC).

In some embodiments, processing circuitry QQ170 may include one or more of radio frequency (RF) transceiver circuitry QQ172 and baseband processing circuitry QQ174. In some embodiments, radio frequency (RF) transceiver circuitry QQ172 and baseband processing circuitry QQ174 may be on separate chips (or sets of chips), boards, or units, such as radio units and digital units. In alternative embodiments, part or all of RF transceiver circuitry QQ172 and baseband processing circuitry QQ174 may be on the same chip or set of chips, boards, or units.

In certain embodiments, some or all of the functionality described herein as being provided by a network node, base station, eNB or other such network device may be performed by processing circuitry QQ170 executing instructions stored on device readable medium QQ180 or memory within processing circuitry QQ170. In alternative embodiments, some or all of the functionality may be provided by processing circuitry QQ170 without executing instructions stored on a separate or discrete device readable medium, such as in a hard-wired manner. In any of those embodiments, whether executing instructions stored on a device readable storage medium or not, processing circuitry QQ170 can be configured to perform the described functionality. The benefits provided by such functionality are not limited to processing circuitry QQ170 alone or to other components of network node QQ160, but are enjoyed by network node QQ160 as a whole, and/or by end users and the wireless network generally.

Device readable medium QQ180 may comprise any form of volatile or non-volatile computer readable memory including, without limitation, persistent storage, solid-state memory, remotely mounted memory, magnetic media, optical media, random access memory (RAM), read-only memory (ROM), mass storage media (for example, a hard disk), removable storage media (for example, a flash drive, a Compact Disk (CD) or a Digital Video Disk (DVD)), and/or any other volatile or non-volatile, non-transitory device readable and/or computer-executable memory devices that store information, data, and/or instructions that may be used by processing circuitry QQ170. Device readable medium QQ180 may store any suitable instructions, data or information, including a computer program, software, an application including one or more of logic, rules, code, tables, etc. and/or other instructions capable of being executed by processing circuitry QQ170 and, utilized by network node QQ160. Device readable medium QQ180 may be used to store any calculations made by processing circuitry QQ170 and/or any data received via interface QQ190. In some embodiments, processing circuitry QQ170 and device readable medium QQ180 may be considered to be integrated.

Interface QQ190 is used in the wired or wireless communication of signalling and/or data between network node QQ160, network QQ106, and/or WDs QQ110. As illustrated, interface QQ190 comprises port(s)/terminal(s) QQ194 to send and receive data, for example to and from network QQ106 over a wired connection. Interface QQ190 also includes radio front end circuitry QQ192 that may be coupled to, or in certain embodiments a part of, antenna QQ162. Radio front end circuitry QQ192 comprises filters QQ198 and amplifiers QQ196. Radio front end circuitry QQ192 may be connected to antenna QQ162 and processing circuitry QQ170. Radio front end circuitry may be configured to condition signals communicated between antenna QQ162 and processing circuitry QQ170. Radio front end circuitry QQ192 may receive digital data that is to be sent out to other network nodes or WDs via a wireless connection. Radio front end circuitry QQ192 may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters QQ198 and/or amplifiers QQ196. The radio signal may then be transmitted via antenna QQ162. Similarly, when receiving data, antenna QQ162 may collect radio signals which are then converted into digital data by radio front end circuitry QQ192. The digital data may be passed to processing circuitry QQ170. In other embodiments, the interface may comprise different components and/or different combinations of components.

In certain alternative embodiments, network node QQ160 may not include separate radio front end circuitry QQ192, instead, processing circuitry QQ170 may comprise radio front end circuitry and may be connected to antenna QQ162 without separate radio front end circuitry QQ192. Similarly, in some embodiments, all or some of RF transceiver circuitry QQ172 may be considered a part of interface QQ190. In still other embodiments, interface QQ190 may include one or more ports or terminals QQ194, radio front end circuitry QQ192, and RF transceiver circuitry QQ172, as part of a radio unit (not shown), and interface QQ190 may communicate with baseband processing circuitry QQ174, which is part of a digital unit (not shown).

Antenna QQ162 may include one or more antennas, or antenna arrays, configured to send and/or receive wireless signals. Antenna QQ162 may be coupled to radio front end circuitry QQ190 and may be any type of antenna capable of transmitting and receiving data and/or signals wirelessly. In some embodiments, antenna QQ162 may comprise one or more omni-directional, sector or panel antennas operable to transmit/receive radio signals between, for example, 2 GHz and 66 GHz. An omni-directional antenna may be used to transmit/receive radio signals in any direction, a sector antenna may be used to transmit/receive radio signals from devices within a particular area, and a panel antenna may be a line of sight antenna used to transmit/receive radio signals in a relatively straight line. In some instances, the use of more than one antenna may be referred to as MIMO. In certain embodiments, antenna QQ162 may be separate from network node QQ160 and may be connectable to network node QQ160 through an interface or port.

Antenna QQ162, interface QQ190, and/or processing circuitry QQ170 may be configured to perform any receiving operations and/or certain obtaining operations described herein as being performed by a network node. Any information, data and/or signals may be received from a wireless device, another network node and/or any other network equipment. Similarly, antenna QQ162, interface QQ190, and/or processing circuitry QQ170 may be configured to perform any transmitting operations described herein as being performed by a network node. Any information, data and/or signals may be transmitted to a wireless device, another network node and/or any other network equipment.

Power circuitry QQ187 may comprise, or be coupled to, power management circuitry and is configured to supply the components of network node QQ160 with power for performing the functionality described herein. Power circuitry QQ187 may receive power from power source QQ186. Power source QQ186 and/or power circuitry QQ187 may be configured to provide power to the various components of network node QQ160 in a form suitable for the respective components (e.g., at a voltage and current level needed for each respective component). Power source QQ186 may either be included in, or external to, power circuitry QQ187 and/or network node QQ160. For example, network node QQ160 may be connectable to an external power source (e.g., an electricity outlet) via an input circuitry or interface such as an electrical cable, whereby the external power source supplies power to power circuitry QQ187. As a further example, power source QQ186 may comprise a source of power in the form of a battery or battery pack which is connected to, or integrated in, power circuitry QQ187. The battery may provide backup power should the external power source fail. Other types of power sources, such as photovoltaic devices, may also be used.

Alternative embodiments of network node QQ160 may include additional components beyond those shown in Figure QQ1 that may be responsible for providing certain aspects of the network node's functionality, including any of the functionality described herein and/or any functionality necessary to support the subject matter described herein. For example, network node QQ160 may include user interface equipment to allow input of information into network node QQ160 and to allow output of information from network node QQ160. This may allow a user to perform diagnostic, maintenance, repair, and other administrative functions for network node QQ160.

As used herein, wireless device (WD) refers to a device capable, configured, arranged and/or operable to communicate wirelessly with network nodes and/or other wireless devices. Unless otherwise noted, the term WD may be used interchangeably herein with user equipment (UE). Communicating wirelessly may involve transmitting and/or receiving wireless signals using electromagnetic waves, radio waves, infrared waves, and/or other types of signals suitable for conveying information through air. In some embodiments, a WD may be configured to transmit and/or receive information without direct human interaction. For instance, a WD may be designed to transmit information to a network on a predetermined schedule, when triggered by an internal or external event, or in response to requests from the network. Examples of a WD include, but are not limited to, a smart phone, a mobile phone, a cell phone, a voice over IP (VoIP) phone, a wireless local loop phone, a desktop computer, a personal digital assistant (PDA), a wireless cameras, a gaming console or device, a music storage device, a playback appliance, a wearable terminal device, a wireless endpoint, a mobile station, a tablet, a laptop, a laptop-embedded equipment (LEE), a laptop-mounted equipment (LME), a smart device, a wireless customer-premise equipment (CPE), a vehicle-mounted wireless terminal device, etc. A WD may support device-to-device (D2D) communication, for example by implementing a 3GPP standard for sidelink communication, vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-everything (V2X) and may in this case be referred to as a D2D communication device. As yet another specific example, in an Internet of Things (IoT) scenario, a WD may represent a machine or other device that performs monitoring and/or measurements and transmits the results of such monitoring and/or measurements to another WD and/or a network node. The WD may in this case be a machine-to-machine (M2M) device, which may in a 3GPP context be referred to as an

MTC device. As one particular example, the WD may be a UE implementing the 3GPP narrow band internet of things (NB-IoT) standard. Particular examples of such machines or devices are sensors, metering devices such as power meters, industrial machinery, or home or personal appliances (e.g. refrigerators, televisions, etc.) personal wearables (e.g., watches, fitness trackers, etc.). In other scenarios, a WD may represent a vehicle or other equipment that is capable of monitoring and/or reporting on its operational status or other functions associated with its operation. A WD as described above may represent the endpoint of a wireless connection, in which case the device may be referred to as a wireless terminal. Furthermore, a WD as described above may be mobile, in which case it may also be referred to as a mobile device or a mobile terminal.

As illustrated, wireless device QQ110 includes antenna QQ111, interface QQ114, processing circuitry QQ120, device readable medium QQ130, user interface equipment QQ132, auxiliary equipment QQ134, power source QQ136 and power circuitry QQ137. WD QQ110 may include multiple sets of one or more of the illustrated components for different wireless technologies supported by WD QQ110, such as, for example, GSM, WCDMA, LTE, NR, WIFI, WiMAX, or Bluetooth wireless technologies, just to mention a few. These wireless technologies may be integrated into the same or different chips or set of chips as other components within WD QQ110.

Antenna QQ111 may include one or more antennas or antenna arrays, configured to send and/or receive wireless signals, and is connected to interface QQ114. In certain alternative embodiments, antenna QQ111 may be separate from WD QQ110 and be connectable to WD QQ110 through an interface or port. Antenna QQ111, interface QQ114, and/or processing circuitry QQ120 may be configured to perform any receiving or transmitting operations described herein as being performed by a WD. Any information, data and/or signals may be received from a network node and/or another WD. In some embodiments, radio front end circuitry and/or antenna QQ111 may be considered an interface.

As illustrated, interface QQ114 comprises radio front end circuitry QQ112 and antenna QQ111. Radio front end circuitry QQ112 comprise one or more filters QQ118 and amplifiers QQ116. Radio front end circuitry QQ114 is connected to antenna QQ111 and processing circuitry QQ120 and is configured to condition signals communicated between antenna QQ111 and processing circuitry QQ120. Radio front end circuitry QQ112 may be coupled to or a part of antenna QQ111. In some embodiments, WD QQ110 may not include separate radio front end circuitry QQ112; rather, processing circuitry QQ120 may comprise radio front end circuitry and may be connected to antenna QQ111. Similarly, in some embodiments, some or all of RF transceiver circuitry QQ122 may be considered a part of interface QQ114. Radio front end circuitry QQ112 may receive digital data that is to be sent out to other network nodes or WDs via a wireless connection. Radio front end circuitry QQ112 may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters QQ118 and/or amplifiers QQ116. The radio signal may then be transmitted via antenna QQ111. Similarly, when receiving data, antenna QQ111 may collect radio signals which are then converted into digital data by radio front end circuitry QQ112. The digital data may be passed to processing circuitry QQ120. In other embodiments, the interface may comprise different components and/or different combinations of components.

Processing circuitry QQ120 may comprise a combination of one or more of a microprocessor, controller, microcontroller, central processing unit, digital signal processor, application-specific integrated circuit, field programmable gate array, or any other suitable computing device, resource, or combination of hardware, software, and/or encoded logic operable to provide, either alone or in conjunction with other WD QQ110 components, such as device readable medium QQ130, WD QQ110 functionality. Such functionality may include providing any of the various wireless features or benefits discussed herein. For example, processing circuitry QQ120 may execute instructions stored in device readable medium QQ130 or in memory within processing circuitry QQ120 to provide the functionality disclosed herein.

As illustrated, processing circuitry QQ120 includes one or more of RF transceiver circuitry QQ122, baseband processing circuitry QQ124, and application processing circuitry QQ126. In other embodiments, the processing circuitry may comprise different components and/or different combinations of components. In certain embodiments processing circuitry QQ120 of WD QQ110 may comprise a SOC. In some embodiments, RF transceiver circuitry QQ122, baseband processing circuitry QQ124, and application processing circuitry QQ126 may be on separate chips or sets of chips. In alternative embodiments, part or all of baseband processing circuitry QQ124 and application processing circuitry QQ126 may be combined into one chip or set of chips, and RF transceiver circuitry QQ122 may be on a separate chip or set of chips. In still alternative embodiments, part or all of RF transceiver circuitry QQ122 and baseband processing circuitry QQ124 may be on the same chip or set of chips, and application processing circuitry QQ126 may be on a separate chip or set of chips. In yet other alternative embodiments, part or all of RF transceiver circuitry QQ122, baseband processing circuitry QQ124, and application processing circuitry QQ126 may be combined in the same chip or set of chips. In some embodiments, RF transceiver circuitry QQ122 may be a part of interface QQ114. RF transceiver circuitry QQ122 may condition RF signals for processing circuitry QQ120.

