source distinct from the plurality of repeater servers and distinct from the first content source;

(C) responsive to a first request that causes the first primary resource to be served to a first client from the first content source:

(c1) selecting at least a first repeater server to serve the first referenced resource to the first client;

(c2) responsive to the first repeater server being requested to serve the first referenced resource:

(c21) checking to determine whether a copy of the first referenced resource is available on the first repeater server;

(c22) if a copy of the first referenced resource is available on the first repeater server, attempting to serve the copy of the first referenced resource to the client from the first repeater server; and

(c23) if a copy of the first referenced resource is not available on the first repeater server, replicating the first referenced resource on the first repeater;

(D) responsive to a second request that causes the second primary resource to be served to a second client from the second content source:

(d1) selecting at least a second repeater server to serve the second referenced resource to the second client;

(d2) responsive to the second repeater server being requested to serve the second referenced resource:

(d21) checking to determine whether a copy of the second referenced resource is available on the second repeater server;

(d22) if a copy of the second referenced resource is available on the second repeater server, attempting to serve the copy of the

second referenced resource to the client from the second repeater server; and

(d23) if a copy of the second referenced resource is not available on the second repeater server, replicating the second referenced resource on the second repeater.

REMARKS

By this preliminary amendment, the Title and Abstract of the Disclosure have been changed, claim 1 has been canceled and new claims 2-26 have been added. No new matter has been added.

Claims 2-26 are pending in this application.

An early action and allowance of this application are respectfully requested.

CHARGE STATEMENT: Deposit Account No. 501860, order no. **2711-0073**.
The Commissioner is hereby authorized to charge any fee specifically authorized hereafter, or any missing or insufficient fee(s) filed, or asserted to be filed, or which should have been filed herewith or concerning any paper filed hereafter, and which may be required under Rules 16-18 (missing or insufficiencies only) now or hereafter relative to this application and the resulting Official Document under Rule 20, or credit any overpayment, to our Accounting/ Order Nos. shown above, for which purpose a duplicate copy of this sheet is attached.
This CHARGE STATEMENT does not authorize charge of the issue fee until/unless an issue fee transmittal sheet is filed.

CUSTOMER NUMBER 42624	Respectfully submitted, By: /Brian Siritzky/ Brian Siritzky, Ph.D., Reg. No. 37,497
Davidson Berquist Jackson & Gowdey LLP 4300 Wilson Blvd., 7th Floor, Arlington, Virginia 22203 Main: (703) 894-6400 ● FAX: (703) 894-6430	

ABSTRACT OF THE DISCLOSURE

A system in which a plurality of content providers provide multiple resources to multiple clients, wherein each content provider provides at least some resources via one or more content sources associated with that content provider. A client requests a resource from a content provider, where the resources includes references to other resources of the content provider. Referenced resources are served to requesting clients from a shared content delivery network (CDN) formed from a plurality of servers distinct from content sources associated with said content providers. The content sources may be origin servers associated with the respective content providers. The referenced resources may be video content, audio content, text, image content, web pages, HTML files, XML files, files in a markup language, documents, hypertext documents, data files, and embedded resources.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:		Atty. Docket No.:	2711-0073
FARBER, David et al.		Confirmation No.:	3296
Appln. No.:	11/065,412	Group Art Unit:	2157
Filed:	February 23, 2005	Examiner:	Unassigned
Title:	SHARED CONTENT DELIVERY INFRASTRUCTURE (AS AMENDED)	Date:	June 26, 2007

AMENDMENT TRANSMITTAL

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

Sir:

This is an amendment in the above-identified application and includes the attachments hereto. The signature below is treated as the signature to the attachments in the absence of a signature thereto.

FEE REQUIREMENTS

	Claims remaining after amendment		*Highest number previously Paid For*		*Present Extra*	*Rate: Large/Small Entity*	
1. *Total*	33	minus	20	*	= 13	X $50 / $ 25 =	$650
			* If this number is less than 20, enter "20"				
2. *Independent Claims*	5	minus	3	**	= 2	X $200 / $100 =	$400
			** If this number is less than 3, enter "3"				
3. If amendment enters multiple dependent claim(s) into this application for first time (leave this line blank if this is an reissue application)						$360 / $180 =	$360
4. **Original due date:**							
				Check time period and enter appropriate fee			
5. **Petition is hereby made** to extend the original due date to cover the date this response is filed for which the requisite fee is:				☐ 1 month ☐ 2 months. ☐ 3 months ☐ 4 months ☐ 5 months.		$120 / $60 $450 / $225 $1020 / $510 $1590 / $795 $2160 / $1080	$0
6. ☐ Attached is a Petition/Fee under Rule No.						$	$0
7. Other Fee for							$0
8. **Total Fee:**							$1410

This is a 2 page form, continued on next page . . .

9. ☒ Please charge the total fee on line 8 above to our deposit account below under the stated order number.
Our Deposit Account No.: 501860 Our Order No. (Client-Matter No.): 2711-0073

CHARGE STATEMENT: Deposit Account No. 501860, order no. 2711-0073.
The Commissioner is hereby authorized to charge any fee specifically authorized hereafter, or any missing or insufficient fee(s) filed, or asserted to be filed, or which should have been filed herewith or concerning any paper filed hereafter, and which may be required under Rules 16-18 (missing or insufficiencies only) now or hereafter relative to this application and the resulting Official Document under Rule 20, or credit any overpayment, to our Accounting/Order Nos. shown above, for which purpose a duplicate copy of this sheet is attached **This CHARGE STATEMENT does not authorize charge of the issue fee until/unless an issue fee transmittal sheet is filed.**

CUSTOMER NUMBER 42624	Respectfully submitted, By: /Brian Siritzky/ Brian Siritzky, Ph.D.; Reg. No. 37,497

Davidson Berquist Jackson & Gowdey LLP
4300 Wilson Blvd., 7th Floor, Arlington, VA 22203
Main: (703) 894-6400 ● FAX: (703) 894-6430

Electronic Patent Application Fee Transmittal

Application Number:	11065412
Filing Date:	23-Feb-2005
Title of Invention:	Optimized network resource location
First Named Inventor/Applicant Name:	David A. Farber
Filer:	Brian Siritzky
Attorney Docket Number:	2711-0073

Filed as Large Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	1202	13	50	650
Independent claims in excess of 3	1201	2	200	400
Multiple dependent claims	1203	1	360	360
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1410**

Electronic Acknowledgement Receipt	
EFS ID:	1913369
Application Number:	11065412
International Application Number:	
Confirmation Number:	3296
Title of Invention:	Optimized network resource location
First Named Inventor/Applicant Name:	David A. Farber
Customer Number:	42624
Filer:	Brian Siritzky
Filer Authorized By:	
Attorney Docket Number:	2711-0073
Receipt Date:	26-JUN-2007
Filing Date:	23-FEB-2005
Time Stamp:	19:04:31
Application Type:	Utility

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Preliminary Amendment	2711-0073_Preliminary_Amendment.pdf	323796	no	17
Warnings:					

Information:					
2	Miscellaneous Incoming Letter	Amendment_Transmittal_06-26-2007.pdf	417090	no	2
Warnings:					
Information:					
3	Fee Worksheet (PTO-06)	fee-info.pdf	8383	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	749269		

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

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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

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

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/065,412	02/23/2005	David A. Farber	2711-0073

CONFIRMATION NO. 3296

42624
DAVIDSON BERQUIST JACKSON & GOWDEY LLP
4300 WILSON BLVD., 7TH FLOOR
ARLINGTON, VA 22203

OC000000023539831

Date Mailed: 04/25/2007

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/06/2007.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

POWER OF ATTORNEY,
CORRESPONDENCE ADDRESS
AND REVOCATION OF PRIOR POWERS

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

Sir:

Revocation: I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

Power of Attorney: I hereby appoint the practitioners associated with customer number **42624**, individually and collectively, as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

I authorize Davidson Berquist Jackson & Gowdey, LLP to delete names/numbers of persons no longer with the Firm and to act and rely on instructions from and communicate directly with the entity who first sent this case to them and by whom I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Davidson Berquist Jackson & Gowdey, LLP in writing to the contrary.

Correspondence Address: Please recognize or change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to the address associated with Customer Number **42624**.

Assignee Name and Address:

Level 3 Communications, LLC
1025 Eldorado Blvd.
Broomfield, Colorado 80021

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record The individual whose signature and title is supplied below is authorized to act on behalf of the assignee			
Signature		Date	4.12.2007
Name	Robert M. Yates	Telephone	720-888-2283
Title	Senior Vice President, Assistant General Counsel		

PTO/SB/96 (09-06)
Approved for use through 03/31/2007 OMB 0651-0031
U.S Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Farber et al.

Application No /Patent No : 11/065,412 Filed/Issue Date: February 23, 2005

Entitled: Optimized network resource location

Level 3 Communications, LLC, a corporation
(Name of Assignee) (Type of Assignee e g corporation partnership university government agency etc)

states that it is:
1 ☑ the assignee of the entire right, title, and interest; or

2 ☐ an assignee of less than the entire right, title and interest
(The extent (by percentage) of its ownership interest is_____ %)

in the patent application/patent identified above by virtue of either:

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above The assignment was recorded in the United States Patent and Trademark Office at Reel _____ Frame _____, or for which a copy thereof is attached

OR

B ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1 From: Inventors To: Sandpiper Networks, Inc.
The document was recorded in the United States Patent and Trademark Office at
Reel 009208, Frame 0519, or for which a copy thereof is attached

2 From: Sandpiper Networks, Inc. To: Digital Island, Inc.
The document was recorded in the United States Patent and Trademark Office at
Reel 010981, Frame 0389, or for which a copy thereof is attached.

3 From: Digital Island, Inc. To: Cable & Wireless Internet Services, Inc.
The document was recorded in the United States Patent and Trademark Office at
Reel 013296, Frame 0239, or for which a copy thereof is attached

☑ Additional documents in the chain of title are listed on a supplemental sheet

☑ As required by 37 CFR 3 73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3 11

[NOTE: A separate copy (*i e* , a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302 08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee

/Brian Siritzky/ Reg. No. 37,497	April 6, 2007
Signature	Date
Brian Siritzky	703.894.6400
Printed or Typed Name	Telephone Number
Attorney, Reg. No. 37,497	
Title	

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office U.S Department of Commerce, P.O Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**

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

STATEMENT UNDER 3.37(B) CONTINUED

4	From: **Cable & Wireless Internet Services, Inc.** To: **Savvis Asset Holdings, Inc.** The document was recorded in the United States Patent and Trademark Office at Reel 017073 Frame 0142
5	From: **Savvis Asset Holdings, Inc.** To: **Savvis, Inc.** The document was recorded in the United States Patent and Trademark Office at Reel 016038 Frame 0526.
6	From: **Savvis, Inc.** To: **Savvis Communications Corporation** The document was recorded in the United States Patent and Trademark Office at Reel 016004 Frame 0209.
7	From: **Savvis Communications Corporation** To: **Mount Shasta Acquisition LLC** The document was recorded in the United States Patent and Trademark Office at Reel 018847 Frame 0065.
8.	From: **Mount Shasta Acquisition LLC** To: **Level 3 Communications, LLC** The document was recorded in the United States Patent and Trademark Office at Reel 018847 Frame 0077

Electronic Acknowledgement Receipt	
EFS ID:	1662573
Application Number:	11065412
International Application Number:	
Confirmation Number:	3296
Title of Invention:	Optimized network resource location
First Named Inventor/Applicant Name:	David A. Farber
Customer Number:	8791
Filer:	Brian Siritzky
Filer Authorized By:	
Attorney Docket Number:	6233P001DC3
Receipt Date:	06-APR-2007
Filing Date:	23-FEB-2005
Time Stamp:	18:23:15
Application Type:	Utility

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	20070406181709320.pdf	168318	no	3
Warnings:					

Information:	
Total Files Size (in bytes):	168318

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

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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

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

OIPE JUN 23 2005 PATENT & TRADEMARK OFFICE JC172

IFW

Docket No.: 6233P001DC3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:

DAVID A. FARBER, ET AL.