In certain embodiments, some or all of the functionality described herein as being performed by a WD may be provided by processing circuitry QQ120 executing instructions stored on device readable medium QQ130, which in certain embodiments may be a computer-readable storage medium. In alternative embodiments, some or all of the functionality may be provided by processing circuitry QQ120 without executing instructions stored on a separate or discrete device readable storage medium, such as in a hard-wired manner. In any of those particular embodiments, whether executing instructions stored on a device readable storage medium or not, processing circuitry QQ120 can be configured to perform the described functionality. The benefits provided by such functionality are not limited to processing circuitry QQ120 alone or to other components of WD QQ110, but are enjoyed by WD QQ110 as a whole, and/or by end users and the wireless network generally.

Processing circuitry QQ120 may be configured to perform any determining, calculating, or similar operations (e.g., certain obtaining operations) described herein as being performed by a WD. These operations, as performed by processing circuitry QQ120, may include processing information obtained by processing circuitry QQ120 by, for example, converting the obtained information into other information, comparing the obtained information or converted information to information stored by WD QQ110, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination.

Device readable medium QQ130 may be operable to store a computer program, software, an application including one or more of logic, rules, code, tables, etc. and/or other instructions capable of being executed by processing circuitry QQ120. Device readable medium QQ130 may include computer memory (e.g., Random Access Memory (RAM) or Read Only Memory (ROM)), mass storage media (e.g., a hard disk), removable storage media (e.g., a Compact Disk (CD) or a Digital Video Disk (DVD)), and/or any other volatile or non-volatile, non-transitory device readable and/or computer executable memory devices that store information, data, and/or instructions that may be used by processing circuitry QQ120. In some embodiments, processing circuitry QQ120 and device readable medium QQ130 may be considered to be integrated.

User interface equipment QQ132 may provide components that allow for a human user to interact with WD QQ110. Such interaction may be of many forms, such as visual, audial, tactile, etc. User interface equipment QQ132 may be operable to produce output to the user and to allow the user to provide input to WD QQ110. The type of interaction may vary depending on the type of user interface equipment QQ132 installed in WD QQ110. For example, if WD QQ110 is a smart phone, the interaction may be via a touch screen; if WD QQ110 is a smart meter, the interaction may be through a screen that provides usage (e.g., the number of gallons used) or a speaker that provides an audible alert (e.g., if smoke is detected). User interface equipment QQ132 may include input interfaces, devices and circuits, and output interfaces, devices and circuits. User interface equipment QQ132 is configured to allow input of information into WD QQ110 and is connected to processing circuitry QQ120 to allow processing circuitry QQ120 to process the input information. User interface equipment QQ132 may include, for example, a microphone, a proximity or other sensor, keys/buttons, a touch display, one or more cameras, a USB port, or other input circuitry. User interface equipment QQ132 is also configured to allow output of information from WD QQ110, and to allow processing circuitry QQ120 to output information from WD QQ110. User interface equipment QQ132 may include, for example, a speaker, a display, vibrating circuitry, a USB port, a headphone interface, or other output circuitry. Using one or more input and output interfaces, devices, and circuits, of user interface equipment QQ132, WD QQ110 may communicate with end users and/or the wireless network and allow them to benefit from the functionality described herein.

Auxiliary equipment QQ134 is operable to provide more specific functionality which may not be generally performed by WDs. This may comprise specialized sensors for doing measurements for various purposes, interfaces for additional types of communication such as wired communications etc. The inclusion and type of components of auxiliary equipment QQ134 may vary depending on the embodiment and/or scenario.

Power source QQ136 may, in some embodiments, be in the form of a battery or battery pack. Other types of power sources, such as an external power source (e.g., an electricity outlet), photovoltaic devices or power cells, may also be used. WD QQ110 may further comprise power circuitry QQ137 for delivering power from power source QQ136 to the various parts of WD QQ110 which need power from power source QQ136 to carry out any functionality described or indicated herein. Power circuitry QQ137 may in certain embodiments comprise power management circuitry. Power circuitry QQ137 may additionally or alternatively be operable to receive power from an external power source; in which case WD QQ110 may be connectable to the external power source (such as an electricity outlet) via input circuitry or an interface such as an electrical power cable. Power circuitry QQ137 may also in certain embodiments be operable to deliver power from an external power

source to power source QQ136. This may be, for example, for the charging of power source QQ136. Power circuitry QQ137 may perform any formatting, converting, or other modification to the power from power source QQ136 to make the power suitable for the respective components of WD QQ110 to which power is supplied.

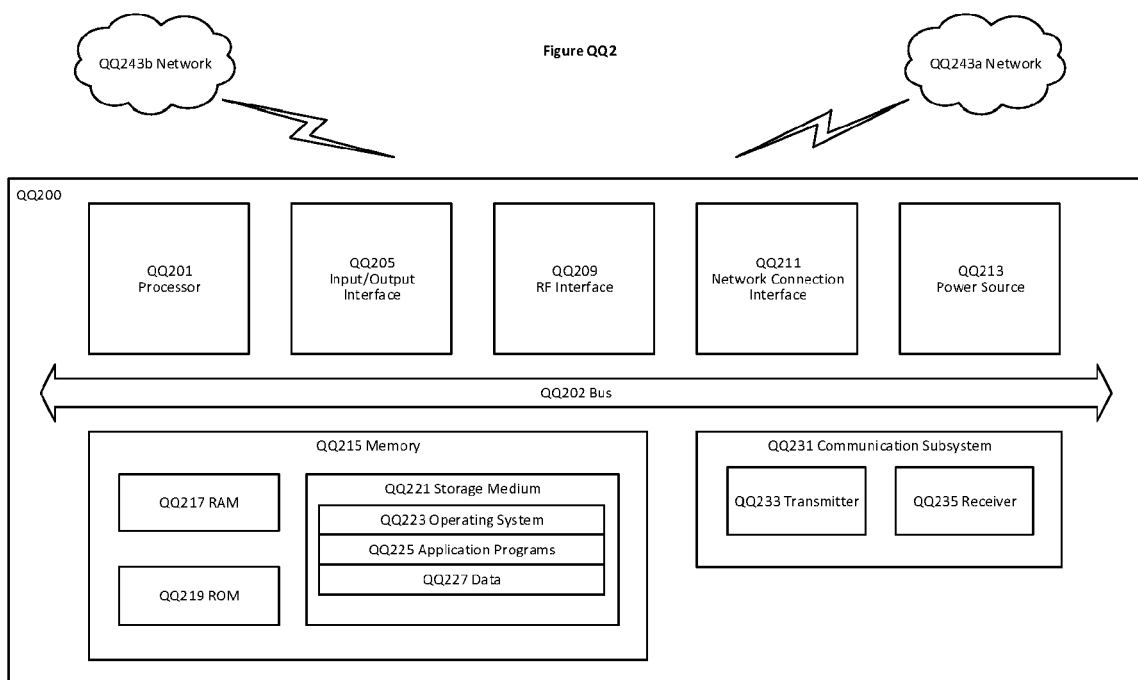


Figure QQ2: User Equipment in accordance with some embodiments

Figure QQ2 illustrates one embodiment of a UE in accordance with various aspects described herein. As used herein, a user equipment or UE may not necessarily have a user in the sense of a human user who owns and/or operates the relevant device. Instead, a UE may represent a device that is intended for sale to, or operation by, a human user but which may not, or which may not initially, be associated with a specific human user (e.g., a smart sprinkler controller). Alternatively, a UE may represent a device that is not intended for sale to, or operation by, an end user but which may be associated with or operated for the benefit of a user (e.g., a smart power meter). UE QQ200 may be any UE identified by the 3rd Generation Partnership Project (3GPP), including a NB-IoT UE, a machine type communication (MTC) UE, and/or an enhanced MTC (eMTC) UE. UE QQ200, as illustrated in Figure QQ2, is one example of a WD configured for communication in accordance with one or more communication standards promulgated by the 3rd Generation Partnership Project (3GPP), such as 3GPP's GSM, UMTS, LTE, and/or 5G standards. As mentioned previously, the term WD and UE may be used interchangeably. Accordingly, although Figure QQ2 is a UE, the components discussed herein are equally applicable to a WD, and vice-versa.

In Figure QQ2, UE QQ200 includes processing circuitry QQ201 that is operatively coupled to input/output interface QQ205, radio frequency (RF) interface QQ209, network connection interface QQ211, memory QQ215 including random access memory (RAM) QQ217, read-only memory (ROM) QQ219, and

storage medium QQ221 or the like, communication subsystem QQ231, power source QQ233, and/or any other component, or any combination thereof. Storage medium QQ221 includes operating system QQ223, application program QQ225, and data QQ227. In other embodiments, storage medium QQ221 may include other similar types of information. Certain UEs may utilize all of the components shown in Figure QQ2, or only a subset of the components. The level of integration between the components may vary from one UE to another UE. Further, certain UEs may contain multiple instances of a component, such as multiple processors, memories, transceivers, transmitters, receivers, etc.

In Figure QQ2, processing circuitry QQ201 may be configured to process computer instructions and data. Processing circuitry QQ201 may be configured to implement any sequential state machine operative to execute machine instructions stored as machine-readable computer programs in the memory, such as one or more hardware-implemented state machines (e.g., in discrete logic, FPGA, ASIC, etc.); programmable logic together with appropriate firmware; one or more stored program, general-purpose processors, such as a microprocessor or Digital Signal Processor (DSP), together with appropriate software; or any combination of the above. For example, the processing circuitry QQ201 may include two central processing units (CPUs). Data may be information in a form suitable for use by a computer.

In the depicted embodiment, input/output interface QQ205 may be configured to provide a communication interface to an input device, output device, or input and output device. UE QQ200 may be configured to use an output device via input/output interface QQ205. An output device may use the same type of interface port as an input device. For example, a USB port may be used to provide input to and output from UE QQ200. The output device may be a speaker, a sound card, a video card, a display, a monitor, a printer, an actuator, an emitter, a smartcard, another output device, or any combination thereof. UE QQ200 may be configured to use an input device via input/output interface QQ205 to allow a user to capture information into UE QQ200. The input device may include a touch-sensitive or presence-sensitive display, a camera (e.g., a digital camera, a digital video camera, a web camera, etc.), a microphone, a sensor, a mouse, a trackball, a directional pad, a trackpad, a scroll wheel, a smartcard, and the like. The presence-sensitive display may include a capacitive or resistive touch sensor to sense input from a user. A sensor may be, for instance, an accelerometer, a gyroscope, a tilt sensor, a force sensor, a magnetometer, an optical sensor, a proximity sensor, another like sensor, or any combination thereof. For example, the input device may be an accelerometer, a magnetometer, a digital camera, a microphone, and an optical sensor.

In Figure QQ2, RF interface QQ209 may be configured to provide a communication interface to RF components such as a transmitter, a receiver, and an antenna. Network connection interface QQ211 may be configured to provide a communication interface to network QQ243a. Network QQ243a may encompass wired and/or wireless networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, network QQ243a may comprise a Wi-Fi network. Network connection interface QQ211 may be configured to include a receiver and a transmitter interface used to communicate with one or more other devices over a communication network according to one or more communication protocols, such as Ethernet, TCP/IP, SONET, ATM, or the like. Network connection interface QQ211 may implement receiver and transmitter

functionality appropriate to the communication network links (e.g., optical, electrical, and the like). The transmitter and receiver functions may share circuit components, software or firmware, or alternatively may be implemented separately.

RAM QQ217 may be configured to interface via bus QQ202 to processing circuitry QQ201 to provide storage or caching of data or computer instructions during the execution of software programs such as the operating system, application programs, and device drivers. ROM QQ219 may be configured to provide computer instructions or data to processing circuitry QQ201. For example, ROM QQ219 may be configured to store invariant low-level system code or data for basic system functions such as basic input and output (I/O), startup, or reception of keystrokes from a keyboard that are stored in a non-volatile memory. Storage medium QQ221 may be configured to include memory such as RAM, ROM, programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), magnetic disks, optical disks, floppy disks, hard disks, removable cartridges, or flash drives. In one example, storage medium QQ221 may be configured to include operating system QQ223, application program QQ225 such as a web browser application, a widget or gadget engine or another application, and data file QQ227. Storage medium QQ221 may store, for use by UE QQ200, any of a variety of various operating systems or combinations of operating systems.

Storage medium QQ221 may be configured to include a number of physical drive units, such as redundant array of independent disks (RAID), floppy disk drive, flash memory, USB flash drive, external hard disk drive, thumb drive, pen drive, key drive, high-density digital versatile disc (HD-DVD) optical disc drive, internal hard disk drive, Blu-Ray optical disc drive, holographic digital data storage (HDDS) optical disc drive, external mini-dual in-line memory module (DIMM), synchronous dynamic random access memory (SDRAM), external micro-DIMM SDRAM, smartcard memory such as a subscriber identity module or a removable user identity (SIM/RUIM) module, other memory, or any combination thereof. Storage medium QQ221 may allow UE QQ200 to access computer-executable instructions, application programs or the like, stored on transitory or non-transitory memory media, to off-load data, or to upload data. An article of manufacture, such as one utilizing a communication system may be tangibly embodied in storage medium QQ221, which may comprise a device readable medium.

In Figure QQ2, processing circuitry QQ201 may be configured to communicate with network QQ243b using communication subsystem QQ231. Network QQ243a and network QQ243b may be the same network or networks or different network or networks. Communication subsystem QQ231 may be configured to include one or more transceivers used to communicate with network QQ243b. For example, communication subsystem QQ231 may be configured to include one or more transceivers used to communicate with one or more remote transceivers of another device capable of wireless communication such as another WD, UE, or base station of a radio access network (RAN) according to one or more communication protocols, such as IEEE 802.QQ2, CDMA, WCDMA, GSM, LTE, UTRAN, WiMax, or the like. Each transceiver may include transmitter QQ233 and/or receiver QQ235 to implement transmitter or receiver functionality, respectively, appropriate to the RAN links (e.g., frequency allocations and the like). Further, transmitter QQ233 and receiver QQ235 of each transceiver may share circuit components, software or firmware, or alternatively may be implemented separately.

In the illustrated embodiment, the communication functions of communication subsystem QQ231 may include data communication, voice communication, multimedia communication, short-range communications such as Bluetooth, near-field communication, location-based communication such as the use of the global positioning system (GPS) to determine a location, another like communication function, or any combination thereof. For example, communication subsystem QQ231 may include cellular communication, Wi-Fi communication, Bluetooth communication, and GPS communication. Network QQ243b may encompass wired and/or wireless networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, network QQ243b may be a cellular network, a Wi-Fi network, and/or a near-field network. Power source QQ213 may be configured to provide alternating current (AC) or direct current (DC) power to components of UE QQ200.

The features, benefits and/or functions described herein may be implemented in one of the components of UE QQ200 or partitioned across multiple components of UE QQ200. Further, the features, benefits, and/or functions described herein may be implemented in any combination of hardware, software or firmware. In one example, communication subsystem QQ231 may be configured to include any of the components described herein. Further, processing circuitry QQ201 may be configured to communicate with any of such components over bus QQ202. In another example, any of such components may be represented by program instructions stored in memory that when executed by processing circuitry QQ201 perform the corresponding functions described herein. In another example, the functionality of any of such components may be partitioned between processing circuitry QQ201 and communication subsystem QQ231. In another example, the non-computationally intensive functions of any of such components may be implemented in software or firmware and the computationally intensive functions may be implemented in hardware.

Figure QQ3

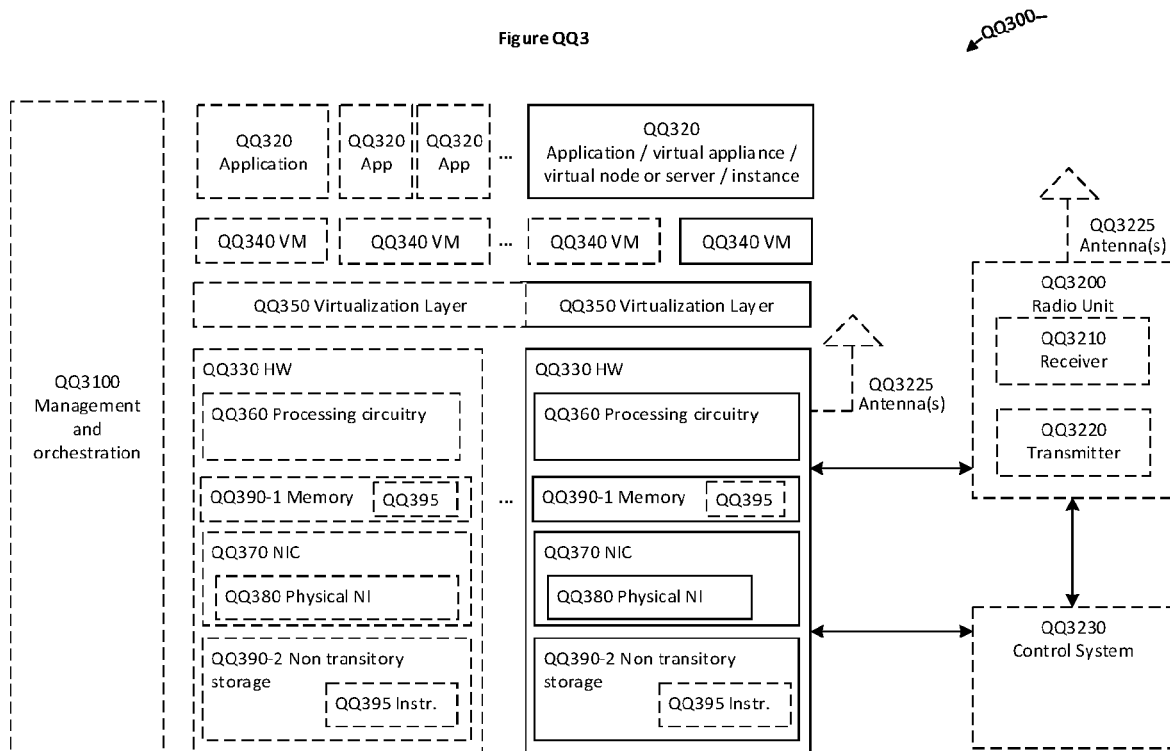


Figure QQ3: Virtualization environment in accordance with some embodiments

Figure QQ3 is a schematic block diagram illustrating a virtualization environment QQ300 in which functions implemented by some embodiments may be virtualized. In the present context, virtualizing means creating virtual versions of apparatuses or devices which may include virtualizing hardware platforms, storage devices and networking resources. As used herein, virtualization can be applied to a node (e.g., a virtualized base station or a virtualized radio access node) or to a device (e.g., a UE, a wireless device or any other type of communication device) or components thereof and relates to an implementation in which at least a portion of the functionality is implemented as one or more virtual components (e.g., via one or more applications, components, functions, virtual machines or containers executing on one or more physical processing nodes in one or more networks).

In some embodiments, some or all of the functions described herein may be implemented as virtual components executed by one or more virtual machines implemented in one or more virtual environments QQ300 hosted by one or more of hardware nodes QQ330. Further, in embodiments in which the virtual node is not a radio access node or does not require radio connectivity (e.g., a core network node), then the network node may be entirely virtualized.

The functions may be implemented by one or more applications QQ320 (which may alternatively be called software instances, virtual appliances, network functions, virtual nodes, virtual network functions, etc.) operative to implement some of the features, functions, and/or benefits of some of the embodiments disclosed herein. Applications QQ320 are run in virtualization environment QQ300 which provides hardware QQ330

comprising processing circuitry QQ360 and memory QQ390. Memory QQ390 contains instructions QQ395 executable by processing circuitry QQ360 whereby application QQ320 is operative to provide one or more of the features, benefits, and/or functions disclosed herein.

Virtualization environment QQ300, comprises general-purpose or special-purpose network hardware devices QQ330 comprising a set of one or more processors or processing circuitry QQ360, which may be commercial off-the-shelf (COTS) processors, dedicated Application Specific Integrated Circuits (ASICs), or any other type of processing circuitry including digital or analog hardware components or special purpose processors. Each hardware device may comprise memory QQ390-1 which may be non-persistent memory for temporarily storing instructions QQ395 or software executed by processing circuitry QQ360. Each hardware device may comprise one or more network interface controllers (NICs) QQ370, also known as network interface cards, which include physical network interface QQ380. Each hardware device may also include non-transitory, persistent, machine-readable storage media QQ390-2 having stored therein software QQ395 and/or instructions executable by processing circuitry QQ360. Software QQ395 may include any type of software including software for instantiating one or more virtualization layers QQ350 (also referred to as hypervisors), software to execute virtual machines QQ340 as well as software allowing it to execute functions, features and/or benefits described in relation with some embodiments described herein.

Virtual machines QQ340, comprise virtual processing, virtual memory, virtual networking or interface and virtual storage, and may be run by a corresponding virtualization layer QQ350 or hypervisor. Different embodiments of the instance of virtual appliance QQ320 may be implemented on one or more of virtual machines QQ340, and the implementations may be made in different ways.

During operation, processing circuitry QQ360 executes software QQ395 to instantiate the hypervisor or virtualization layer QQ350, which may sometimes be referred to as a virtual machine monitor (VMM). Virtualization layer QQ350 may present a virtual operating platform that appears like networking hardware to virtual machine QQ340.

As shown in Figure QQ3, hardware QQ330 may be a standalone network node with generic or specific components. Hardware QQ330 may comprise antenna QQ3225 and may implement some functions via virtualization. Alternatively, hardware QQ330 may be part of a larger cluster of hardware (e.g. such as in a data center or customer premise equipment (CPE)) where many hardware nodes work together and are managed via management and orchestration (MANO) QQ3100, which, among others, oversees lifecycle management of applications QQ320.

Virtualization of the hardware is in some contexts referred to as network function virtualization (NFV). NFV may be used to consolidate many network equipment types onto industry standard high-volume server hardware, physical switches, and physical storage, which can be located in data centers, and customer premise equipment.

In the context of NFV, virtual machine QQ340 may be a software implementation of a physical machine that runs programs as if they were executing on a physical, non-virtualized machine. Each of virtual machines QQ340, and that part of hardware QQ330 that executes that virtual machine, be it hardware dedicated to that

virtual machine and/or hardware shared by that virtual machine with others of the virtual machines QQ340, forms a separate virtual network elements (VNE).

Still in the context of NFV, Virtual Network Function (VNF) is responsible for handling specific network functions that run in one or more virtual machines QQ340 on top of hardware networking infrastructure QQ330 and corresponds to application QQ320 in Figure QQ3.

In some embodiments, one or more radio units QQ3200 that each include one or more transmitters QQ3220 and one or more receivers QQ3210 may be coupled to one or more antennas QQ3225. Radio units QQ3200 may communicate directly with hardware nodes QQ330 via one or more appropriate network interfaces and may be used in combination with the virtual components to provide a virtual node with radio capabilities, such as a radio access node or a base station.

In some embodiments, some signalling can be affected with the use of control system QQ3230 which may alternatively be used for communication between the hardware nodes QQ330 and radio units QQ3200.