Application No.: 11/065,412

Filed: February 23, 2005

For: **Optimized Network Resource Location**

Art Group: 2157

Examiner: Unassigned

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.97

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

In accordance with the duty of disclosure, enclosed is a copy of IDS Citation Form PTO/SB/08 or PTO-1449, together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed). This IDS and IDS Citation Form are being submitted before the mailing of a first Office Action. It is respectfully requested that the cited references be considered and that the enclosed copy of PTO/SB/08 be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s). Some or all of the references listed on the enclosed PTO/SB/08 were previously identified in the parent application (Application No. 09/612,598, filed July 7, 2000) and copies of the references were furnished at that time. Accordingly, per 37 CFR §1.98(d)(1) additional copies of those references are not submitted herewith.

The submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made in the subject application and is not to be construed as an admission that the information cited in this statement is material to patentability.

Please charge any fees due to Deposit Account 02-2666. A duplicate copy of the Fee Transmittal (PTO/SB/17) is enclosed for this purpose.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: June 21, 2005

William W. Schaal, Reg. No. 39,018

12400 Wilshire Boulevard, 7th Floor
Los Angeles, CA 90025
Telephone: (714) 557-3800

I hereby certify that this correspondence is being deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Susan McFarlane — *06-21-05*

Susan McFarlane — ***Date***

OIPE JC172 JUN 23 2005 PATENT & TRADEMARK OFFICE

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application No.	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Art Unit	2157
Examiner Name	Unassigned
Total Number of Pages in This Submission: 14	Attorney Docket Number: 6233P001DC3

ENCLOSURES ***(check all that apply)***

- ☒ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment / Response
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☒ Information Disclosure Statement
  - ☒ PTO/SB/08
- ☐ Certified Copy of Priority Document(s)
- ☐ Response to Missing Parts/ Incomplete Application
  - ☐ Basic Filing Fee
  - ☐ Declaration/POA
  - ☐ Response to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s)
- ☐ After Allowance Communication to Group
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to Group **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☐ Other Enclosure(s) *(please identify below):*

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	William W. Schaal, Reg. No. 39,018 BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
Signature	
Date	June 21, 2005

CERTIFICATE OF MAILING/TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Typed or printed name	**Susan McFarlane**		
Signature		Date	**June 21, 2005**

Based on PTO/SB/21 (04-04) as modified by Blakely, Sokoloff, Taylor & Zafman (wlr) 06/04/2004.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

OIPE JC172 JUN 23 2005 PATENT & TRADEMARK OFFICE

FEE TRANSMITTAL for FY 2005

Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27.

TOTAL AMOUNT OF PAYMENT ($) 0.00

Complete if Known	
Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Examiner Name	Unassigned
Art Unit	2157
Attorney Docket No.	6233P001DC3

METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ None ☐ Other (please identify): _____

☒ Deposit Account Deposit Account Number: 02-2666 Deposit Account Name: Blakely, Sokoloff, Taylor & Zafman LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☒ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, except for the filing fee

☒ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR §§ 1.16, 1.17, 1.18 and 1.20. ☐ Credit any overpayments

FEE CALCULATION

1. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims	4	- 20* =	0	x	50.00	=	$0.00
Independent Claims	2	- 3* =	0	x	200.00	=	$0.00
Multiple Dependent						=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	50	2202	25	Claims in excess of 20
1201	200	2201	100	Independent claims in excess of 3
1203	360	2203	180	Multiple Dependent claim, if not paid
1204	300	2204	150	**Reissue independent claims over original patent
1205	300	2205	150	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (1) ($) 0.00

***or number previously paid, if greater, For Reissues, see below*

2. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
2053	130	2053	130	Non-English specification	
1251	120	2251	60	Extension for reply within first month	
1252	450	2252	225	Extension for reply within second month	
1253	1,020	2253	510	Extension for reply within third month	
1254	1,590	2254	795	Extension for reply within fourth month	
1255	2,160	2255	1,080	Extension for reply within fifth month	
1401	500	2401	250	Notice of Appeal	
1402	500	2402	250	Filing a brief in support of an appeal	
1403	1,000	2403	500	Request for oral hearing	
1451	1,510	2451	1,510	Petition to institute a public use proceeding	
1460	130	2460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
1809	790	1809	395	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	790	2810	395	For each additional invention to be examined (37 CFR § 1.129(b))	
Other fee (specify)					

SUBTOTAL (2) ($)

SUBMITTED BY Complete (if applicable)

Name (Print/Type)	William W. Schaal	Registration No. (Attorney/Agent)	39,018	Telephone	(714) 557-3800
Signature				Date	06/21/05

Based on PTO/SB/17 (12-04) as modified by Blakely, Sokoloff, Taylor & Zafman (wlr) 12/15/2004.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

OIPE JC172
JUN 23 2005
PATENT & TRADEMARK OFFICE

PTO/SB/08A(10-01)
Approved for use through 10/31/2002. OMB 0651-0031
US Patent & Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known

Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Group Art Unit	2157
Examiner Name	Unknown

Sheet 1 of 9

Attorney Docket No: 6233P001DC3

US PATENT DOCUMENTS

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known

Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Group Art Unit	2157
Examiner Name	Unknown

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	Group Art Unit	2157
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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	11/065,412
	Filing Date	February 23, 2005
	First Named Inventor	David A. Farber
	Group Art Unit	2157
	Examiner Name	Unknown
Sheet 9 of 9	Attorney Docket No: 6233P001DC3	

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T[2]**
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OIPE JG172 JUN 23 2005 PATENT & TRADEMARK OFFICE

IFW

Docket No.: 6233P001DC3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:

DAVID A. FARBER, ET AL.

Application No.: 11/065,412

Filed: February 23, 2005

For: **Optimized Network Resource Location**

Art Group: 2157

Examiner: Unassigned

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.97

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

In accordance with the duty of disclosure, enclosed is a copy of IDS Citation Form PTO/SB/08 or PTO-1449, together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed). This IDS and IDS Citation Form are being submitted before the mailing of a first Office Action. It is respectfully requested that the cited references be considered and that the enclosed copy of PTO/SB/08 be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s). Some or all of the references listed on the enclosed PTO/SB/08 were previously identified in the parent application (Application No. 09/612,598, filed July 7, 2000) and copies of the references were furnished at that time. Accordingly, per 37 CFR §1.98(d)(1) additional copies of those references are not submitted herewith.

The submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made in the subject application and is not to be construed as an admission that the information cited in this statement is material to patentability.

Please charge any fees due to Deposit Account 02-2666. A duplicate copy of the Fee Transmittal (PTO/SB/17) is enclosed for this purpose.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: June 21, 2005

William W. Schaal, Reg. No. 39,018

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Los Angeles, CA 90025
Telephone: (714) 557-3800

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Susan McFarlane — ***Date***

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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application No.	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Art Unit	2157
Examiner Name	Unassigned
Total Number of Pages in This Submission: 14	Attorney Docket Number: 6233P001DC3

ENCLOSURES ***(check all that apply)***

- ☒ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment / Response
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☒ Information Disclosure Statement
  - ☒ PTO/SB/08
- ☐ Certified Copy of Priority Document(s)
- ☐ Response to Missing Parts/ Incomplete Application
  - ☐ Basic Filing Fee
  - ☐ Declaration/POA
  - ☐ Response to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s)
- ☐ After Allowance Communication to Group
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to Group **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☐ Other Enclosure(s) *(please identify below):*

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	William W. Schaal, Reg. No. 39,018 BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
Signature	
Date	June 21, 2005

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Signature	Susan McFarlane	Date	**June 21, 2005**

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FEE TRANSMITTAL for FY 2005

Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27.

TOTAL AMOUNT OF PAYMENT ($) 0.00

Complete if Known	
Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Examiner Name	Unassigned
Art Unit	2157
Attorney Docket No.	6233P001DC3

METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ None ☐ Other (please identify): _____

☒ Deposit Account Deposit Account Number: 02-2666 Deposit Account Name: Blakely, Sokoloff, Taylor & Zafman LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☒ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, except for the filing fee

☒ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR §§ 1.16, 1.17, 1.18 and 1.20. ☐ Credit any overpayments

FEE CALCULATION

1. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims	4	- 20* =	0	x	50.00	=	$0.00
Independent Claims	2	- 3* =	0	x	200.00	=	$0.00
Multiple Dependent						=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	50	2202	25	Claims in excess of 20
1201	200	2201	100	Independent claims in excess of 3
1203	360	2203	180	Multiple Dependent claim, if not paid
1204	300	2204	150	**Reissue independent claims over original patent
1205	300	2205	150	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (1) ($) 0.00

***or number previously paid, if greater, For Reissues, see below*

2. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
2053	130	2053	130	Non-English specification	
1251	120	2251	60	Extension for reply within first month	
1252	450	2252	225	Extension for reply within second month	
1253	1,020	2253	510	Extension for reply within third month	
1254	1,590	2254	795	Extension for reply within fourth month	
1255	2,160	2255	1,080	Extension for reply within fifth month	
1401	500	2401	250	Notice of Appeal	
1402	500	2402	250	Filing a brief in support of an appeal	
1403	1,000	2403	500	Request for oral hearing	
1451	1,510	2451	1,510	Petition to institute a public use proceeding	
1460	130	2460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
1809	790	1809	395	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	790	2810	395	For each additional invention to be examined (37 CFR § 1.129(b))	
Other fee (specify)					

SUBTOTAL (2) ($)

SUBMITTED BY Complete (if applicable)

Name (Print/Type)	William W. Schaal	Registration No. (Attorney/Agent)	39,018	Telephone	(714) 557-3800
Signature				Date	06/21/05

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Complete if Known	
Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Group Art Unit	2157
Examiner Name	Unknown

Sheet 1 of 9

Attorney Docket No: 6233P001DC3

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document	Class	Subclass	Filing Date If Appropriate
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Group Art Unit	2157
Examiner Name	Unknown

Sheet 2 of 9

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Group Art Unit	2157
Examiner Name	Unknown

Sheet 3 of 9

Attorney Docket No: 6233P001DC3

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Group Art Unit	2157
Examiner Name	Unknown

Sheet 4 of 9

Attorney Docket No: 6233P001DC3

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EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)

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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known

Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Group Art Unit	2157
Examiner Name	Unknown

Sheet 5 of 9

Attorney Docket No: 6233P001DC3

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Examiner Initials*	Foreign Document No	Publication Date	Name of Patentee or Applicant of cited Document	Class	Subclass	T[2]
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EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)

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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	11/065,412
	Filing Date	February 23, 2005
	First Named Inventor	David A. Farber
	Group Art Unit	2157
	Examiner Name	Unknown
Sheet 6 of 9	Attorney Docket No: 6233P001DC3	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	**Foreign Document No**	**Publication Date**	**Name of Patentee or Applicant of cited Document**	**Class**	**Subclass**	**T[2]**
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OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T[2]**
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EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)
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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	11/065,412
	Filing Date	February 23, 2005
	First Named Inventor	David A. Farber
	Group Art Unit	2157
	Examiner Name	Unknown
Sheet 7 of 9	Attorney Docket No: 6233P001DC3	

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T[2]**
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known

Application Number	11/065,412
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Group Art Unit	2157
Examiner Name	Unknown

Sheet 8 of 9

Attorney Docket No: 6233P001DC3

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
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PTO/SB/08A(10-01)
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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	11/065,412
	Filing Date	February 23, 2005
	First Named Inventor	David A. Farber
	Group Art Unit	2157
	Examiner Name	Unknown
Sheet 9 of 9	Attorney Docket No: 6233P001DC3	

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16805 U.S.PTO 022305

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	6233P001DC3
First Inventor	David A. Farber, et al.
Title	Optimized Network Resource Location
Express Mail Label No.	EV589924728US

113013 U.S.PTO 11/06542 022305

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

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

1. ☒ Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original and a duplicate for fee processing)*
2. ☐ Applicant claims small entity status. See 37 CFR 1.27.
3. ☒ Specification *[Total Pages 55]* *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. ☒ Drawing(s) *(35 U.S.C. 113)* *[Total Sheets 6]*
5. Oath or Declaration (signed) *[Total Pages 2]*
   a. ☐ Newly executed (original or copy)
   b. ☒ Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 18 completed)*
      i. ☐ DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☐ Application Data Sheet. See 37 CFR 1.76
7. ☐ CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ paper
   c. ☐ Statements verifying identity of above copies
9. ☐ Assignment Papers (cover sheet & document(s))
10. ☐ 37 C.F.R. § 3.73(b) Statement *(when there is an assignee)* ☐ Power of Attorney
11. ☐ English Translation Document *(if applicable)*
12. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
13. ☒ Preliminary Amendment ☐ Application Amended to Reflect Claim of Priority
14. ☒ Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. ☐ Nonpublication Request under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. ☒ Other: Request for Extension of Time

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: 09/612,598

Prior application Information: Examiner _____ *Group/Art Unit:* _____

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

☒ *Customer Number* **08791** *or* ☐ *Correspondence address below*

Name	Blakely, Sokoloff, Taylor & Zafman LLP				
Address	12400 Wilshire Boulevard, 7th Floor				
City	Los Angeles	State	California	Zip Code	90025
Country		Telephone	(714) 557-3800	Fax	(714) 557-3347

Name (Print/Type)	William W. Schaal	Registration No. (Attorney/Agent)	39,018
Signature		Date	02/23/05

Based on PTO/SB/05 (04-04) as modified by Blakely, Sokoloff, Taylor & Zafman (wtr) 06/04/2004.
SEND TO: Mail Stop Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

1 of 3

16805 U.S. PTO
022305

Effective 12/08/2004
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818)

FEE TRANSMITTAL for FY 2005

☐ Applicant claims small entity status. See 37 CFR 1.27.