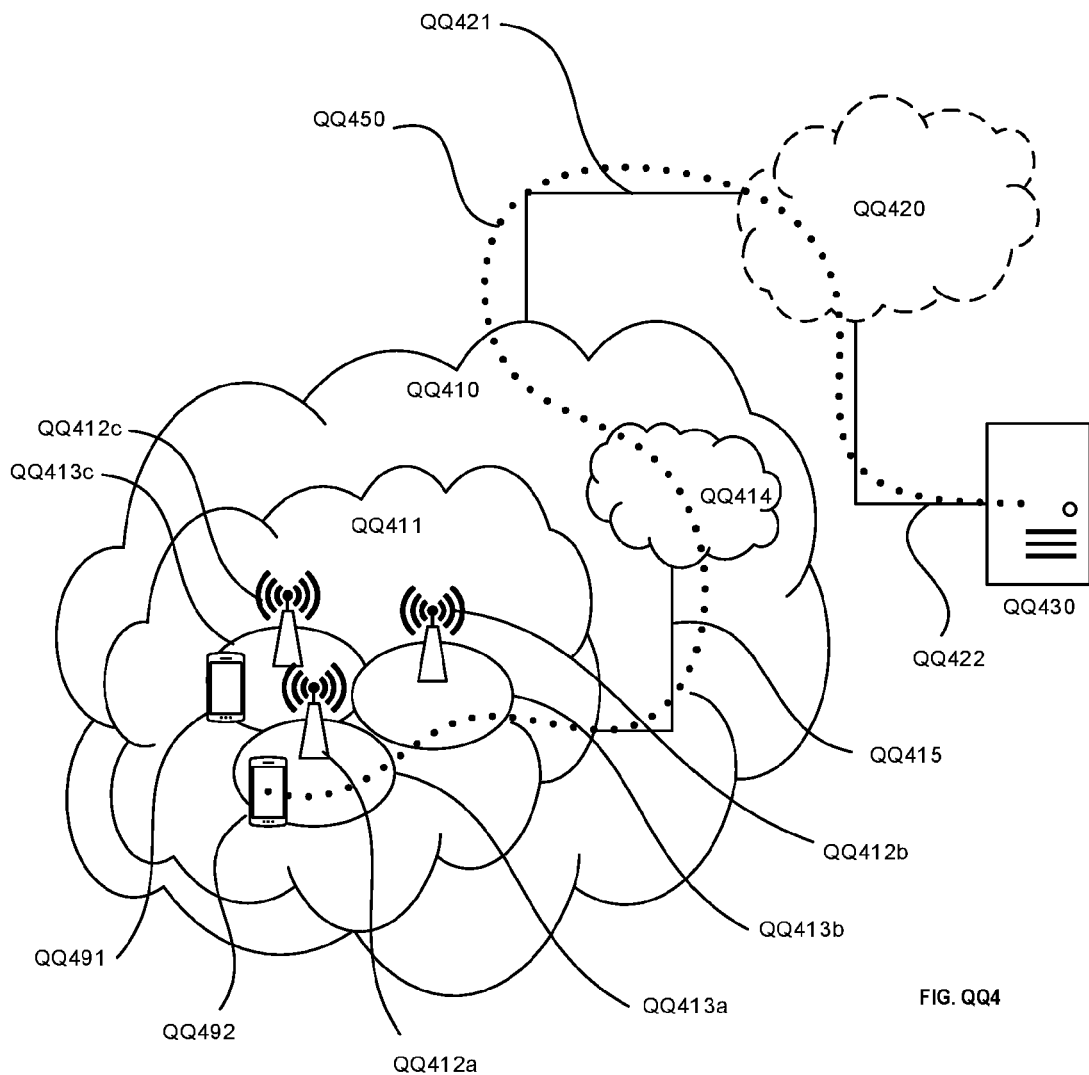


FIG. QQ4

Figure QQ4: Telecommunication network connected via an intermediate network to a host computer in accordance with some embodiments

With reference to FIGURE QQ4, in accordance with an embodiment, a communication system includes telecommunication network QQ410, such as a 3GPP-type cellular network, which comprises access network QQ411, such as a radio access network, and core network QQ414. Access network QQ411 comprises a plurality of base stations QQ412a, QQ412b, QQ412c, such as NBs, eNBs, gNBs or other types of wireless access points, each defining a corresponding coverage area QQ413a, QQ413b, QQ413c. Each base station QQ412a, QQ412b, QQ412c is connectable to core network QQ414 over a wired or wireless connection QQ415. A first UE QQ491 located in coverage area QQ413c is configured to wirelessly connect to, or be paged by, the corresponding base

station QQ412c. A second UE QQ492 in coverage area QQ413a is wirelessly connectable to the corresponding base station QQ412a. While a plurality of UEs QQ491, QQ492 are illustrated in this example, the disclosed embodiments are equally applicable to a situation where a sole UE is in the coverage area or where a sole UE is connecting to the corresponding base station QQ412.

Telecommunication network QQ410 is itself connected to host computer QQ430, which may be embodied in the hardware and/or software of a standalone server, a cloud-implemented server, a distributed server or as processing resources in a server farm. Host computer QQ430 may be under the ownership or control of a service provider, or may be operated by the service provider or on behalf of the service provider. Connections QQ421 and QQ422 between telecommunication network QQ410 and host computer QQ430 may extend directly from core network QQ414 to host computer QQ430 or may go via an optional intermediate network QQ420. Intermediate network QQ420 may be one of, or a combination of more than one of, a public, private or hosted network; intermediate network QQ420, if any, may be a backbone network or the Internet; in particular, intermediate network QQ420 may comprise two or more sub-networks (not shown).

The communication system of Figure QQ4 as a whole enables connectivity between the connected UEs QQ491, QQ492 and host computer QQ430. The connectivity may be described as an over-the-top (OTT) connection QQ450. Host computer QQ430 and the connected UEs QQ491, QQ492 are configured to communicate data and/or signaling via OTT connection QQ450, using access network QQ411, core network QQ414, any intermediate network QQ420 and possible further infrastructure (not shown) as intermediaries. OTT connection QQ450 may be transparent in the sense that the participating communication devices through which OTT connection QQ450 passes are unaware of routing of uplink and downlink communications. For example, base station QQ412 may not or need not be informed about the past routing of an incoming downlink communication with data originating from host computer QQ430 to be forwarded (e.g., handed over) to a connected UE QQ491. Similarly, base station QQ412 need not be aware of the future routing of an outgoing uplink communication originating from the UE QQ491 towards the host computer QQ430.

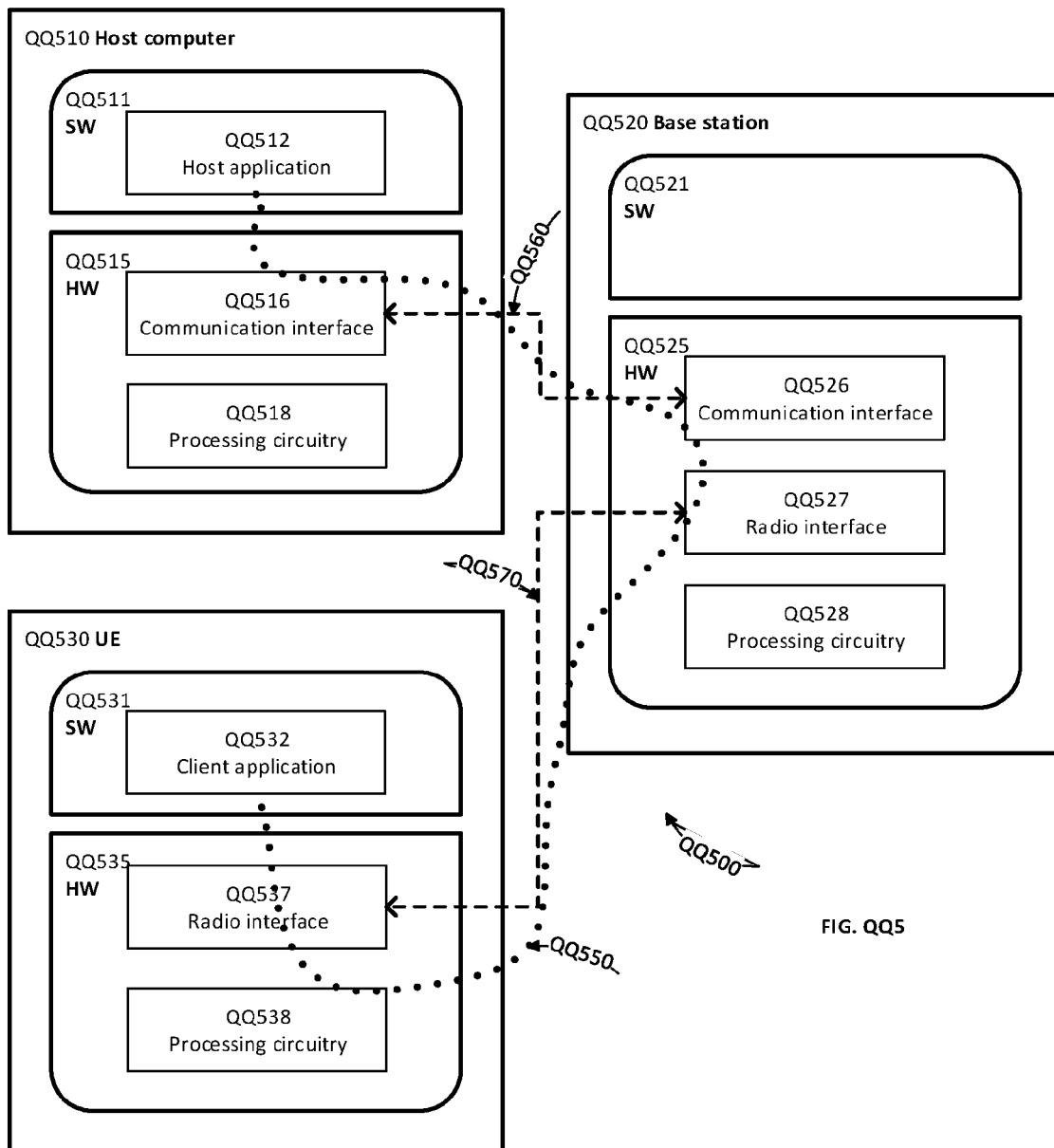


FIG. QQ5

Figure QQ5: Host computer communicating via a base station with a user equipment over a partially wireless connection in accordance with some embodiments

Example implementations, in accordance with an embodiment, of the UE, base station and host computer discussed in the preceding paragraphs will now be described with reference to Figure QQ5. In communication system QQ500, host computer QQ510 comprises hardware QQ515 including communication interface QQ516 configured to set up and maintain a wired or wireless connection with an interface of a different communication device of communication system QQ500. Host computer QQ510 further comprises processing circuitry QQ518, which may have storage and/or processing capabilities. In particular, processing circuitry QQ518 may comprise one or more programmable processors, application-specific integrated circuits, field

programmable gate arrays or combinations of these (not shown) adapted to execute instructions. Host computer QQ510 further comprises software QQ511, which is stored in or accessible by host computer QQ510 and executable by processing circuitry QQ518. Software QQ511 includes host application QQ512. Host application QQ512 may be operable to provide a service to a remote user, such as UE QQ530 connecting via OTT connection QQ550 terminating at UE QQ530 and host computer QQ510. In providing the service to the remote user, host application QQ512 may provide user data which is transmitted using OTT connection QQ550.

Communication system QQ500 further includes base station QQ520 provided in a telecommunication system and comprising hardware QQ525 enabling it to communicate with host computer QQ510 and with UE QQ530. Hardware QQ525 may include communication interface QQ526 for setting up and maintaining a wired or wireless connection with an interface of a different communication device of communication system QQ500, as well as radio interface QQ527 for setting up and maintaining at least wireless connection QQ570 with UE QQ530 located in a coverage area (not shown in Figure QQ5) served by base station QQ520. Communication interface QQ526 may be configured to facilitate connection QQ560 to host computer QQ510. Connection QQ560 may be direct or it may pass through a core network (not shown in Figure QQ5) of the telecommunication system and/or through one or more intermediate networks outside the telecommunication system. In the embodiment shown, hardware QQ525 of base station QQ520 further includes processing circuitry QQ528, which may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. Base station QQ520 further has software QQ521 stored internally or accessible via an external connection.

Communication system QQ500 further includes UE QQ530 already referred to. Its hardware QQ535 may include radio interface QQ537 configured to set up and maintain wireless connection QQ570 with a base station serving a coverage area in which UE QQ530 is currently located. Hardware QQ535 of UE QQ530 further includes processing circuitry QQ538, which may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. UE QQ530 further comprises software QQ531, which is stored in or accessible by UE QQ530 and executable by processing circuitry QQ538. Software QQ531 includes client application QQ532. Client application QQ532 may be operable to provide a service to a human or non-human user via UE QQ530, with the support of host computer QQ510. In host computer QQ510, an executing host application QQ512 may communicate with the executing client application QQ532 via OTT connection QQ550 terminating at UE QQ530 and host computer QQ510. In providing the service to the user, client application QQ532 may receive request data from host application QQ512 and provide user data in response to the request data. OTT connection QQ550 may transfer both the request data and the user data. Client application QQ532 may interact with the user to generate the user data that it provides.

It is noted that host computer QQ510, base station QQ520 and UE QQ530 illustrated in Figure QQ5 may be similar or identical to host computer QQ430, one of base stations QQ412a, QQ412b, QQ412c and one of UEs QQ491, QQ492 of Figure QQ4, respectively. This is to say, the inner workings of these entities may be as shown in Figure QQ5 and independently, the surrounding network topology may be that of Figure QQ4.

In Figure QQ5, OTT connection QQ550 has been drawn abstractly to illustrate the communication between host computer QQ510 and UE QQ530 via base station QQ520, without explicit reference to any intermediary devices and the precise routing of messages via these devices. Network infrastructure may determine the routing, which it may be configured to hide from UE QQ530 or from the service provider operating host computer QQ510, or both. While OTT connection QQ550 is active, the network infrastructure may further take decisions by which it dynamically changes the routing (e.g., on the basis of load balancing consideration or reconfiguration of the network).

Wireless connection QQ570 between UE QQ530 and base station QQ520 is in accordance with the teachings of the embodiments described throughout this disclosure. One or more of the various embodiments improve the performance of OTT services provided to UE QQ530 using OTT connection QQ550, in which wireless connection QQ570 forms the last segment. More precisely, the teachings of these embodiments may improve the latency and power consumption and thereby provide benefits such as reduced user waiting time, better responsiveness, and extended battery lifetime.

A measurement procedure may be provided for the purpose of monitoring data rate, latency and other factors on which the one or more embodiments improve. There may further be an optional network functionality for reconfiguring OTT connection QQ550 between host computer QQ510 and UE QQ530, in response to variations in the measurement results. The measurement procedure and/or the network functionality for reconfiguring OTT connection QQ550 may be implemented in software QQ511 and hardware QQ515 of host computer QQ510 or in software QQ531 and hardware QQ535 of UE QQ530, or both. In embodiments, sensors (not shown) may be deployed in or in association with communication devices through which OTT connection QQ550 passes; the sensors may participate in the measurement procedure by supplying values of the monitored quantities exemplified above, or supplying values of other physical quantities from which software QQ511, QQ531 may compute or estimate the monitored quantities. The reconfiguring of OTT connection QQ550 may include message format, retransmission settings, preferred routing etc.; the reconfiguring need not affect base station QQ520, and it may be unknown or imperceptible to base station QQ520. Such procedures and functionalities may be known and practiced in the art. In certain embodiments, measurements may involve proprietary UE signaling facilitating host computer QQ510's measurements of throughput, propagation times, latency and the like. The measurements may be implemented in that software QQ511 and QQ531 causes messages to be transmitted, in particular empty or 'dummy' messages, using OTT connection QQ550 while it monitors propagation times, errors etc.

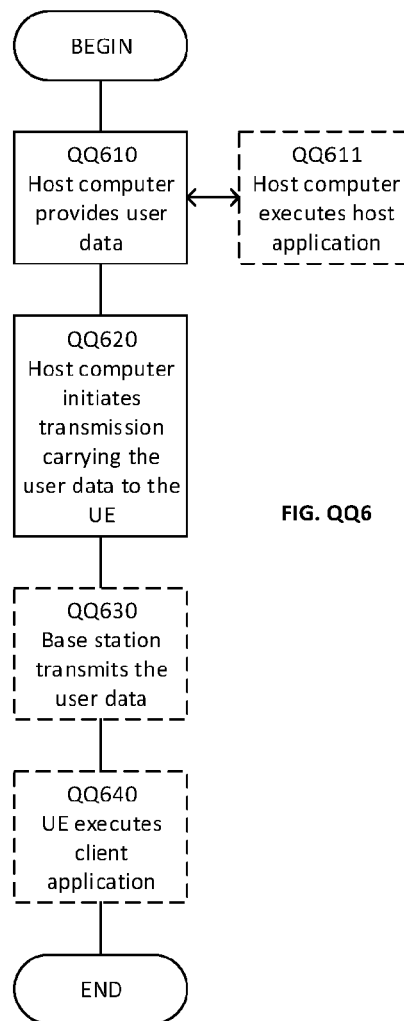


FIG. QQ6

Figure QQ6: Methods implemented in a communication system including a host computer, a base station and a user equipment in accordance with some embodiments

Figure QQ6 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to Figures QQ4 and QQ5. For simplicity of the present disclosure, only drawing references to Figure QQ6 will be included in this section. In step QQ610, the host computer provides user data. In substep QQ611 (which may be optional) of step QQ610, the host computer provides the user data by executing a host application. In step QQ620, the host computer initiates a transmission carrying the user data to the UE. In step QQ630 (which may be optional), the base station transmits to the UE the user data which was carried in the transmission that the host computer initiated, in accordance with the teachings of the embodiments described throughout this disclosure. In step QQ640 (which may also be optional), the UE executes a client application associated with the host application executed by the host computer.

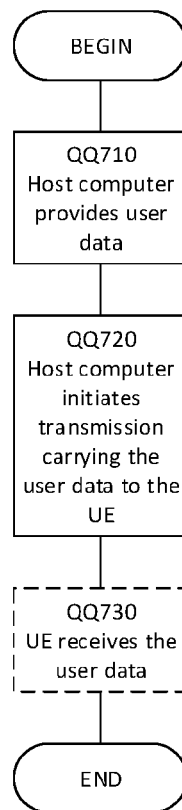
**FIG. QQ7**

Figure QQ7: Methods implemented in a communication system including a host computer, a base station and a user equipment in accordance with some embodiments

Figure QQ7 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to Figures QQ4 and QQ5. For simplicity of the present disclosure, only drawing references to Figure QQ7 will be included in this section. In step QQ710 of the method, the host computer provides user data. In an optional substep (not shown) the host computer provides the user data by executing a host application. In step QQ720, the host computer initiates a transmission carrying the user data to the UE. The transmission may pass via the base station, in accordance with the teachings of the embodiments described throughout this disclosure. In step QQ730 (which may be optional), the UE receives the user data carried in the transmission.

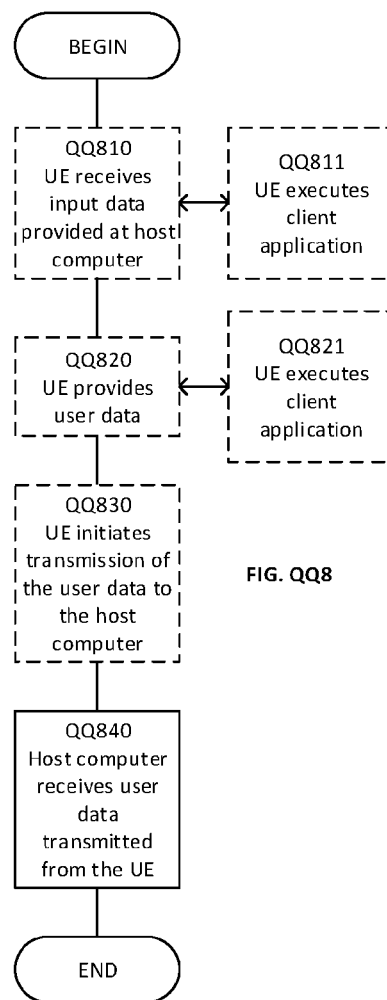


FIG. QQ8

Figure QQ8: Methods implemented in a communication system including a host computer, a base station and a user equipment in accordance with some embodiments

Figure QQ8 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to Figures QQ4 and QQ5. For simplicity of the present disclosure, only drawing references to Figure QQ8 will be included in this section. In step QQ810 (which may be optional), the UE receives input data provided by the host computer. Additionally or alternatively, in step QQ820, the UE provides user data. In substep QQ821 (which may be optional) of step QQ820, the UE provides the user data by executing a client application. In substep QQ811 (which may be optional) of step QQ810, the UE executes a client application which provides the user data in reaction to the received input data provided by the host computer. In providing the user data, the executed client application may further consider user input received from the user. Regardless of the specific manner in which the user data was provided, the UE initiates, in substep QQ830 (which may be optional), transmission of the user data to the host computer. In step QQ840 of the method, the host computer receives the user data transmitted from the UE, in accordance with the teachings of the embodiments described throughout this disclosure.

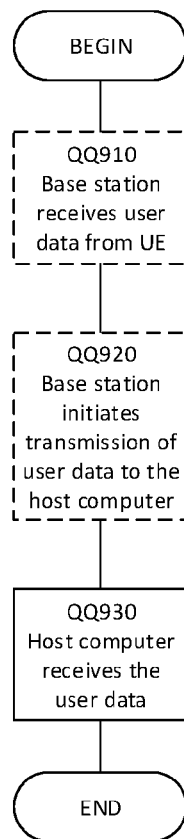


FIG. QQ9

Figure QQ9: Methods implemented in a communication system including a host computer, a base station and a user equipment in accordance with some embodiments

Figure QQ9 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to Figures QQ4 and QQ5. For simplicity of the present disclosure, only drawing references to Figure QQ9 will be included in this section. In step QQ910 (which may be optional), in accordance with the teachings of the embodiments described throughout this disclosure, the base station receives user data from the UE. In step QQ920 (which may be optional), the base station initiates transmission of the received user data to the host computer. In step QQ930 (which may be optional), the host computer receives the user data carried in the transmission initiated by the base station.

Any appropriate steps, methods, features, functions, or benefits disclosed herein may be performed through one or more functional units or modules of one or more virtual apparatuses. Each virtual apparatus may comprise a number of these functional units. These functional units may be implemented via processing circuitry, which may include one or more microprocessor or microcontrollers, as well as other digital hardware, which may include digital signal processors (DSPs), special-purpose digital logic, and the like. The processing circuitry may be configured to execute program code stored in memory, which may include one or several types of memory such as read-only memory (ROM), random-access memory (RAM), cache memory, flash memory devices, optical storage devices, etc. Program code stored in memory includes program instructions for executing one or

more telecommunications and/or data communications protocols as well as instructions for carrying out one or more of the techniques described herein. In some implementations, the processing circuitry may be used to cause the respective functional unit to perform corresponding functions according one or more embodiments of the present disclosure.

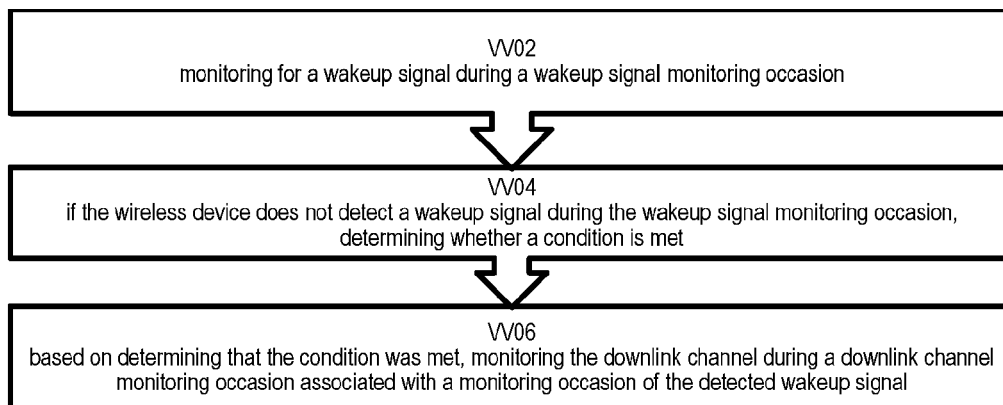


Figure VV: Method in accordance with some embodiments

Figure VV depicts a method in accordance with particular embodiments, the method begins at step VV02 with monitoring for a wakeup signal during a wakeup signal monitoring occasion. If the wireless device detects a wakeup signal during the wakeup signal monitoring occasion, the wireless device may monitor a downlink channel during a downlink channel monitoring occasion associated with a monitoring occasion of the detected wakeup signal. The wireless device may resume monitoring for other wakeup signals at a later time, e.g., after re-entering a sleep or DRX mode.

If, however, the wireless device does not detect a wakeup signal during the wakeup signal monitoring occasion, at step VV04, the wireless device may determine whether a condition is met. The wireless device may fail to detect a wakeup signal if no wakeup signal was sent by the network node or if the wireless device missed a wakeup signal (e.g., the network node sent a wake up signal, but the wireless device failed to receive the wakeup signal at all, or the wireless device received the wake up signal but was unable to successfully decode it). In certain embodiments, determining whether the condition is met may be based on whether conditions exist that increase the likelihood that the wireless device missed a wakeup signal that was sent by the network node. For example, a determination may be made if the wireless device is in a deep fade or other challenging RF environment. In particular, in certain embodiments, the condition may be whether a measured value, e.g., a quality metric or a decoder metric, at the wireless device is below a predetermined threshold value. In this example, the wireless device may determine the condition is met if the signal quality is below the threshold, implying that even if a wakeup signal was transmitted, the wireless device would not have been able to detect it.

At step VV06, if the condition was met, the wireless device monitors the downlink channel during a downlink channel monitoring occasion associated with a monitoring occasion of the detected wakeup signal. For example, even if the wakeup signal was not detected, the wireless device may still monitor the PDCCH as if it did. This may increase the robustness of the wireless device's wakeup signal operation to ensure it receives downlink information from the network node with less missed transmissions. Alternatively, if the condition is not

met (e.g., if the wireless device is in a good RF environment), failure to detect the wakeup signal may indicate that the network node did not send any wakeup signal to the wireless device such that, in certain embodiments, the wireless device need not wakeup and monitor the PDCCH. This may conserve battery power of the wireless device under conditions where the wireless is unlikely to have missed a wakeup signal. Accordingly, a conditional wakeup signal operation may be implemented via the method shown in Figure VV.