TOTAL AMOUNT OF PAYMENT	($)	2,020.00

Complete if Known	
Application Number	Unassigned
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Examiner Name	
Art Unit	
Attorney Docket No.	6233P001DC3

METHOD OF PAYMENT *(check all that apply)*

☒ Check ☐ Credit card ☐ Money Order ☐ None ☐ Other (please identify): _____

☒ Deposit Account Deposit Account Number: 02-2666 Deposit Account Name: Blakely, Sokoloff, Taylor & Zafman LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☒ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, except for the filing fee

☒ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR §§ 1.16, 1.17, 1.18 and 1.20. ☒ Credit any overpayments

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
		Small Entity		Small Entity		Small Entity	
Application Type	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee(s) Paid ($)
Utility	300	150	500	250	200	100	1,000.00
Design	200	100	100	50	130	65	
Plant	200	100	300	150	160	80	
Reissue	300	150	500	250	600	300	
Provisional	200	100	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description

Each claim over 20 or, for Reissues, each claim over 20 and more than in the original patent

Each independent claim over 3 or, Reissues, each independent claim more than in the original patent

Multiple independent claims

Total Claims		Extra Claims		Fee ($)		Fee Paid
4	- 20 or HP =	0	X	50.00	=	$0.00

HP = highest number of total claims paid for, if greater than 20

Indep. Claims		Extra Claims		Fee ($)		Fee Paid
2	- 3 or HP =	0	X	200.00	=	$0.00

HP = highest number of independent claims paid for, if greater than 3

Multiple Dependent Claims	
Fee ($)	Fee Paid

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets of sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets	Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)		Fee Paid ($)
61	- 100 = -39	/ 50 =		(round up to a whole number) X		=	

4. OTHER FEE(S)

	Fees Paid ($)
Non-English Specification, $130 fee (no small entity discount)	
Other: Extension of Time (3) Three Month	1,020.00
Recording of a patent assignment	

5. TOTAL AMOUNT OF PAYMENT ($) 2,020.00

SUBMITTED BY				Complete (if applicable)	
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:

DAVID A. FARBER, ET AL.

Application No.: Unassigned

Filed: February 23, 2005

For: **Optimized Network Resource Location**

Art Group:

Examiner:

PETITION FOR EXTENSION OF TIME PURSUANT TO 37 C.F.R. § 1.136(a)

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

Sir:

In accordance with 37 C.F. R. § 1.136(a), Applicants for the above-identified application respectfully Petition the Commissioner for a three (3) month extension of time, extending the period for response to February 23, 2005, from the Final Office Action dated August 23, 2004. The petition filing fee of $1,020.00 and a Request for filing a 1.53(b) continuation are attached.

If it should be determined that a longer extension of time is required to prevent this application from being abandoned, please charge any additional fees to Deposit Account No. 02-2666. A copy of the Fee Transmittal is enclosed for deposit account charging purposes.

Respectfully submitted,

Blakely, Sokoloff, Taylor & Zafman LLP

Date: February 23, 2005

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CERTIFICATE OF MAILING/TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Date

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UNITED STATES PATENT APPLICATION

FOR

OPTIMIZED NETWORK RESOURCE LOCATION

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OPTIMIZED NETWORK RESOURCE LOCATION

1. Field of the Invention

This invention relates to replication of resources in computer networks.

2. Background of the Invention

The advent of global computer networks, such as the Internet, have led to entirely new and different ways to obtain information. A user of the Internet can now access information from anywhere in the world, with no regard for the actual location of either the user or the information. A user can obtain information simply by knowing a network address for the information and providing that address to an appropriate application program such as a network browser.

The rapid growth in popularity of the Internet has imposed a heavy traffic burden on the entire network. Solutions to problems of demand (e.g., better accessibility and faster communication links) only increase the strain on the supply. Internet Web sites (referred to here as "publishers") must handle ever-increasing bandwidth needs, accommodate dynamic changes in load, and improve performance for distant browsing clients, especially those overseas. The adoption of content-rich applications, such as live audio and video, has further exacerbated the problem.

To address basic bandwidth growth needs, a Web publisher typically subscribes to additional bandwidth from an Internet service provider (ISP), whether in the form of larger or additional "pipes" or channels from the ISP to the publisher's premises, or in the form of large bandwidth commitments in an ISP's remote hosting server collection. These increments are not always as fine-grained as the publisher needs, and quite often lead times can cause the publisher's Web site capacity to lag behind demand.

To address more serious bandwidth growth problems, publishers may develop more complex and costly custom solutions. The solution to the most common need, increasing capacity, is generally based on replication of hardware resources and site

content (known as mirroring), and duplication of bandwidth resources. These solutions, however, are difficult and expensive to deploy and operate. As a result, only the largest publishers can afford them, since only those publishers can amortize the costs over many customers (and Web site hits).

A number of solutions have been developed to advance replication and mirroring. In general, these technologies are designed for use by a single Web site and do not include features that allow their components to be shared by many Web sites simultaneously.

Some solution mechanisms offer replication software that helps keep mirrored servers up-to-date. These mechanisms generally operate by making a complete copy of a file system. One such system operates by transparently keeping multiple copies of a file system in synch. Another system provides mechanisms for explicitly and regularly copying files that have changed. Database systems are particularly difficult to replicate, as they are continually changing. Several mechanisms allow for replication of databases, although there are no standard approaches for accomplishing it. Several companies offering proxy caches describe them as replication tools. However, proxy caches differ because they are operated on behalf of clients rather than publishers.

Once a Web site is served by multiple servers, a challenge is to ensure that the load is appropriately distributed or balanced among those servers. Domain name-server-based round-robin address resolution causes different clients to be directed to different mirrors.

Another solution, load balancing, takes into account the load at each server (measured in a variety of ways) to select which server should handle a particular request.

Load balancers use a variety of techniques to route the request to the appropriate server. Most of those load-balancing techniques require that each server be an exact replica of the primary Web site. Load balancers do not take into account the "network distance" between the client and candidate mirror servers.

Assuming that client protocols cannot easily change, there are two major problems in the deployment of replicated resources. The first is how to select which copy of the resource to use. That is, when a request for a resource is made to a single server, how should the choice of a replica of the server (or of that data) be made. We call this problem the "rendezvous problem". There are a number of ways to get clients to rendezvous at distant mirror servers. These technologies, like load balancers, must route a request to an appropriate server, but unlike load balancers, they take network performance and topology into account in making the determination.

A number of companies offer products which improve network performance by prioritizing and filtering network traffic.

Proxy caches provide a way for client aggregators to reduce network resource consumption by storing copies of popular resources close to the end users. A client aggregator is an Internet service provider or other organization that brings a large number of clients operating browsers to the Internet. Client aggregators may use proxy caches to reduce the bandwidth required to serve web content to these browsers. However, traditional proxy caches are operated on behalf of Web clients rather than Web publishers.

Proxy caches store the most popular resources from all publishers, which means they must be very large to achieve reasonable cache efficiency. (The efficiency of a cache is defined as the number of requests for resources which are already cached divided by the total number of requests.)

Proxy caches depend on cache control hints delivered with resources to determine when the resources should be replaced. These hints are predictive, and are necessarily often incorrect, so proxy caches frequently serve stale data. In many cases, proxy cache operators instruct their proxy to ignore hints in order to make the cache more efficient, even though this causes it to more frequently serve stale data.

Proxy caches hide the activity of clients from publishers. Once a resource is cached, the publisher has no way of knowing how often it was accessed from the cache.

SUMMARY OF THE INVENTION

This invention provides a way for servers in a computer network to off-load their processing of requests for selected resources by determining a different server (a "repeater") to process those requests. The selection of the repeater can be made dynamically, based on information about possible repeaters.

If a requested resource contains references to other resources, some or all of these references can be replaced by references to repeaters.

Accordingly, in one aspect, this invention is a method of processing resource requests in a computer network. First a client makes a request for a particular resource from an origin server, the request including a resource identifier for the particular resource, the resource identifier sometimes including an indication of the origin server. Requests arriving at the origin server do not always include an indication of the origin server; since they are sent to the origin server, they do not need to name it. A mechanism referred to as a reflector, co-located with the origin server, intercepts the request from the client to the origin server and decides whether to reflect the request or to handle it locally. If the reflector decides to handle the request locally, it forwards it to the origin server, otherwise it selects a "best" repeater to process the request. If the request is reflected, the client is provided with a modified resource identifier designating the repeater.

The client gets the modified resource identifier from the reflector and makes a request for the particular resource from the repeater designated in the modified resource identifier.

When the repeater gets the client's request, it responds by returning the requested resource to the client. If the repeater has a local copy of the resource then it returns that copy, otherwise it forwards the request to the origin server to get the resource, and saves a local copy of the resource in order to serve subsequent requests.

The selection by the reflector of an appropriate repeater to handle the request can be done in a number of ways. In the preferred embodiment, it is done by first pre-

partitioning the network into "cost groups" and then determining which cost group the client is in. Next, from a plurality of repeaters in the network, a set of repeaters is selected, the members of the set having a low cost relative to the cost group which the client is in. In order to determine the lowest cost, a table is maintained and regularly updated to define the cost between each group and each repeater. Then one member of the set is selected, preferably randomly, as the best repeater.

If the particular requested resource itself can contain identifiers of other resources, then the resource may be rewritten (before being provided to the client). In particular, the resource is rewritten to replace at least some of the resource identifiers contained therein with modified resource identifiers designating a repeater instead of the origin server. As a consequence of this rewriting process, when the client requests other resources based on identifiers in the particular requested resource, the client will make those requests directly to the selected repeater, bypassing the reflector and origin server entirely.

Resource rewriting must be performed by reflectors. It may also be performed by repeaters, in the situation where repeaters "peer" with one another and make copies of resources which include rewritten resource identifiers that designate a repeater.

In a preferred embodiment, the network is the Internet and the resource identifier is a uniform resource locator (URL) for designating resources on the Internet, and the modified resource identifier is a URL designating the repeater and indicating the origin server (as described in step B3 below), and the modified resource identifier is provided to the client using a REDIRECT message. Note, only when the reflector is "reflecting" a request is the modified resource identifier provided using a REDIRECT message.

In another aspect, this invention is a computer network comprising a plurality of origin servers, at least some of the origin servers having reflectors associated therewith, and a plurality of repeaters.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which the reference characters refer to like parts throughout and in which:

FIGURE 1 depicts a portion of a network environment according to the present invention; and

FIGURES 2-6 are flow charts of the operation of the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

Overview

FIGURE 1 shows a portion of a network environment **100** according to the present invention, wherein a mechanism (reflector **108**, described in detail below) at a server (herein origin server **102**) maintains and keeps track of a number of partially replicated servers or repeaters **104a**, **104b**, and **104c**. Each repeater **104a**, **104b**, and **104c** replicates some or all of the information available on the origin server **102** as well as information available on other origin servers in the network **100**. Reflector **108** is connected to a particular repeater known as its "contact" repeater ("Repeater B" **104b** in the system depicted in FIGURE 1). Preferably each reflector maintains a connection with a single repeater known as its contact, and each repeater maintains a connection with a special repeater known as its master repeater (e.g., repeater **104m** for repeaters **104a**, **104b** and **104c** in FIGURE 1).

Thus, a repeater can be considered as a dedicated proxy server that maintains a partial or sparse mirror of the origin server **102**, by implementing a distributed coherent cache of the origin server. A repeater may maintain a (partial) mirror of more than one origin server. In some embodiments, the network **100** is the Internet and repeaters

mirror selected resources provided by origin servers in response to clients' HTTP (hypertext transfer protocol) and FTP (file transfer protocol) requests.

A client **106** connects, via the network **100**, to origin server **102** and possibly to one or more repeaters **104a** etc.

Origin server **102** is a server at which resources originate. More generally, the origin server **102** is any process or collection of processes that provide resources in response to requests from a client **106**. Origin server **102** can be any off-the-shelf Web server. In a preferred embodiment, origin server **102** is typically a Web server such as the Apache server or Netscape Communications Corporation's Enterprise™ server.

Client **106** is a processor requesting resources from origin server **102** on behalf of an end user. The client **106** is typically a user agent (e.g., a Web browser such as Netscape Communications Corporation's Navigator™) or a proxy for a user agent. Components other than the reflector **108** and the repeaters **104a, 104b,** etc., may be implemented using commonly available software programs. In particular, this invention works with any HTTP client (e.g., a Web browser), proxy cache, and Web server. In addition, the reflector **108** might be fully integrated into the data server **112** (for instance, in a Web Server). These components might be loosely integrated based on the use of extension mechanisms (such as so-called add-in modules) or tightly integrated by modifying the service component specifically to support the repeaters.

Resources originating at the origin server **102** may be static or dynamic. That is, the resources may be fixed or they may be created by the origin server **102** specifically in response to a request. Note that the terms "static" and "dynamic" are relative, since a static resource may change at some regular, albeit long, interval.

Resource requests from the client **106** to the origin server **102** are intercepted by reflector **108** which for a given request either forwards the request on to the origin server **102** or conditionally reflects it to some repeater **104a, 104b**, etc. in the network **100**. That is, depending on the nature of the request by the client **106** to the origin server **102**, the reflector **108** either serves the request locally (at the origin server **102**), or selects one

of the repeaters (preferably the best repeater for the job) and reflects the request to the selected repeater. In other words, the reflector **108** causes requests for resources from origin server **102**, made by client **106**, to be either served locally by the origin server **102** or transparently reflected to the best repeater **104a, 104b**, etc. The notion of a best repeater and the manner in which the best repeater is selected are described in detail below.

Repeaters **104a, 104b**, etc. are intermediate processors used to service client requests thereby improving performance and reducing costs in the manner described herein. Within repeaters **104a, 104b**, etc., are any processes or collections of processes that deliver resources to the client **106** on behalf of the origin server **102**. A repeater may include a repeater cache **110**, used to avoid unnecessary transactions with the origin server **102**.

The reflector **108** is a mechanism, preferably a software program, that intercepts requests that would normally be sent directly to the origin server **102**. While shown in the drawings as separate components, the reflector **108** and the origin server **102** are typically co-located, e.g., on a particular system such as data server **112**. (As discussed below, the reflector **108** may even be a "plug in" module that becomes part of the origin server **102**.

FIGURE **1** shows only a part of a network **100** according to this invention. A complete operating network consists of any number of clients, repeaters, reflectors, and origin servers. Reflectors communicate with the repeater network, and repeaters in the network communicate with one another.

Uniform Resource Locators

Each location in a computer network has an address which can generally be specified as a series of names or numbers. In order to access information, an address for that information must be known. For example, on the World Wide Web ("the Web") which is a subset of the Internet, the manner in which information address locations are

provided has been standardized into Uniform Resource Locators (URLs). URLs specify the location of resources (information, data files, etc.) on the network.

The notion of URLs becomes even more useful when hypertext documents are used. A hypertext document is one which includes, within the document itself, links (pointers or references) to the document itself or to other documents. For example, in an on-line legal research system, each case may be presented as a hypertext document. When other cases are cited, links to those cases can be provided. In this way, when a person is reading a case, they can follow cite links to read the appropriate parts of cited cases.

In the case of the Internet in general and the World Wide Web specifically, documents can be created using a standardized form known as the Hypertext Markup Language (HTML). In HTML, a document consists of data (text, images, sounds, and the like), including links to other sections of the same document or to other documents. The links are generally provided as URLs, and can be in relative or absolute form. Relative URLs simply omit the parts of the URL which are the same as for the document including the link, such as the address of the document (when linking to the same document), etc. In general, a browser program will fill in missing parts of a URL using the corresponding parts from the current document, thereby forming a fully formed URL including a fully qualified domain name, etc.

A hypertext document may contain any number of links to other documents, and each of those other documents may be on a different server in a different part of the world. For example, a document may contain links to documents in Russia, Africa, China and Australia. A user viewing that document at a particular client can follow any of the links transparently (i.e., without knowing where the document being linked to actually resides). Accordingly, the cost (in terms of time or money or resource allocation) of following one link versus another may be quite significant.

URLs generally have the following form (defined in detail in T. Berners-Lee et al, *Uniform Resource Locators (URL)*, Network Working Group, Request for Comments: 1738,

Category: Standards Track, December 1994, located at "http://ds.internic.net/rfc/rfc1738.txt", which is hereby incorporated herein by reference):

scheme://host[:port]/url-path

where "scheme" can be a symbol such as "*file*" (for a file on the local system), "*ftp*" (for a file on an anonymous FTP file server), "*http*" (for a file on a file on a Web server),and "*telnet*" (for a connection to a Telnet-based service). Other schemes, can also be used and new schemes are added every now and then. The port number is optional, the system substituting a default port number (depending on the scheme) if none is provided. The "host" field maps to a particular network address for a particular computer. The "url-path" is relative to the computer specified in the "host" field. A url-path is typically, but not necessarily, the pathname of a file in a web server directory.

For example, the following is a URL identifying a file "F" in the path "A/B/C" on a computer at "*www.uspto.gov*":

http://www.uspto.gov/A/B/C/F

In order to access the file "F" (the resource) specified by the above URL, a program (e.g., a browser) running on a user's computer (i.e., a client computer) would have to first locate the computer (i.e., a server computer) specified by the host name. I.e., the program would have to locate the server "*www.uspto.gov*". To do this, it would access a Domain Name Server (DNS), providing the DNS with the host name ("*www.uspto.gov*"). The DNS acts as a kind of centralized directory for resolving addresses from names. If the DNS determines that there is a (remote server) computer corresponding to the name "*www.uspto.gov*", it will provide the program with an actual computer network address for that server computer. On the Internet this is called an Internet Protocol (or IP) address and it has the form "123.345.456.678". The program on the user's (client) computer would then use the actual address to access the remote (server) computer.

The program opens a connection to the HTTP server (Web server) on the remote computer "*www.uspto.gov*" and uses the connection to send a request message to the remote computer (using the HTTP scheme). The message is typically an HTTP GET request which includes the url-path of the requested resource, "A/B/C/F". The HTTP server receives the request and uses it to access the resource specified by the url-path "A/B/C/F". The server returns the resource over the same connection.

Thus, conventionally HTTP client requests for Web resources at an origin server **102** are processed as follows (see **FIGURE 2**) (This is a description of the process when no reflector **108** is installed.):

A1. A browser (e.g., Netscape's Navigator) at the client receives a resource identifier (i.e., a URL) from a user.

A2. The browser extracts the host (origin server) name from the resource identifier, and uses a domain name server (DNS) to look up the network (IP) address of the corresponding server. The browser also extracts a port number, if one is present, or uses a default port number (the default port number for http requests is 80).

A3. The browser uses the server's network address and port number to establish a connection between the client **106** and the host or origin server **102**.

A4. The client **106** then sends a (GET) request over the connection identifying the requested resource.

A5. The origin server **102** receives the request and

A6. locates or composes the corresponding resource.

A7. The origin server **102** then sends back to the client **106** a reply containing the requested resource (or some form of error indicator if the resource is unavailable). The reply is sent to the client over the same connection as that on which the request was received from the client.

A8. The client **106** receives the reply from the origin server **102.**

There are many variations of this basic model. For example, in one variation, instead of providing the client with the resource, the origin server can tell the client to re-request the resource by another name. To do so, in A7 the server **102** sends back to the client **106** a reply called a "REDIRECT" which contains a new URL indicating the other name. The client **106** then repeats the entire sequence, normally without any user intervention, this time requesting the resource identified by the new URL.

System Operation

In this invention reflector **108** effectively takes the place of an ordinary Web server or origin server **102.** The reflector **108** does this by taking over the origin server's IP address and port number. In this way, when a client tries to connect to the origin server **102,** it will actually connect to the reflector **108.** The original Web server (or origin server **102**) must then accept requests at a different network (IP) address, or at the same IP address but on a different port number. Thus, using this invention, the server referred to in A3-A7 above is actually a reflector **108.**

Note that it is also possible to leave the origin server's network address as it is and to let the reflector run at a different address or on a different port. In this way the reflector does not intercept requests sent to the origin server, but can still be sent requests addressed specifically to the reflector. Thus the system can be tested and configured without interrupting its normal operation.

The reflector **108** supports the processing as follows (see **FIGURE 3**):
upon receipt of a request,

B1 The reflector **108** analyzes the request to determine whether or not to reflect the request. To do this, first the reflector determines whether the sender (client **106**) is a browser or a repeater. Requests issued by repeaters must be served locally by the origin server **102**. This determination can be made by looking up the network (IP) address of the sender in a list of known repeater network (IP) addresses. Alternatively, this determination could be made by attaching information to a request to indicate that the request is from a specific repeater, or repeaters can request resources from a special port other than the one used for ordinary clients.

B2 If the request is not from a repeater, the reflector looks up the requested resource in a table (called the "rule base") to determine whether the resource requested is "repeatable". Based on this determination, the reflector either reflects the request (B3, described below) or serves the request locally (B4, described below).

The rule base is a list of regular expressions and associated attributes. (Regular expressions are well-known in the field of computer science. A small bibliography of their use is found in *Aho, et al.*, "Compilers, Principles, techniques and tools", Addison-Wesley, 1986, pp. 157-158.) The resource identifier (URL) for a given request is looked up in the rule base by matching it sequentially with each regular expression. The first match identifies the attributes for the resource, namely repeatable or local. If there is no match in the rule base, a default attribute is used. Each reflector has its own rule base, which is manually configured by the reflector operator.

B3. To reflect a request, (to serve a request locally go to B4), as shown in FIGURE 4, the reflector determines (B3-1) the best repeater to reflect the request to, as described in detail below. The reflector then creates (B3-2) a new resource identifier (URL) (using the requested URL and the best repeater) that identifies the same resource at the selected repeater.

It is necessary that the reflection step create a single URL containing the URL of the original resource, as well as the identity of the selected repeater. A special form of URL is created to provide this information. This is done by creating a new URL as follows:

D1. Given a repeater name, scheme, origin server name and path, create a new URL. If the scheme is "http", the preferred embodiment uses the following format:

http://<repeater>/<server>/<path>

If the form used is other than "http", the preferred embodiment uses the following format:

http://<repeater>/<server>@proxy=<scheme>@/<path>

The reflector can also attach a MIME type to the request, to cause the repeater to provide that MIME type with the result. This is useful because many protocols (such as FTP) do not provide a way to attach a MIME type to a resource. The format is

http://<repeater>/<server>@proxy=<scheme>:<type>@/<path>

This URL is interpreted when received by the repeater.

The reflector then sends (B3-3) a REDIRECT reply containing this new URL to the requesting client. The HTTP REDIRECT command allows the reflector to send the browser a single URL to retry the request.

B4. To serve a request locally, the request is sent by the reflector to ("forwarded to") the origin server **102**. In this mode, the reflector acts as a reverse proxy server. The origin server **102** processes the request in the normal manner (A5-A7). The reflector then obtains the origin server's reply to the request which it inspects to determine if the requested resource is an HTML document, i.e., whether the requested resource is one which itself contains resource identifiers.