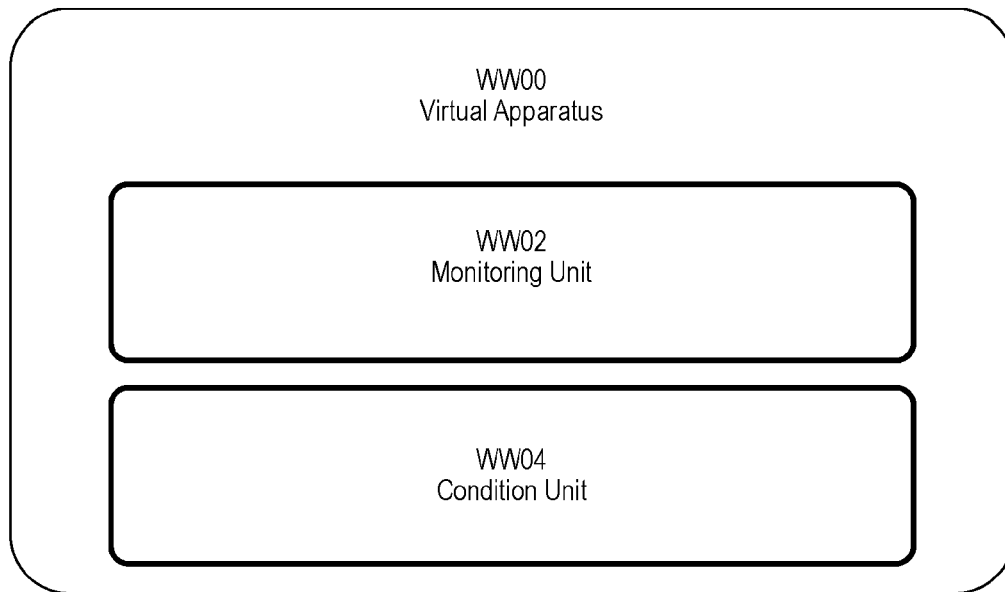


Figure WW: Virtualization apparatus in accordance with some embodiments

Figure WW illustrates a schematic block diagram of an apparatus WW00 in a wireless network (for example, the wireless network shown in Figure QQ1). The apparatus may be implemented in a wireless device or network node (e.g., wireless device QQ110 or network node QQ160 shown in Figure QQ1). Apparatus WW00 is operable to carry out the example method described with reference to Figure VV and possibly any other processes or methods disclosed herein. It is also to be understood that the method of Figure VV is not necessarily carried out solely by apparatus WW00. At least some operations of the method can be performed by one or more other entities.

Virtual Apparatus WW00 may comprise processing circuitry, which may include one or more microprocessor or microcontrollers, as well as other digital hardware, which may include digital signal processors (DSPs), special-purpose digital logic, and the like. The processing circuitry may be configured to execute program code stored in memory, which may include one or several types of memory such as read-only memory (ROM), random-access memory, cache memory, flash memory devices, optical storage devices, etc. Program code stored in memory includes program instructions for executing one or more telecommunications and/or data communications protocols as well as instructions for carrying out one or more of the techniques described herein, in several embodiments. In some implementations, the processing circuitry may be used to cause monitoring unit WW02, the condition unit WW04, and any other suitable units of apparatus WW00 to perform corresponding functions according one or more embodiments of the present disclosure.

As illustrated in Figure WW, apparatus WW00 includes monitoring unit WW02 and condition unit WW04. Monitoring unit WW02 is configured monitor for a wakeup signal during a wakeup signal monitoring occasion. If a wakeup signal is detected during the wakeup signal monitoring occasion, the downlink channel may be monitored during a downlink channel monitoring occasion associated with a monitoring occasion of the detected wakeup signal. Further monitoring for other wakeup signals may be continued at a later time, e.g., after re-entering a sleep or DRX mode. If, however, a wakeup signal is not detected during the wakeup signal monitoring occasion, condition unit WW04 may determine whether a condition is met. For example, condition unit WW04 may determine whether conditions exist that increase the likelihood that the wakeup signal was missed (e.g., the wireless device was unable to detect or decode a wakeup signal sent by the network node). In particular, in certain embodiments, the condition may be whether a measured value, e.g., a quality metric or a decoder metric, at the wireless device is below a predetermined threshold value. In this example, condition unit WW04 may determine the condition is met if the signal quality is below the threshold, implying that even if a wakeup signal was transmitted, monitoring unit WW02 would not have been able to detect it.

Additionally, monitoring unit WW02 may also monitor the downlink channel during a downlink channel monitoring occasion associated with a monitoring occasion of the detected wakeup signal. For example, even if the wakeup signal was not detected, PDCCH may be monitored as if the wakeup signal was detected. This may increase the robustness of the wakeup signal operation to ensure that downlink information is received with less missed transmissions. Accordingly, a conditional wakeup signal operation may be implemented using virtual apparatus WW00.

The term unit may have conventional meaning in the field of electronics, electrical devices and/or electronic devices and may include, for example, electrical and/or electronic circuitry, devices, modules, processors, memories, logic solid state and/or discrete devices, computer programs or instructions for carrying out respective tasks, procedures, computations, outputs, and/or displaying functions, and so on, as such as those that are described herein.

In some embodiments a computer program, computer program product or computer readable storage medium comprises instructions which when executed on a computer perform any of the embodiments disclosed herein. In further examples the instructions are carried on a signal or carrier and which are executable on a computer wherein when executed perform any of the embodiments disclosed herein.

EMBODIMENTS**Group A Embodiments**

1. A method performed by a wireless device, the method comprising:
 - monitoring for a wakeup signal during a wakeup signal monitoring occasion;
 - if the wireless device detects a wakeup signal during the wakeup signal monitoring occasion:
 - i. monitoring a downlink channel during a downlink channel monitoring occasion associated with the detected wakeup signal;
 - ii. abstaining from monitoring for other wakeup signals while monitoring the downlink channel; and
 - iii. resuming monitoring for other wakeup signals at subsequent wakeup signal monitoring occasions;
 - if the wireless device does not detect a wakeup signal during the wakeup signal monitoring occasion, continuing to monitor for other wakeup signals at subsequent wakeup signal monitoring occasions.
2. The method of embodiment 1, further comprising abstaining from monitoring for other wakeup signals based on an indication from a network node to not monitor for wakeup signals during specified times.
3. The method of any of the previous embodiments, wherein if the wireless device detects a wakeup signal, the method further comprises:
 - detecting a downlink signal while monitoring the downlink channel;
 - setting an inactivity timer after detecting the downlink signal;
 - abstaining from monitoring for other wakeup signal while the inactivity timer is running.
4. The method of any of the previous embodiments, further comprising:
 - resetting the inactivity timer in response to detecting a subsequent downlink signal in the downlink channel before the inactivity timer expired.
5. A method performed by a wireless device, the method comprising:
 - monitoring for a wakeup signal during a wakeup signal monitoring occasion;
 - if the wireless device does not detect a wakeup signal during the wakeup signal monitoring occasion:

- i. determining whether a condition is met;
 - ii. based on determining that the condition was met, monitoring the downlink channel during a downlink channel monitoring occasion associated with a monitoring occasion of the detected wakeup signal.
6. The method of embodiment 5, wherein the condition is whether a quality metric is below a predetermined threshold, wherein the quality metric is based on one or more of a RSRP, a RSRQ, a CSI condition, a synchronization condition, etc.
7. The method of embodiment 5, wherein the condition is whether a decoding metric is below a predetermined threshold, wherein the decoding metric is one of a S-metric, a mean extrinsic information magnitude, a soft value quality metric, a message reliability, a path metric, etc.
8. The method of any of embodiments 5-7, further comprising:
 - receiving information from the network node from which the wireless device obtains the condition (e.g., quality metric or decoding metric) that the wireless device is to use in determining whether the condition is met.
9. The method of embodiment 5, further comprising, in response to detecting a wakeup signal during the wakeup signal monitoring occasion, monitoring a downlink channel during a downlink channel monitoring occasion associated with the detected wakeup signal.
10. The method of embodiment 9, further comprising resuming monitoring for other wakeup signals at subsequent wakeup signal monitoring occasions.
11. The method of any of embodiments 9-10, further comprising:
 - detecting a downlink signal on the downlink channel during the downlink channel monitoring occasion;
 - setting an inactivity timer after detecting the downlink signal;
 - abstaining from monitoring for other wakeup signal while the inactivity timer is running.
12. A method performed by a wireless device, the method comprising:
 - monitoring for a wakeup signal during a wakeup signal monitoring occasion;
 - if the wireless device detects a wakeup signal during the wakeup signal monitoring occasion:

- i. transmitting an acknowledgement signal to a network node associated with the detected wakeup signal; and
 - ii. monitoring a downlink channel during a downlink channel monitoring occasion associated with the detected wakeup signal;
 - if the wireless device does not detect a wakeup signal during the wakeup signal monitoring occasion, continuing to monitor for other wakeup signals at subsequent wakeup signal monitoring occasions.
13. The method of embodiment 9, further comprising:
- determining, based on the detected wakeup signal, to send the acknowledgement signal to the network node.
14. The method of embodiment 9, further comprising:
- receiving a configuration from a network, wherein the configuration specifies the wireless device to send an acknowledgement signal in response to detecting the wakeup signal after a predetermined period of time or number of slots/subslots after detection.
15. A method performed by a wireless device, the method comprising:
- receiving an indication from a network node to monitor for a wakeup signal in the next N number of wakeup signal monitoring occasions;
 - after the Nth wakeup signal monitoring occasion, monitoring a downlink channel during one or more downlink channel monitoring occasions (e.g., without waiting for a wakeup signal to prompt the monitoring of the downlink channel).
16. The method of embodiment 15, further comprising:
- detecting a wakeup signal in one of the N wakeup signal monitoring occasions;
 - in response to the detection, monitoring the downlink channel one or more downlink channel monitoring occasions associated with the detected wakeup signal.
17. The method of any of embodiments 15-16, wherein the indication from the network node further indicates to monitor M number of the next N number of wakeup signal monitoring occasions, wherein $M < N$.
18. The method of any of the previous embodiments, further comprising:
- providing user data; and
 - forwarding the user data to a host computer via the transmission to the base station.

Group B Embodiments

19. A method performed by a network node, the method comprising:
 - transmitting for a wakeup signal to a wireless device during a wakeup signal monitoring occasion;
 - transmitting a downlink signal on a downlink channel during a downlink channel monitoring occasion associated with the wakeup signal; and
 - abstaining from transmitting another wakeup signal to the wireless device until after a predetermined period of time.
20. The method of embodiment 19, wherein the predetermined period of time is based on a preconfigured time period during which the wireless device abstains from monitoring for other wakeup signals.
21. The method of any of the previous embodiments,
 - sending a configuration to the wireless device, wherein the configuration comprises instructions for the wireless device, in response to detecting a downlink signal while monitoring the downlink channel, to:
 - i. set an inactivity timer after detecting the downlink signal; and
 - ii. abstain from monitoring for other wakeup signal while the inactivity timer is running.
22. A method performed by a network node, the method comprising:
 - transmitting, to a wireless device, information indicating one or more conditions during which, in the event that the wireless device fails to detect a wakeup signal during a wakeup signal monitoring occasion, the wireless device is to monitor a downlink channel (e.g., without waiting to receive the wakeup signal).
23. The method of embodiment 22, wherein the one or more conditions comprise a threshold value.
24. The method of any of embodiments 22-23, wherein the one or more conditions comprise a quality metric, wherein the quality metric is based on one or more of a RSRP, a RSRQ, a CSI condition, a synchronization condition, etc.
25. The method of any of embodiments 22-24, wherein the one or more conditions comprise a decoding metric, wherein the decoding metric is one of a S-metric, a mean extrinsic information magnitude, a soft value quality metric, a message reliability, a path metric, etc.
26. The method of any of embodiments 22-25, further comprising:
 - determining the information indicating the one or more conditions.
27. The method of embodiment 26, wherein the information indicating the one or more conditions is determined based on a likelihood that the wireless device will fail to detect the wakeup signal when the one or more conditions are met.

28. The method of any of embodiments 22-27, further comprising:

- transmitting a wakeup signal to a wireless device during a wakeup signal monitoring occasion; and
- transmitting a downlink signal on a downlink channel during a downlink channel monitoring occasion associated with the wakeup signal.

29. A method performed by a network node, the method comprising:

- transmitting for a wakeup signal to a wireless device during a wakeup signal monitoring occasion; and
- receiving an acknowledgement signal to a network node associated with the detected wakeup signal; and
- in response to the acknowledgment signal, transmitting a downlink signal on a downlink channel during a downlink channel monitoring occasion associated with the wakeup signal.

30. The method of embodiment 29, further comprising:

- transmitting a message instructing the wireless device to send acknowledgement signals in response to detecting wakeup signals.

31. The method of embodiment 30, further comprising:

- determining whether to transmit the message instructing the wireless device to send the acknowledgement signals based on a range of the cell served by the network node or a quality metric value measured at the wireless device.