B5. If the resource is an HTML document then the reflector rewrites the HTML document by modifying resource identifiers (URLs) within it, as described below. The resource, possibly as modified by rewriting, is then returned in a reply to the requesting client **106**.

If the requesting client is a repeater, the reflector may temporarily disable any cache-control modifiers which the origin server attached to the reply. These disabled cache-control modifiers are later re-enabled when the content is served from the repeater. This mechanism makes it possible for the origin server to prevent resources from being cached at normal proxy caches, without affecting the behavior of the cache at the repeater.

B6. Whether the request is reflected or handled locally, details about the transaction, such as the current time, the address of the requester, the URL requested, and the type of response generated, are written by the

reflector to a local log file.

By using a rule base (B2), it is possible to selectively reflect resources. There are a number of reasons that certain particular resources cannot be effectively repeated (and therefore should not be reflected), for instance:

- the resource is composed uniquely for each request;
- the resource relies on a so-called cookie (browsers will not send cookies to repeaters with different domain names);
- the resource is actually a program (such as a Java applet) that will run on the client and that wishes to connect to a service (Java requires that the service be running on the same machine that provided the applet).

In addition, the reflector **108** can be configured so that requests from certain network addresses (e.g., requests from clients on the same local area network as the reflector itself) are never reflected. Also, the reflector may choose not to reflect requests because the reflector is exceeding its committed aggregate information rate, as described below.

A request which is reflected is automatically mirrored at the repeater when the repeater receives and processes the request.

The combination of the reflection process described here and the caching process described below effectively creates a system in which repeatable resources are migrated to and mirrored at the selected reflector, while non-repeatable resources are not mirrored.

Alternate Approach

Placing the origin server name in the reflected URL is generally a good strategy, but it may be considered undesirable for aesthetic or (in the case, e.g., of cookies) certain technical reasons.

It is possible to avoid the need for placing both the repeater name and the server name in the URL. Instead, a "family" of names may be created for a given origin server, each name identifying one of the repeaters used by that server.

For instance, if www.example.com is the origin server, names for three repeaters might be created:

wr1.example.com
wr2.example.com
wr3.example.com

The name "wr1.example.com" would be an alias for repeater 1, which might also be known by other names such as "wr1.anotherExample.com" and "wr1.example.edu".

If the repeater can determine by which name it was addressed, it can use this information (along with a table that associates repeater alias names with origin server names) to determine which origin server is being addressed. For instance, if repeater 1 is addressed as wr1.example.com, then the origin server is "www.example.com"; if it is addressed as "wr1.anotherExample.com", then the origin server is "www.anotherExample.com".

The repeater can use two mechanisms to determine by which alias it is addressed:

1. Each alias can be associated with a different IP address. Unfortunately, this solution does not scale well, as IP addresses are currently scarce, and the number of IP addresses required grows as the product of origin servers and repeaters.
2. The repeater can attempt to determine the alias name used by inspecting the "host:" tag in the HTTP header of the request. Unfortunately, some old browsers still in use do not attach the "host:" tag to a request. Reflectors would need to identify such browsers (the browser identity is a part of each request) and avoid this form of reflection.

How a Repeater Handles a Request

When a browser receives a REDIRECT response (as produced in B3), it reissues

a request for the resource using the new resource identifier (URL) (A1-A5). Because the new identifier refers to a repeater instead of the origin server, the browser now sends a request for the resource to the repeater which processes a request as follows, with reference to FIGURE 5:

C1. First the repeater analyzes the request to determine the network address of the requesting client and the path of the resource requested. Included in the path is an origin server name (as described above with reference to B3).

C2. The repeater uses an internal table to verify that the origin server belongs to a known "subscriber". A subscriber is an entity (e.g., a company) that publishes resources (e.g., files) via one or more origin servers. When the entity subscribes, it is permitted to utilize the repeater network. The subscriber tables described below include the information that is used to link reflectors to subscribers.

If the request is not for a resource from a known subscriber, the request is rejected. To reject a request, the repeater returns a reply indicating that the requested resource does not exist.

C3. The repeater then determines whether the requested resource is cached locally. If the requested resource is in the repeater's cache it is retrieved. On the other hand, if a valid copy of the requested resource is not in the repeater's cache, the repeater modifies the incoming URL, creating a request that it issues directly to the originating reflector which processes it (as in B1-B6). Because this request to the originating reflector is from a repeater, the reflector always returns the requested resource rather than reflecting the request. (Recall that reflectors always handle requests from repeaters locally.) If the repeater obtained the resource from the origin

server, the repeater then caches the resource locally.

If a resource is not cached locally, the cache can query its "peer caches" to see if one of them contains the resource, before or at the same time as requesting the resource from the reflector/origin server. If a peer cache responds positively in a limited period of time (preferably a small fraction of a second), the resource will be retrieved from the peer cache.

C4. The repeater then constructs a reply including the requested resource (which was retrieved from the cache or from the origin server) and sends that reply to the requesting client.

C5. Details about the transaction, such as the associated reflector, the current time, the address of the requester, the URL requested, and the type of response generated, are written to a local log file at the repeater.

Note that the bottom row of FIGURE 2 refers to an origin server, or a reflector, or a repeater, depending on what the URL in step A1 identifies.

Selecting the Best Repeater

If the reflector **108** determines that it will reflect the request, it must then select the best repeater to handle that request (as referred to in step B3-1). This selection is performed by the Best Repeater Selector (BRS) mechanism described here.

The goal of the BRS is to select, quickly and heuristically, an appropriate repeater for a given client given only the network address of the client. An appropriate repeater is one which is not too heavily loaded and which is not too far from the client in terms

of some measure of network distance. The mechanism used here relies on specific, compact, pre-computed data to make a fast decision. Other, dynamic solutions can also be used to select an appropriate repeater.

The BRS relies on three pre-computed tables, namely the Group Reduction Table, the Link Cost Table, and the Load Table. These three tables (described below) are computed off-line and downloaded to each reflector by its contact in the repeater network.

The Group Reduction Table places every network address into a group, with the goal that addresses in a group share relative costs, so that they would have the same best repeater under varying conditions (i.e., the BRS is invariant over the members of the group). .

The Link Cost Table is a two dimensional matrix which specifies the current cost between each repeater and each group. Initially, the link cost between a repeater and a group is defined as the "normalized link cost" between the repeater and the group, as defined below. Over time, the table will be updated with measurements which more accurately reflect the relative cost of transmitting a file between the repeater and a member of the group. The format of the Link Cost Table is <Group ID> <Group ID> <link cost>, where the Group ID's are given as AS numbers.

The Load Table is a one dimensional table which identifies the current load at each repeater. Because repeaters may have different capacities, the load is a value that represents the ability of a given repeater to accept additional work. Each repeater sends its current load to a central master repeater at regular intervals, preferably at least approximately once a minute. The master repeater broadcasts the Load Table to each reflector in the network, via the contact repeater.

A reflector is provided entries in the Load Table only for repeaters which it is assigned to use. The assignment of repeaters to reflectors is performed centrally by a repeater network operator at the master repeater. This assignment makes it possible to modify the service level of a given reflector. For instance, a very active reflector may use

many repeaters, whereas a relatively inactive reflector may use few repeaters.

Tables may also be configured to provide selective repeater service to subscribers in other ways, e.g., for their clients in specific geographic regions, such as Europe or Asia.

Measuring Load

In the presently preferred embodiments, repeater load is measured in two dimensions, namely

1. requests received by the repeater per time interval *(RRPT)*, and
2. bytes sent by the repeater per time interval *(BSPT)*.

For each of these dimensions, a maximum *capacity* setting is set. The maximum capacity indicates the point at which the repeater is considered to be fully loaded. A higher RRPT capacity generally indicates a faster processor, whereas a higher BSPT capacity generally indicates a wider network pipe. This form of load measurement assumes that a given server is dedicated to the task of repeating.

Each repeater regularly calculates its *current* RRPT and BSPT, by accumulating the number of requests received and bytes sent over a short time interval. These measurements are used to determine the repeater's load in each of these dimensions. If a repeater's load exceeds its configured capacity, an alarm message is sent to the repeater network administrator.

The two current load components are combined into a single value indicating overall current load. Similarly, the two maximum capacity components are combined into a single value indicating overall maximum capacity. The components are combined as follows:

$$\text{current-load} = B \times \text{current RRPT} + (1 - B) \times \text{current BSPT}$$

$$\text{max-load} = B \times \text{max RRPT} + (1 - B) \times \text{max BSPT}$$

The factor B, a value between 0 and 1, allows the relative weights of RRPT and BSPT to be adjusted, which favors consideration of either processing power or

bandwidth.

The overall current load and overall maximum capacity values are periodically sent from each repeater to the master repeater, where they are aggregated in the Load Table, a table summarizing the overall load for all repeaters. Changes in the Load Table are distributed automatically to each reflector.

While the preferred embodiment uses a two-dimensional measure of repeater load, any other measure of load can be used.

Combining Link Costs and Load

The BRS computes the cost of servicing a given client from each eligible repeater. The cost is computed by combining the available capacity of the candidate repeater with the cost of the link between that repeater and the client. The link cost is computed by simply looking it up in the Link Cost table.

The cost is determined using the following formula:

$$threshold = K * max\text{-}load$$
$$capacity = max(max\text{-}load - current\text{-}load, e)$$
$$capacity = min(capacity, threshold)$$
$$cost = link\text{-}cost * threshold / capacity$$

In this formula, e is a very small number (epsilon) and K is a tuning factor initial set to 0.5. This formula causes the cost to a given repeater to be increased, at a rate defined by K, if its capacity falls below a configurable threshold.

Given the cost of each candidate repeater, the BRS selects all repeaters within a delta factor of the best score. From this set, the result is selected at random.

The delta factor prevents the BRS from repeatedly selecting a single repeater when scores are similar. It is generally required because available information about load

and link costs loses accuracy over time. This factor is tunable.

Best Repeater Selector (BRS)

The BRS operates as follows, with reference to **FIGURE 6**:

Given a client network address and the three tables described above:

E1. Determine which group the client is in using the Group Reduction Table.

E2. For each repeater in the Link Cost Table and Load Table, determine that repeater's combined cost as follows:

E2a. Determine the maximum and current load on the repeater (using the Load Table).

E2b. Determine the link cost between the repeater and the client's group (using the Link Cost Table).

E2c. Determine the combined cost as described above.

E3. Select a small set of repeaters with the lowest cost.

E4. Select a random member from the set.

Preferably the results of the BRS processing are maintained in a local cache at the reflector **108**. Thus, if the best repeater has recently been determined for a given client (i.e., for a given network address), that best repeater can be reused quickly without being re-determined. Since the calculation described above is based on statically, pre-computed tables, if the tables have not changed then there is no need to re-determine the best repeater.

Determining the Group Reduction and Link Cost Tables

The Group Reduction Table and Link Cost Table used in BRS processing are created and regularly updated by an independent procedure referred to herein as *NetMap*. The *NetMap* procedure is run by executing several phases (described below) as needed.

The term *Group* is used here to refers to an IP "address group".

The term *Repeater Group* refers to a Group that contains the IP address of a repeater.

The term *link cost* refers to a statically determined cost for transmitting data between two Groups. In a presently preferred implementation, this is the minimum of the sums of the costs of the links along each path between them. The link costs of primary concern here are link costs between a Group and a Repeater Group.

The term *relative link cost* refers to the link cost relative to other link costs for the same Group which is calculated by subtracting the minimum link cost from a Group to any Repeater Group from each of its link costs to a Repeater Group.

The term Cost Set refers to a set of Groups that are equivalent in regard to Best Repeater Selection. That is, given the information available, the same repeater would be selected for any of them.

The *NetMap* procedure first processes input files to create an internal database called the Group Registry. These input files describe groups, the IP addresses within groups, and links between groups, and come a variety of sources, including publicly available Internet Routing Registry (IRR) databases, BGP router tables, and probe services that are located at various points around the Internet and use publicly available tools (such as "traceroute") to sample data paths. Once this processing is complete, the Group Registry contains essential information used for further processing, namely (1) the identity of each group, (2) the set of IP addresses in a given group, (3) the presence of links between groups indicating paths over which information may travel, and (4) the

cost of sending data over a given link.

The following processes are then performed on the Group Registry file.

Calculate Repeater Group link costs

The *NetMap* procedure calculates a "link cost" for transmission of data between each Repeater Group and each Group in the Group Registry. This overall link cost is defined as the minimum cost of any path between the two groups, where the cost of a path is equal to the sum of the costs of the individual links in the path. The link cost algorithm presented below is essentially the same as algorithm #562 from ACM journal Transactions on Mathematical Software: "Shortest Path From a Specific Node to All Other Nodes in a Network" by U. Pape, ACM TOMS 6 (1980) pp. 450-455, http://www.netlib.org/toms/562.

In this processing, the term Repeater Group refers to a Group that contains the IP address of a repeater. A group is a neighbor of another group if the Group Registry indicates that there is a link between the two groups.

For each target Repeater Group **T**:

- Initialize the link cost between **T** and itself to zero.
- Initialize the link cost between **T** and every other Group to infinity.
- Create a list **L** that will contain Groups that are equidistant from the target Repeater Group **T**.
- Initialize the list **L** to contain just the target Repeater Group **T** itself.
- While the list **L** is not empty:
    - Create an empty list **L'** of neighbors of members of the list **L**.
    - For each Group **G** in the list **L**:
        - For each Group **N** that is a neighbor of **G**:
            - Let cost refer to the sum of the link cost between **T** and **G**, and the link cost between **G** and **N**.

The cost between **T** and **G** was determined in the previous pass of the algorithm; the link cost between **G** and **N** is from the Group Registry.

- If **cost** is less than the link cost between **T** and **N**:
  - Set the link cost between **T** and **N** to **cost**.
  - Add **N** to **L'** if it is not already on it.

- Set **L** to **L'**.

Calculate Cost Sets

A Cost Set is a set of Groups that are equivalent with respect to Best Repeater Selection. That is, given the information available, the same repeater would be selected for any of them.

The "cost profile" of a Group G is defined herein as the set of costs between G and each Repeater. Two cost profiles are said to be equivalent if the values in one profile differ from the corresponding values in the other profile by a constant amount.

Once a client Group is known, the Best Repeater Selection algorithm relies on the cost profile for information about the Group. If two cost profiles are equivalent, the BRS algorithm would select the same repeater given either profile.

A Cost Set is then a set of groups that have equivalent cost profiles.

The effectiveness of this method can be seen, for example, in the case where all paths to a Repeater from some Group A pass through some other Group B. The two Groups have equivalent cost profiles (and are therefore in the same Cost Set) since whatever Repeater is best for Group A is also going to be best for Group B, regardless of what path is taken between the two Groups.

By normalizing cost profiles, equivalent cost profiles can be made identical. A normalized cost profile is a cost profile in which the minimum cost has the value zero. A normalized cost profile is computed by finding the minimum cost in the profile, and subtracting that value from each cost in the profile.

Cost Sets are then computed using the following algorithm:

- For each Group **G**:
  - Calculate the normalized cost profile for **G**
  - Look for a Cost Set with the same normalized cost profile.
  - If such as set is found, add **G** to the existing Cost Set;
  - otherwise, create a new Cost Set with the calculated normalized cost profile, containing only **G**.

The algorithm for finding Cost Sets employs a hash table to reduce the time necessary to determine whether the desired Cost Set already exists. The hash table uses a hash value computed from cost profile of **G**.

Each Cost Set is then numbered with a unique Cost Sent Index number. Cost Sets are then used in a straightforward manner to generate the Link Cost Table, which gives the cost from each Cost Set to each Repeater.

As described below, the Group Reduction Table maps every IP address to one of these Cost Sets.

Build IP Map

The IP Map is a sorted list of records which map IP address ranges to Link Cost Table keys. The format of the IP map is:

<base IP address> <max IP address> <Link Cost Table key>

where IP addresses are presently represented by 32-bit integers. The entries are sorted by descending base address, and by ascending maximum address among equal base addresses, and by ascending Link Cost Table key among equal base addresses and maximum addresses. Note that ranges may overlap.

The *NetMap* procedure generates an intermediate IP map containing a map between IP address ranges and Cost Set numbers as follows:

- For each Cost Set **S**:
  - For each Group **G** in **S**:
    - For each IP address range in **G**:
      - Add a triple (low address, high address, Cost Set number of S) to the IP map.

The IP map file is then sorted by descending base address, and by ascending maximum address among equal base addresses, and by ascending Cost Set number among equal base addresses and maximum addresses. The sort order for the base address and maximum address minimizes the time to build the Group Reduction Table and produces the proper results for overlapping entries.

Finally, the *NetMap* procedure creates the Group Reduction Table by processing the sorted IP map. The Group Reduction Table maps IP addresses (specified by ranges) into Cost Set numbers. Special processing of the IP map file is required in order to detect overlapping address ranges, and to merge adjacent address ranges in order to minimize the size of the Group Reduction Table.

An ordered list of address range segments is maintained, each segment consisting of a base address **B** and a Cost Set number **N**, sorted by base address **B**. (The maximum address of a segment is the base address of the next segment minus one.)

The following algorithm is used:

- Initialize the list with the elements [-infinity, NOGROUP], [+infinity, NOGROUP].
  - For each entry in the IP map, in sorted order, consisting of (b, m, s),
    - Insert (b, m, s) in the list (recall that IP map entries are of the form (low address, high address Cost Set number of S))
  - For each reserved LAN address range (b, m):

Insert (b, m, LOCAL) in the list.

- For each Repeater at address a:

  Insert (a, a, REPEATER) in the list.

- For each segment S in the ordered list:
  - Merge S with following segments with the same Cost Set
  - Create a Group Reduction Table entry with base address from the base address of S,
    - max address = next segment's base – 1,
    - group ID = Cost Set number of S.

A reserved LAN address range is an address range reserved for use by LANs which should not appear as a global Internet address. LOCAL is a special Cost Set index different from all others, indicating that the range maps to a client which should never be reflected. REPEATER is a special Cost Set index different from all others, indicating that the address range maps to a repeater. NOGROUP is a special Cost Set index different from all others, indicating that this range of addresses has no known mapping.

Given (**B, M, N**), insert an entry in the ordered address list as follows:
Find the last segment (AB, AN) for which AB is less than or equal to B.
If AB is less than B, insert a new segment (B, N) after (AB, AN).
Find the last segment (YB, YN) for which YB is less than or equal to M.
Replace by (XB, N) any segment (XB, NOGROUP) for which XB is greater than B and less than YB.
If YN is not N, and either YN is NOGROUP or YB is less than or equal to B,
    Let (ZB, ZN) be the segment following (YB, YN).
    If M+1 is less than ZB, insert a new segment (M+1, YN)
        before (ZB, ZN).

Replace (YB, YN) by (YB, N).

Rewriting HTML Resources

As explained above with reference to **FIGURE 3** (B5), when a reflector or repeater serves a resource which itself includes resource identifiers (e.g., a HTML resource), that resource is modified (rewritten) to pre-reflect resource identifiers (URLs) of repeatable resources that appear in the resource. Rewriting ensures that when a browser requests repeatable resources identified by the requested resource, it gets them from a repeater without going back to the origin server, but when it requests non-repeatable resources identified by the requested resource, it will go directly to the origin server. Without this optimization, the browser would either make all requests at the origin server (increasing traffic at the origin server and necessitating far more redirections from the origin server), or it would make all requests at the repeater (causing the repeater to redundantly request and copy resources which could not be cached, increasing the overhead of serving such resources).

Rewriting requires that a repeater has been selected (as described above with reference to the Best Repeater Selector). Rewriting uses a so-called BASE directive. The BASE directive lets the HTML identify a different base server. (The base address is normally the address of the HTML resource.)

Rewriting is performed as follows:

F1. A BASE directive is added at the beginning of the HTML resource, or modified where necessary. Normally, a browser interprets relative URLs as being relative to the default base address, namely, the URL of the HTML resource (page) in which they are encountered. The BASE address added specifies the resource at the reflector which originally served the resource. This means that unprocessed relative URLs (such as

those generated by Javascript™ programs) will be interpreted as relative to the reflector. Without this BASE address, browsers would combine relative addresses with repeater names to create URLs which were not in the form required by repeaters (as described above in step D1).

F2. The rewriter identifies directives, such as embedded images and anchors, containing URLs. If the rewriter is running in a reflector, it must parse the HTML file to identify these directives.
If it is running in a repeater, the rewriter may have access to pre-computed information that identifies the location of each URL (placed in the HTML file in step F4).

F3. For each URL encountered in the resource to be re-written, the rewriter must determine whether the URL is repeatable (as in steps B1-B2). If the URL is not repeatable, it is not modified. On the other hand, if the URL is repeatable, it is modified to refer to the selected repeater.

F4. After all URLs have been identified and modified, if the resource is being served to a repeater, a table is appended at the beginning of the resource that identifies the location and content of each URL encountered in the resource. (This step is an optimization which eliminates the need for parsing HTML resources at the repeater.)

F5. Once all changes have been identified, a new length is computed for the resource (page). The length is inserted in the HTTP header prior to serving the resource.

An extension of HTML, known as XML, is currently being developed. The

process of rewriting URLs will be similar for XML, with some differences in the mechanism that parses the resource and identifies embedded URLs.

Handling Non-HTTP Protocols

This invention makes it possible to reflect references to resources that are served by protocols other than HTTP, for instance, the File Transfer Protocol (FTP) and audio/video stream protocols. However, many protocols do not provide the ability to redirect requests. It is, however, possible to redirect references before requests are actually made by rewriting URLs embedded in HTML pages. The following modifications to the above algorithms are used to support this capability.

In F4, the rewriter rewrites URLs for servers if those servers appear in a configurable table of cooperating origin server or so-called co-servers. The reflector operator can define this table to include FTP servers and other servers. A rewritten URL that refers to a non-HTTP resource takes the form:

http://<repeater>/<origin server>@proxy=<scheme>[:<type>]@/resource

where <scheme> is a supported protocol name such as "ftp". This URL format is an alternative to the form shown in B3.

In C3, the repeater looks for a protocol embedded in the arriving request. If a protocol is present and the requested resource is not already cached, the repeater uses the selected protocol instead of the default HTTP protocol to request the resource when serving it and storing it in the cache.

System Configuration and Management

In addition to the processing described above, the repeater network requires various mechanisms for system configuration and network management. Some of these mechanisms are described here.

Reflectors allow their operators to synchronize repeater caches by performing publishing operations. The process of keeping repeater caches synchronized is described below. Publishing indicates that a resource or collection of resources has changed.

Repeaters and reflectors participate in various types of log processing. The results of logs collected at repeaters are collected and merged with logs collected at reflectors, as described below.

Adding Subscribers to the Repeater Network

When a new subscriber is added to the network, information about the subscriber is entered in a Subscriber Table at the master repeater and propagated to all repeaters in the network. This information includes the *Committed Aggregate Information Rate* (CAIR) for servers belonging to the subscriber, and a list of the repeaters that may be used by servers belonging to the subscriber.

Adding Reflectors to the Repeater Network

When a new reflector is added to the network, it simply connects to and announces itself to a contact repeater, preferably using a securely encrypted certificate including the repeater's subscriber identifier.

The contact repeater determines whether the reflector network address is permitted for this subscriber. If it is, the contact repeater accepts the connection and updates the reflector with all necessary tables (using version numbers to determine which tables are out of date).

The reflector processes requests during this time, but is not "enabled" (allowed to reflect requests) until all of its tables are current.

Keeping Repeater Caches Synchronized

Repeater caches are coherent, in the sense that when a change to a resource is identified by a reflector, all repeater caches are notified, and accept the change in a single transaction.

Only the identifier of the changed resource (and not the entire resource) is transmitted to the repeaters; the identifier is used to effectively invalidate the corresponding cached resource at the repeater. This process is far more efficient than broadcasting the content of the changed resource to each repeater.

A repeater will load the newly modified resource the next time it is requested.

A resource change is identified at the reflector either manually by the operator, or through a script when files are installed on the server, or automatically through a change detection mechanism (e.g., a separate process that checks regularly for changes).

A resource change causes the reflector to send an "invalidate" message to its contact repeater, which forwards the message to the master repeater. The invalidate message contains a list of resource identifiers (or regular expressions identifying patterns of resource identifiers) that have changed. (Regular expressions are used to invalidate a directory or an entire server.) The repeater network uses a two-phase commit process to ensure that all repeaters correctly invalidate a given resource.