32. The method of any of embodiments 29-31, further comprising:

- reconfiguring wakeup signal resources for the wireless device in response to receiving an acknowledgement signal from the wireless device.

33. The method of any of embodiments 29-32, further comprising:

- abstaining from sending a downlink signal during a downlink channel monitoring occasion if no acknowledgement signal is sent that corresponds to the downlink channel monitoring occasion.

34. A method performed by a network node, the method comprising:

- transmitting an indication to a wireless device to monitor for a wakeup signal in the next N number of wakeup signal monitoring occasions;
- wherein the indication implicitly or explicitly indicates that after the Nth wakeup signal monitoring occasion, the wireless device is to monitor a downlink channel during one or more downlink channel monitoring occasions (e.g., without waiting for a wakeup signal to prompt

the monitoring of the downlink channel).

35. The method of embodiment 34, further comprising:

- transmitting a wakeup signal in one of the N wakeup signal monitoring occasions; and
- transmitting a downlink channel on a downlink channel monitoring occasion associated with the wakeup signal.

36. The method of any of embodiments 34-35, wherein the indication further indicates to the wireless device to monitor M number of the next N number of wakeup signal monitoring occasions, wherein $M < N$.

37. The method of any of the previous embodiments, further comprising:

- obtaining user data; and
- forwarding the user data to a host computer or a wireless device.

Group C Embodiments

38. A wireless device, the wireless device comprising:

- processing circuitry configured to perform any of the steps of any of the Group A embodiments; and
- power supply circuitry configured to supply power to the wireless device.

39. A base station, the base station comprising:

- processing circuitry configured to perform any of the steps of any of the Group B embodiments;
- power supply circuitry configured to supply power to the base station.

40. A user equipment (UE), the UE comprising:

- an antenna configured to send and receive wireless signals;
- radio front-end circuitry connected to the antenna and to processing circuitry, and configured to condition signals communicated between the antenna and the processing circuitry;
- the processing circuitry being configured to perform any of the steps of any of the Group A embodiments;
- an input interface connected to the processing circuitry and configured to allow input of information into the UE to be processed by the processing circuitry;

- an output interface connected to the processing circuitry and configured to output information from the UE that has been processed by the processing circuitry; and
 - a battery connected to the processing circuitry and configured to supply power to the UE.
41. A computer program, the computer program comprising instructions which when executed on a computer perform any of the steps of any of the Group A embodiments.
42. A computer program product comprising a computer program, the computer program comprising instructions which when executed on a computer perform any of the steps of any of the Group A embodiments.
43. A non-transitory computer-readable storage medium or carrier comprising a computer program, the computer program comprising instructions which when executed on a computer perform any of the steps of any of the Group A embodiments.
44. A computer program, the computer program comprising instructions which when executed on a computer perform any of the steps of any of the Group B embodiments.
45. A computer program product comprising a computer program, the computer program comprising instructions which when executed on a computer perform any of the steps of any of the Group B embodiments.
46. A non-transitory computer-readable storage medium or carrier comprising a computer program, the computer program comprising instructions which when executed on a computer perform any of the steps of any of the Group B embodiments.
47. A communication system including a host computer comprising:
- processing circuitry configured to provide user data; and
 - a communication interface configured to forward the user data to a cellular network for transmission to a user equipment (UE),
 - wherein the cellular network comprises a base station having a radio interface and processing circuitry, the base station's processing circuitry configured to perform any of the steps of any of the Group B embodiments.
48. The communication system of the previous embodiment further including the base station.

49. The communication system of the previous 2 embodiments, further including the UE, wherein the UE is configured to communicate with the base station.
50. The communication system of the previous 3 embodiments, wherein:
- the processing circuitry of the host computer is configured to execute a host application, thereby providing the user data; and
 - the UE comprises processing circuitry configured to execute a client application associated with the host application.
51. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising:
- at the host computer, providing user data; and
 - at the host computer, initiating a transmission carrying the user data to the UE via a cellular network comprising the base station, wherein the base station performs any of the steps of any of the Group B embodiments.
52. The method of the previous embodiment, further comprising, at the base station, transmitting the user data.
53. The method of the previous 2 embodiments, wherein the user data is provided at the host computer by executing a host application, the method further comprising, at the UE, executing a client application associated with the host application.
54. A user equipment (UE) configured to communicate with a base station, the UE comprising a radio interface and processing circuitry configured to perform the of the previous 3 embodiments.
55. A communication system including a host computer comprising:
- processing circuitry configured to provide user data; and
 - a communication interface configured to forward user data to a cellular network for transmission to a user equipment (UE),
 - wherein the UE comprises a radio interface and processing circuitry, the UE's components configured to perform any of the steps of any of the Group A embodiments.

56. The communication system of the previous embodiment, wherein the cellular network further includes a base station configured to communicate with the UE.
57. The communication system of the previous 2 embodiments, wherein:
- the processing circuitry of the host computer is configured to execute a host application, thereby providing the user data; and
 - the UE's processing circuitry is configured to execute a client application associated with the host application.
58. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising:
- at the host computer, providing user data; and
 - at the host computer, initiating a transmission carrying the user data to the UE via a cellular network comprising the base station, wherein the UE performs any of the steps of any of the Group A embodiments.
59. The method of the previous embodiment, further comprising at the UE, receiving the user data from the base station.
60. A communication system including a host computer comprising:
- communication interface configured to receive user data originating from a transmission from a user equipment (UE) to a base station,
 - wherein the UE comprises a radio interface and processing circuitry, the UE's processing circuitry configured to perform any of the steps of any of the Group A embodiments.
61. The communication system of the previous embodiment, further including the UE.
62. The communication system of the previous 2 embodiments, further including the base station, wherein the base station comprises a radio interface configured to communicate with the UE and a communication interface configured to forward to the host computer the user data carried by a transmission from the UE to the base station.
63. The communication system of the previous 3 embodiments, wherein:
- the processing circuitry of the host computer is configured to execute a host application; and

- the UE's processing circuitry is configured to execute a client application associated with the host application, thereby providing the user data.
64. The communication system of the previous 4 embodiments, wherein:
- the processing circuitry of the host computer is configured to execute a host application, thereby providing request data; and
 - the UE's processing circuitry is configured to execute a client application associated with the host application, thereby providing the user data in response to the request data.
65. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising:
- at the host computer, receiving user data transmitted to the base station from the UE, wherein the UE performs any of the steps of any of the Group A embodiments.
66. The method of the previous embodiment, further comprising, at the UE, providing the user data to the base station.
67. The method of the previous 2 embodiments, further comprising:
- at the UE, executing a client application, thereby providing the user data to be transmitted; and
 - at the host computer, executing a host application associated with the client application.
68. The method of the previous 3 embodiments, further comprising:
- at the UE, executing a client application; and
 - at the UE, receiving input data to the client application, the input data being provided at the host computer by executing a host application associated with the client application,
 - wherein the user data to be transmitted is provided by the client application in response to the input data.
69. A communication system including a host computer comprising a communication interface configured to receive user data originating from a transmission from a user equipment (UE) to a base station, wherein the base station comprises a radio interface and processing circuitry, the base station's processing circuitry configured to perform any of the steps of any of the Group B embodiments.

70. The communication system of the previous embodiment further including the base station.
71. The communication system of the previous 2 embodiments, further including the UE, wherein the UE is configured to communicate with the base station.
72. The communication system of the previous 3 embodiments, wherein:
- the processing circuitry of the host computer is configured to execute a host application;
 - the UE is configured to execute a client application associated with the host application, thereby providing the user data to be received by the host computer.
73. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising:
- at the host computer, receiving, from the base station, user data originating from a transmission which the base station has received from the UE, wherein the UE performs any of the steps of any of the Group A embodiments.
74. The method of the previous embodiment, further comprising at the base station, receiving the user data from the UE.
75. The method of the previous 2 embodiments, further comprising at the base station, initiating a transmission of the received user data to the host computer.

ABBREVIATIONS

At least some of the following abbreviations may be used in this disclosure. If there is an inconsistency between abbreviations, preference should be given to how it is used above. If listed multiple times below, the first listing should be preferred over any subsequent listing(s).

RSRP	Reference Signal Received Power
CSI-RSRP	CSI Reference Signal Received Power
CSI-RSRQ	CSI Reference Signal Received Quality
SS-RSRP	Synchronization Signal Reference Signal Received Power
SS-RSRQ	Synchronization Signal Reference Signal Received Quality
TBS	Transport block size
SCS	Subcarrier spacing
eMBB	enhanced Mobile BroadBand
LTE	Long Term Evolution
NR	Next Radio
PDCCH	Physical Downlink Control Channel
UE	User Equipment
1x RTT	CDMA2000 1x Radio Transmission Technology
3GPP	3rd Generation Partnership Project
5G	5th Generation
ABS	Almost Blank Subframe
ARQ	Automatic Repeat Request
AWGN	Additive White Gaussian Noise
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
CA	Carrier Aggregation
CC	Carrier Component
CCCH SDU	Common Control Channel SDU
CDMA	Code Division Multiplexing Access
CGI	Cell Global Identifier
CIR	Channel Impulse Response
CP	Cyclic Prefix
CPICH	Common Pilot Channel
CPICH Ec/No	CPICH Received energy per chip divided by the power density in the band
CQI	Channel Quality Information
C-RNTI	Cell RNTI
CSI	Channel State Information
DCCH	Dedicated Control Channel
DL	Downlink
DM	Demodulation

DMRS	Demodulation Reference Signal
DRX	Discontinuous Reception
DTX	Discontinuous Transmission
DTCH	Dedicated Traffic Channel
DUT	Device Under Test
E-CID	Enhanced Cell-ID (positioning method)
E-SMLC	Evolved-Serving Mobile Location Centre
ECGI	Evolved CGI
eNB	E-UTRAN NodeB
ePDCCH	enhanced Physical Downlink Control Channel
E-SMLC	evolved Serving Mobile Location Center
E-UTRA	Evolved UTRA
E-UTRAN	Evolved UTRAN
FDD	Frequency Division Duplex
FFS	For Further Study
GERAN	GSM EDGE Radio Access Network
gNB	Base station in NR
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile communication
HARQ	Hybrid Automatic Repeat Request
HO	Handover
HSPA	High Speed Packet Access
HRPD	High Rate Packet Data
LOS	Line of Sight
LPP	LTE Positioning Protocol
LTE	Long-Term Evolution
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Services
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MBSFN ABS	MBSFN Almost Blank Subframe
MDT	Minimization of Drive Tests
MIB	Master Information Block
MME	Mobility Management Entity
MSC	Mobile Switching Center
NPDCCH	Narrowband Physical Downlink Control Channel
NR	New Radio
OCNG	OFDMA Channel Noise Generator
OFDM	Orthogonal Frequency Division Multiplexing

OFDMA	Orthogonal Frequency Division Multiple Access
OSS	Operations Support System
OTDOA	Observed Time Difference of Arrival
O&M	Operation and Maintenance
PBCH	Physical Broadcast Channel
P-CCPCH	Primary Common Control Physical Channel
PCell	Primary Cell
PCFICH	Physical Control Format Indicator Channel
PDCCH	Physical Downlink Control Channel
PDP	Profile Delay Profile
PDSCH	Physical Downlink Shared Channel
PGW	Packet Gateway
PHICH	Physical Hybrid-ARQ Indicator Channel
PLMN	Public Land Mobile Network
PMI	Precoder Matrix Indicator
PRACH	Physical Random Access Channel
PRS	Positioning Reference Signal
PSS	Primary Synchronization Signal
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
RACH	Random Access Channel
QAM	Quadrature Amplitude Modulation
RAN	Radio Access Network
RAT	Radio Access Technology
RLM	Radio Link Management
RNC	Radio Network Controller
RNTI	Radio Network Temporary Identifier
RRC	Radio Resource Control
RRM	Radio Resource Management
RS	Reference Signal
RSCP	Received Signal Code Power
RSRP	Reference Symbol Received Power OR Reference Signal Received Power
RSRQ	Reference Signal Received Quality OR Reference Symbol Received Quality
RSSI	Received Signal Strength Indicator
RSTD	Reference Signal Time Difference
SCH	Synchronization Channel
SCell	Secondary Cell

SDU	Service Data Unit
SFN	System Frame Number
SGW	Serving Gateway
SI	System Information
SIB	System Information Block
SNR	Signal to Noise Ratio
SON	Self Optimized Network
SS	Synchronization Signal
SSS	Secondary Synchronization Signal
TDD	Time Division Duplex
TDOA	Time Difference of Arrival
TOA	Time of Arrival
TSS	Tertiary Synchronization Signal
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunication System
USIM	Universal Subscriber Identity Module
UTDOA	Uplink Time Difference of Arrival
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network
WCDMA	Wide CDMA
WLAN	Wide Local Area Network