The invalidation process operates as follows:

The master broadcasts a "phase 1" invalidation request to all repeaters indicating the resources and regular expressions describing sets of resources to be invalidated.

When each repeater receives the phase 1 message, it first places the resource identifiers or regular expressions into a list of resource identifiers pending invalidation.

Any resource requested (in C3) that is in the pending invalidation list may not be served from the cache. This prevents the cache from requesting the resource from a peer cache which may not have received an invalidation notice. Were it to request a resource in this manner, it might replace the newly invalidated resource by the same, now stale, data.

The repeater then compares the resource identifier of each resource in its cache against the resource identifiers and regular expressions in the list.

Each match is invalidated by marking it stale and optionally removing it from the cache. This means that a future request for the resource will cause it to retrieve a new copy of the resource from the reflector.

When the repeater has completed the invalidation, it returns an acknowledgment to the master. The master waits until all repeaters have acknowledged the invalidation request.

If a repeater fails to acknowledge within a given period, it is disconnected from the master repeater. When it reconnects, it will be told to flush its entire cache, which will eliminate any consistency problem. (To avoid flushing the entire cache, the master could keep a log of all invalidations performed, sorted by date, and flush only files invalidated since the last time the reconnecting repeater successfully completed an invalidation. In the presently preferred embodiments this is not done since it is believed that repeaters will seldom disconnect.)

When all repeaters have acknowledged invalidation (or timed out) the repeater broadcasts a "phase 2" invalidation request to all repeaters. This causes the repeaters to remove the corresponding resource identifiers and regular expressions from the list of resource identifiers pending invalidation.

In another embodiment, the invalidation request will be extended to allow a "server push". In such requests, after phase 2 of the invalidation process has completed, the repeater receiving the invalidation request will immediately request a new copy of the invalidated resource to place in its cache.

Logs and Log Processing

Web server activity logs are fundamental to monitoring the activity in a Web site. This invention creates "merged logs" that combine the activity at reflectors with the

activity at repeaters, so that a single activity log appears at the origin server showing all Web resource requests made on behalf of that site at any repeater.

This merged log can be processed by standard processing tools, as if it had been generated locally.

On a periodic basis, the master repeater (or its delegate) collects logs from each repeater. The logs collected are merged, sorted by reflector identifier and timestamp, and stored in a dated file on a per-reflector basis. The merged log for a given reflector represents the activity of all repeaters on behalf of that reflector. On a periodic basis, as configured by the reflector operator, a reflector contacts the master repeater to request its merged logs. It downloads these and merges them with its locally maintained logs, sorting by timestamp. The result is a merged log that represents all activity on behalf of repeaters and the given reflector.

Activity logs are optionally extended with information important to the repeater network, if the reflector is configured to do so by the reflector operator. In particular, an "extended status code" indicates information about each request, such as:

1. request was served by a reflector locally;
2. request was reflected to a repeater;*
3. request was served by a reflector to a repeater;*
4. request for non-repeatable resource was served by repeater;*
5. request was served by a repeater from the cache;
6. request was served by a repeater after filling cache;
7. request pending invalidation was served by a repeater.

(The activities marked with "*" represent intermediate states of a request and do not normally appear in a final activity log.)

In addition, activity logs contain a duration, and extended precision timestamps. The duration makes it possible to analyze the time required to serve a resource, the bandwidth used, the number of requests handled in parallel at a given time, and other quite useful information. The extended precision timestamp makes it possible to

accurately merge activity logs.

Repeaters use the Network Time Protocol (NTP) to maintain synchronized clocks. Reflectors may either use NTP or calculate a time bias to provide roughly accurate timestamps relative to their contact repeater.

Enforcing Committed Aggregate Information Rate

The repeater network monitors and limits the aggregate rate at which data is served on behalf of a given subscriber by all repeaters. This mechanism provides the following benefits:

1. provides a means of pricing repeater service;
2. provides a means for estimating and reserving capacity at repeaters;
3. provides a means for preventing clients of a busy site from limiting access to other sites.

For each subscriber, a "threshold aggregate information rate" (TAIR) is configured and maintained at the master repeater. This threshold is not necessarily the committed rate, it may be a multiple of committed rate, based on a pricing policy.

Each repeater measures the information rate component of each reflector for which it serves resources, periodically (typically about once a minute), by recording the number of bytes transmitted on behalf of that reflector each time a request is delivered. The table thus created is sent to the master repeater once per period. The master repeater combines the tables from each repeater, summing the measured information of each reflector over all repeaters that serve resources for that reflector, to determine the "measured aggregate information rate" (MAIR) for each reflector.

If the MAIR for a given reflector is greater than the TAIR for that reflector, the MAIR is transmitted by the master to all repeaters and to the respective reflector.

When a reflector receives a request, it determines whether its most recently calculated MAIR is greater than its TAIR. If this is the case, the reflector

probabilistically decides whether to suppress reflection, by serving the request locally (in B2). The probability of suppressing the reflection increases as an exponential function of the difference between the MAIR and the CAIR.

Serving a request locally during a peak period may strain the local origin server, but it prevents this subscriber from taking more than allocated bandwidth from the shared repeater network.

When a repeater receives a request for a given subscriber (in C2), it determines whether the subscriber is running near its threshold aggregate information rate. If this is the case, it probabilistically decides whether to reduce its load by redirecting the request back to the reflector. The probability increases exponentially as the reflector's aggregate information rate approaches its limit.

If a request is reflected back to a reflector, a special character string is attached to the resource identifier so that the receiving reflector will not attempt to reflect it again. In the current system, this string has the form

"src=overload".

The reflector tests for this string in B2.

The mechanism for limiting Aggregate Information Rate described above is fairly coarse. It limits at the level of sessions with clients (since once a client has been reflected to a given repeater, the rewriting process tends to keep the client coming back to that repeater) and, at best, individual requests for resources. A more fine-grained mechanism for enforcing TAIR limits within repeaters operates by reducing the bandwidth consumption of a busy subscriber when other subscribers are competing for bandwidth.

The fine-grained mechanism is a form of data "rate shaping". It extends the mechanism that copies resource data to a connection when a reply is being sent to a client. When an output channel is established at the time a request is received, the repeater identifies which subscriber the channel is operating for, in C2, and records the subscriber in a data field associated with the channel. Each time a "write" operation is

about to be made to the channel, the Metered Output Stream first inspects the current values of the MAIR and TAIR, calculated above, for the given subscriber. If the MAIR is larger than the TAIR, then the mechanism pauses briefly before performing the write operation. The length of the pause is proportional to the amount the MAIR exceeds the TAIR. The pause ensures that tasks sending other resources to other clients, perhaps on behalf of other subscribers, will have an opportunity to send their data.

Repeater Network Resilience

The repeater network is capable of recovering when a repeater or network connection fails.

A repeater cannot operate unless it is connected to the master repeater. The master repeater exchanges critical information with other repeaters, including information about repeater load, aggregate information rate, subscribers, and link cost.

If a master fails, a "succession" process ensures that another repeater will take over the role of master, and the network as a whole will remain operational. If a master fails, or a connection to a master fails through a network problem, any repeater attempting to communicate with the master will detect the failure, either through an indication from TCP/IP, or by timing out from a regular "heartbeat" message it sends to the master.

When any repeater is disconnected from its master, it immediately tries to reconnect to a series of potential masters based on a configurable file called its "succession list".

The repeater tries each system on the list in succession until it successfully connects to a master. If in this process, it comes to its own name, it takes on the role of master, and accepts connections from other repeaters. If a repeater which is not at the top of the list becomes the master, it is called the "temporary master".

A network partition may cause two groups of repeaters each to elect a master. When the partition is corrected, it is necessary that the more senior master take over the

network. Therefore, when a repeater is temporary master, it regularly tries to reconnect to any master above it in the succession list. If it succeeds, it immediately disconnects from all of the repeaters connected to it. When they retry their succession lists, they will connect to the more senior master repeater.

To prevent losses of data, a temporary master does not accept configuration changes and does not process log files. In order to take on these tasks, it must be informed that it is primary master by manual modification of its successor list. Each repeater regularly reloads its successor list to determine whether it should change its idea of who the master is.

If a repeater is disconnected from the master, it must resynchronize its cache when it reconnects to the master. The master can maintain a list of recent cache invalidations and send to the repeater any invalidations it was not able to process while disconnected. If this list is not available for some reason (for instance, because the reflector has been disconnected too long), the reflector must invalidate its entire cache.

A reflector is not permitted to reflect requests unless it is connected to a repeater. The reflector relies on its contact repeater for critical information, such as load and Link Cost Tables, and current aggregate information rate. A reflector that is not connected to a repeater can continue to receive requests and handle them locally.

If a reflector loses its connection with a repeater, due to a repeater failure or network outage, it continues to operate while it tries to connect to a repeater.

Each time a reflector attempts to connect to a repeater, it uses DNS to identify a set of candidate repeaters given a domain name that represents the repeater network. The reflector tries each repeater in this set until it makes a successful contact. Until a successful contact is made, the reflector serves all requests locally. When a reflector connects to a repeater, the repeater can tell it to attempt to contact a different repeater; this allows the repeater network to ensure that no individual repeater has too many contacts.

When contact is made, the reflector provides the version number of each of its tables to its contact repeater. The repeater then decides which tables should be updated and sends appropriate updates to the reflector. Once all tables have been updated, the repeater notifies the reflector that it may now start reflecting requests.

Using a Proxy Cache within a Repeater

Repeaters are intentionally designed so that any proxy cache can be used as a component within them. This is possible because the repeater receives HTTP requests and converts them to a form recognized by the proxy cache.

On the other hand, several modifications to a standard proxy cache have been or may be made as optimizations. This includes, in particular, the ability to conveniently invalidate a resource, the ability to support cache quotas, and the ability to avoid making an extra copy of each resource as it passes from the proxy cache through the repeater to the requester.

In a preferred embodiment, a proxy cache is used to implement C3. The proxy cache is dedicated for use only by one or more repeaters. Each repeater requiring a resource from the proxy cache constructs a proxy request from the inbound resource request. A normal HTTP GET request to a server contains only the pathname part of the URL—the scheme and server name are implicit. (In an HTTP GET request to a repeater, the pathname part of the URL includes the name of the origin server on behalf of which the request is being made, as described above.) However, a proxy agent GET request takes an entire URL. Therefore, the repeater must construct a proxy request containing the entire URL from the path portion of the URL it receives. Specifically, if the incoming request takes the form:

GET /<origin server>/<path>

then the repeater constructs a proxy request of the form:

GET http://<origin server>/<path>

and if the incoming request takes the form:

GET <origin server>@proxy=<scheme>:<type>@/<path>

then the repeater constructs a proxy request of the form:

GET <scheme>://<origin server>/<path>

Cache Control

HTTP replies contain directives called cache control directives, which are used to indicate to a cache whether the attached resource may be cached and if so, when it should expire. A Web site administrator configures the Web site to attach appropriate directives. Often, the administrator will not know how long a page will be fresh, and must define a short expiration time to try to prevent caches from serving stale data. In many cases, a Web site operator will indicate a short expiration time only in order to receive the requests (or hits) that would otherwise be masked by the presence of a cache. This is known in the industry as "cache-busting". Although some cache operators may consider cache-busting to be impolite, advertisers who rely on this information may consider it imperative.

When a resource is stored in a repeater, its cache directives can be ignored by the repeater, because the repeater receives explicit invalidation events to determine when a resource is stale. When a proxy cache is used as the cache at the repeater, the associated cache directives may be temporarily disabled. However, they must be re-enabled when the resource is served from the cache to a client, in order to permit the cache-control policy (including any cache-busting) to take effect.

The present invention contains mechanisms to prevent the proxy cache within a repeater from honoring cache control directives, while permitting the directives to be served from the repeater.

When a reflector serves a resource to a repeater in B4, it replaces all cache directives by modified directives that are ignored by the repeater proxy cache. It does this by prefixing a distinctive string such as "wr-" to the beginning of the HTTP tag. Thus, "expires" becomes "wr-expires", and "cache-control" becomes "wr-cache-control". This prevents the proxy cache itself from honoring the directives. When a repeater serves a resource in C4, and the requesting client is not another repeater, it searches for HTTP tags beginning with "wr-" and removes the "wr-". This allows the clients retrieving the resource to honor the directives.