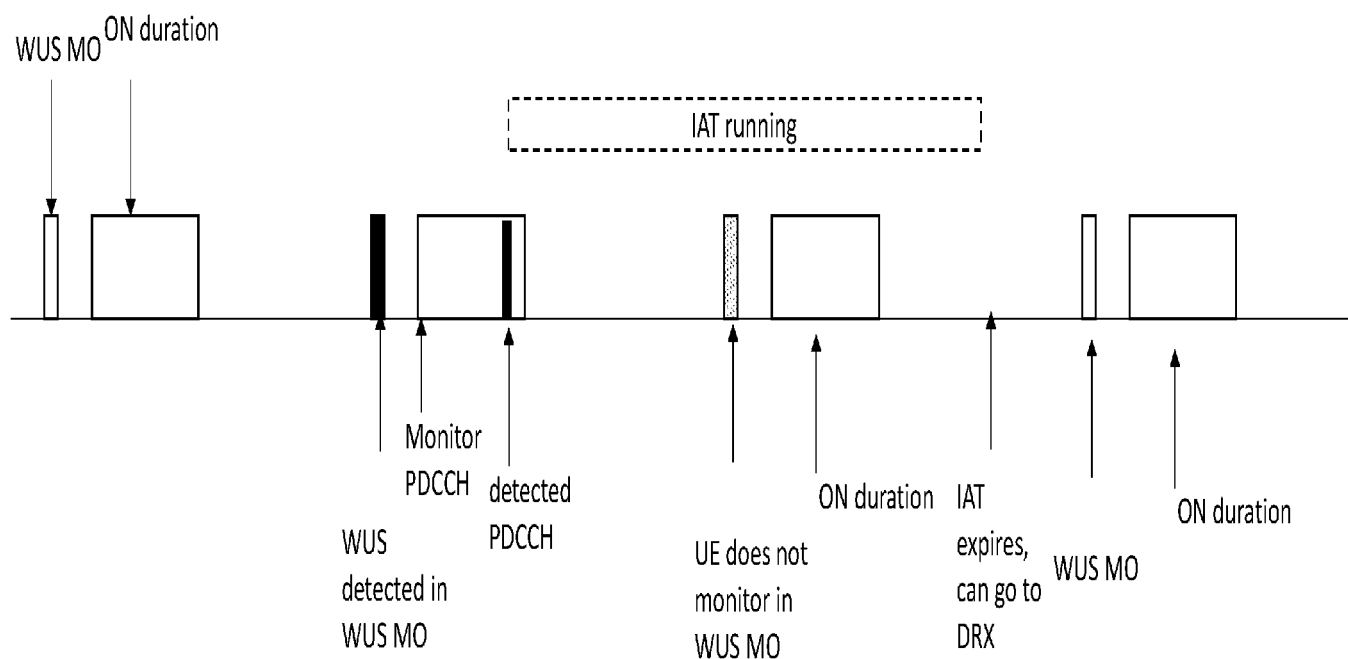


Figure 2

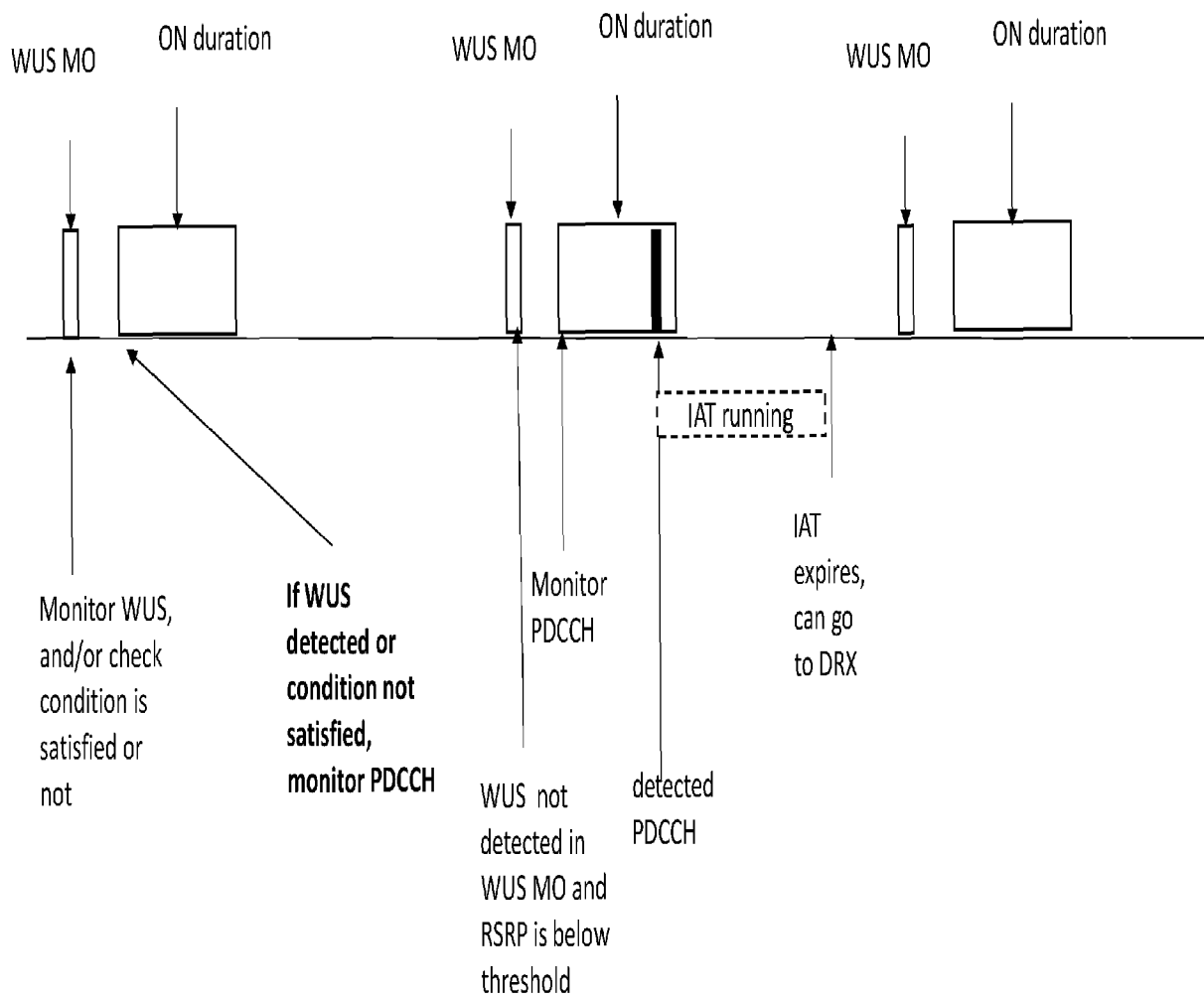


Figure 3

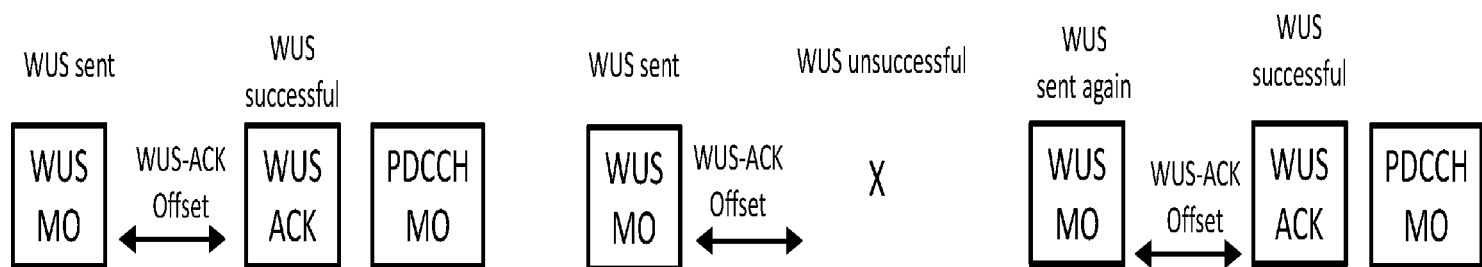


Figure 4

Command to
Monitor WUS
for N occasions

Command to
Monitor WUS
for N1 occasions

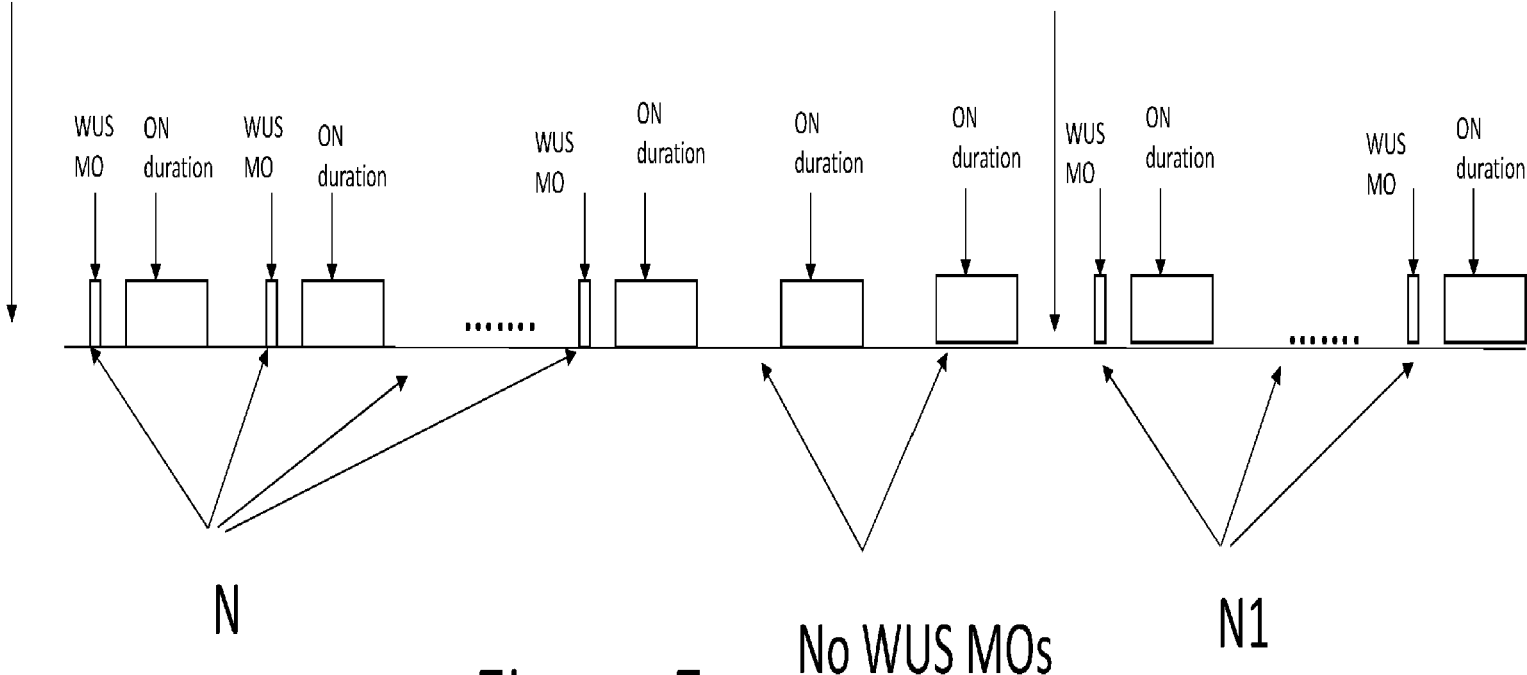


Figure 5

Electronic Acknowledgement Receipt	
EFS ID:	34680767
Application Number:	62784114
International Application Number:	
Confirmation Number:	8737
Title of Invention:	Conditional Wake-Up Signal Configuration for New Radio
First Named Inventor/Applicant Name:	Ajit Nimbalker
Customer Number:	5073
Filer:	Chad Christian Walters/Wendy Flottman
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Attorney Docket Number:	017997.1838
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Time Stamp:	18:09:38
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 280
RAM confirmation Number	122618INTEFSW00011115020384
Deposit Account	
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			427e60c0301c363f9ac1e3b7fc2ed9cf2eb65548		
Warnings:					
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2	Application Data Sheet	ADS.pdf	9112823	no	10
			75c78030915d692d2fb70af4cb0ff01ffb6a582		
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3	Specification	Application.pdf	727424	no	54
			31cd439b3551c753b3df065e6eed527c51430993		
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4	Drawings-only black and white line drawings	Figures.pdf	126205	no	4
			e54ea9f418074f70e3d2ddb72043e065fcea72e		
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Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	30182	no	2
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