Resource Revalidation

There are several cases where a resource may be cached so long as the origin server is consulted each time it is served. In one case, the request for the resource is attached to a so-called "cookie". The origin server must be presented with the cookie to record the request and determine whether the cached resource may be served or not. In another case, the request for the resource is attached to an authentication header (which identifies the requester with a user id and password). Each new request for the resource must be tested at the origin server to assure that the requester is authorized to access the resource.

The HTTP 1.1 specification defines a reply header titled "Must-Revalidate" which allows an origin server to instruct a proxy cache to "revalidate" a resource each time a request is received. Normally, this mechanism is used to determine whether a resource is still fresh. In the present invention, Must-Revalidate makes it possible to ask an origin server to validate a request that is otherwise served from a repeater.

The reflector rule base contains information that determines which resources may be repeated but must be revalidated each time they are served. For each such resource, in B4, the reflector attaches a Must-Revalidate header. Each time a request comes to a repeater for a cached resource marked with a Must-Revalidate header, the request is forwarded to the reflector for validation prior to serving the requested resource.

Cache Quotas

The cache component of a repeater is shared among those subscribers that reflect clients to that repeater. In order to allow subscribers fair access to storage facilities, the cache may be extended to support quotas.

Normally, a proxy cache may be configured with a disk space threshold T. Whenever more than T bytes are stored in the cache, the cache attempts to find resources to eliminate.

Typically a cache uses the least-recently-used (LRU) algorithm to determine which resources to eliminate; more sophisticated caches use other algorithms. A cache may also support several threshold values—for instance, a lower threshold which, when reached, causes a low priority background process to remove items from the cache, and a higher threshold which, when reached, prevents resources from being cached until sufficient free disk space has been reclaimed.

If two subscribers A and B share a cache, and more resources of subscriber A are accessed during a period of time than resources of subscriber B, then fewer of B's resources will be in the cache when new requests arrive. It is possible that, due to the behavior of A, B's resources will never be cached when they are requested. In the present invention, this behavior is undesirable. To address this issue, the invention extends the cache at a repeater to support cache quotas.

The cache records the amount of space used by each subscriber in D_S, and supports a configurable threshold T_S for each subscriber.

Whenever a resource is added to the cache (at C3), the value D_S is updated for the subscriber providing the resource. If D_S is larger than T_S, the cache attempts to find resources to eliminate, from among those resources associated with subscriber S. The cache is effectively partitioned into separate areas for each subscriber.

The original threshold T is still supported. If the sum of reserved segments for each subscriber is smaller than the total space reserved in the cache, the remaining area is "common" and subject to competition among subscribers.

Note, this mechanism might be implemented by modifying the existing proxy cache discussed above, or it might also be implemented without modifying the proxy cache—if the proxy cache at least makes it possible for an external program to obtain a list of resources in the cache, and to remove a given resource from the cache.

Rewriting from Repeaters

When a repeater receives a request for a resource, its proxy cache may be configured to determine whether a peer cache contains the requested resource. If so, the proxy cache obtains the resource from the peer cache, which can be faster than obtaining it from the origin server (the reflector). However, a consequence of this is that rewritten HTML resources retrieved from the peer cache would identify the wrong repeater. Thus, to allow for cooperating proxy caches, resources are preferably rewritten at the repeater.

When a resource is rewritten for a repeater, a special tag is placed at the beginning of the resource. When constructing a reply, the repeater inspects the tag to determine whether the resource indicates that additional rewriting is necessary. If so, the repeater modifies the resource by replacing references to the old repeater with references to the new repeater.

It is only necessary to perform this rewriting when a resource is served to the proxy cache at another repeater.

Repeater-Side Include

Sometimes, an origin server constructs a custom resource for each request (for instance, when inserting an advertisement based on the history of the requesting client). In such a case, that resource must be served locally rather than repeated. Generally, a custom resource contains, along with the custom information, text and references to other, repeatable, resources.

The process that assembles a "page" from a text resource and possibly one or more image resources is performed by the Web browser, directed by HTML. However, it is not possible using HTML to cause a browser to assemble a page using text or directives from a separate resource. Therefore, custom resources often necessarily contain large amounts of static text that would otherwise be repeatable.

To resolve this potential inefficiency, repeaters recognize a special directive called a "repeater side include". This directive makes it possible for the repeater to assemble a custom resource, using a combination of repeatable and local resources. In this way, the static text can be made repeatable, and only the special directive need be served locally by the reflector.

For example, a resource X might consist of custom directives selecting an advertising banner, followed by a large text article. To make this resource repeatable, the Web site administrator must break out a second resource, Y, to select the banner. Resource X is modified to contain a repeater-side include directive identifying resource Y, along with the article. Resource Y is created and contains only the custom directives selecting an ad banner. Now resource X is repeatable, and only resource Y, which is relatively small, is not repeatable.

When a repeater constructs a reply, it determines whether the resource being served is an HTML resource, and if so, scans it for repeater-side include directives. Each such directive includes a URL, which the repeater resolves and substitutes in place of the directive. The entire resource must be assembled before it is served, in order to determine its final size, as the size is included in a reply header ahead of the resource.

Thus, a method and apparatus for dynamically replicating selected resources in computer networks is provided. One skilled in the art will appreciate that the present invention can be practiced by other than the described embodiments, which are presented for purposes of illustration and not limitation, and the present invention is limited only by the claims that follow.

What is claimed:

1. A method of processing resource requests in a computer network, the method comprising,

(i) by a client:

(A) making a request for a particular resource from an origin server, the request including a resource identifier for the particular resource;

(ii) by a reflector:

(B) intercepting the request from the client to the origin server;

(C) selecting a repeater to process the request;

(D) providing to the client a modified resource identifier designating the repeater;

(iii) by the client:

(E) receiving the modified resource identifier from the reflector; and

(F) making a request for the particular resource from the repeater designated in the modified resource identifier;

(iv) by the repeater:

(G) receiving the request from the client; and

(H) returning the requested resource to the client. 2. A method as in claim 1 further comprising, by the repeater:

(I) making a request for the resource from the origin server; and

(J) receiving the resource from the origin server.

3. A method as in claim 1 wherein the selecting of a repeater by the reflector comprises:

(C1) partitioning the network into groups;

(C2) determining which group the client is in;

(C3) selecting, from a plurality of repeaters in the network, a set of repeaters having a lowest cost relative to the group which the client is in; and

(C4) selecting as the repeater a member of the selected set of repeaters.

4. A method as in claim 3, wherein the cost of a repeater is a value based on that repeater's current load and a maximum load for that repeater.

5. A method as in claim 3, wherein the cost of a repeater is a value based on a predicted cost or speed of transmission between the repeater and a client in the group.

6. A method as in claim 1 wherein the particular resource itself contains at least one other resource identifier of at least one other resource, the method further comprising:

rewriting the particular resource to replace at least some of the resource identifiers contained therein with modified resource identifiers designating a repeater instead of the origin server.

7. A method as in claim 6 wherein the rewriting is performed by one of the repeater, the reflector or another repeater.

8. A method of processing resource requests in a computer network, the method comprising,

(i) by a client:

(A) making a request for a particular resource from an origin server, the request including a resource identifier for the particular resource;

(ii) by a reflector:

(B) intercepting the request from the client to the origin server;

(C) determining whether to reflect the request to a repeater;

(D) when the reflector determines not to reflect the request, forwarding the request to the origin server, otherwise

(D1) selecting a repeater to process the request;

(D2) providing to the client a modified resource identifier designating the repeater.

9. A method as in claim 8, further comprising, when the reflector determines to reflect the request,

(iii) by the client:

(E) receiving the modified resource identifier from the reflector; and

(F) making a request for the particular resource from the repeater designated in the modified resource identifier;

(iv) by the repeater:

(G) receiving the request from the client; and

(H) returning the requested resource to the client.

10. A method as in claim 8 wherein the reflector determines whether to reflect a request by comparing the resource identifier with regular expression patterns of repeatable resources.

11. A method as in claim 8, wherein the reflector has a threshold aggregate information rate (TAIR) associated therewith, and wherein the determining of whether to reflect the request to a repeater comprises:

determining whether the TAIR of the reflector is exceeded by a measured aggregate information rate (MAIR) for the reflector, wherein the reflector determines not to reflect the request when the MAIR exceeds the TAIR for the reflector.

12. A method as in claim 8, wherein the reflector has a threshold aggregate information rate (TAIR) associated therewith, and wherein the determining of whether to reflect the request to a repeater comprises:

probabilistically determining whether the TAIR of the reflector is exceeded by a measured aggregate information rate (MAIR) for the reflector, wherein the reflector determines not to reflect the request as an exponential function of the difference between the MAIR and the TAIR.

13. A method as in any of claims 11-12, wherein the MAIR is obtained from repeaters according to the rate at which they have transmitted data on behalf of the reflector during a given time interval.

14. A method as in any one of claims 1-12 wherein the network is the Internet and wherein the resource identifier is a uniform resource locator (URL) for designating resources on the Internet, and wherein the modified resource identifier is a URL designating the repeater and indicating the reflector or origin server, and wherein the modified resource identifier is provided to the client using a REDIRECT message.

15. In a computer network wherein clients request resources from origin servers, a method comprising:

providing at least one repeater;

providing reflectors at some of the origin servers, each reflector intercepting client resource requests made to its respective origin server; and

each reflector selectively redirecting client resource requests for certain resources to one of the repeaters.

16. A method as in claim 15 further comprising, by repeaters in the network:

servicing redirected client resource requests; and

selectively maintaining copies of requested resources,

whereby resources corresponding to redirected resource requests are selectively migrated from their origin servers to one or more repeaters.

17. A computer network comprising:

a plurality of origin servers, at least some of the origin servers having reflectors associated therewith;

a plurality of repeaters; and

a plurality of clients,

wherein each reflector is adapted to intercept resource requests made to its respective origin server and to selectively redirect the resource requests to a dynamically selected repeater.

18. In a computer network wherein clients request resources from origin servers, a reflector mechanism associated with an origin server, the reflector mechanism comprising:

means for intercepting a resource request made by client of an origin server;

means for analyzing the resource request to determine whether to service the request locally at the origin server;

means for determining a best repeater in the network to service the request when

the analyzing means determines that the request should not be serviced locally; and

means for redirecting the client to the best repeater.

19. A reflector mechanism as in claim 18 wherein the network is partitioned into groups and the means for determining the best repeater comprises:

means for determining which group the client is in;

means for selecting, from a plurality of repeaters in the network, a set of repeaters having a lowest cost relative to the group the client is in; and

means for selecting as the best repeater a member of the set of repeaters.

20. A reflector mechanism as in claim 19, wherein the cost of a repeater is a value based on a predicted cost or speed of transmission between the repeater and a client in the group.

21. A mechanism as in claim 19, wherein the cost of a repeater is a value based on that repeaters current load and a maximum load for that repeater.

22. A reflector as in claim 16 wherein the resource itself contains resource identifiers, the reflector further comprising:

means for rewriting the resource to replace at least some of the resource identifiers contained therein with modified resource identifiers designating the repeater instead of the origin server.

23. In a computer network wherein clients request resources from origin servers, a repeater mechanism comprising:

means for receiving a resource request from a client;

means for determining whether the resource is available locally;

means for, when it is determined that the resource is not available locally,

obtaining the resource from an origin server; and

means for providing the resource to the client.

24. A reflector as in claim 18 wherein the resource itself contains resource identifiers, the repeater further comprising:

means for rewriting the resource to replace at least some of the resource identifiers contained therein with modified resource identifiers designating the repeater instead of the origin server.

ABSTRACT OF THE INVENTION

OPTIMIZED NETWORK RESOURCE LOCATION

Resource requests made by clients of origin servers in a network are intercepted by reflector mechanisms and selectively reflected to other servers called repeaters. The reflectors select a best repeater from a set of possible repeaters and redirect the client to the selected best repeater. The client then makes the request of the selected best repeater. The resource is possibly rewritten to replace at least some of the resource identifiers contained therein with modified resource identifiers designating the repeater instead of the origin server.

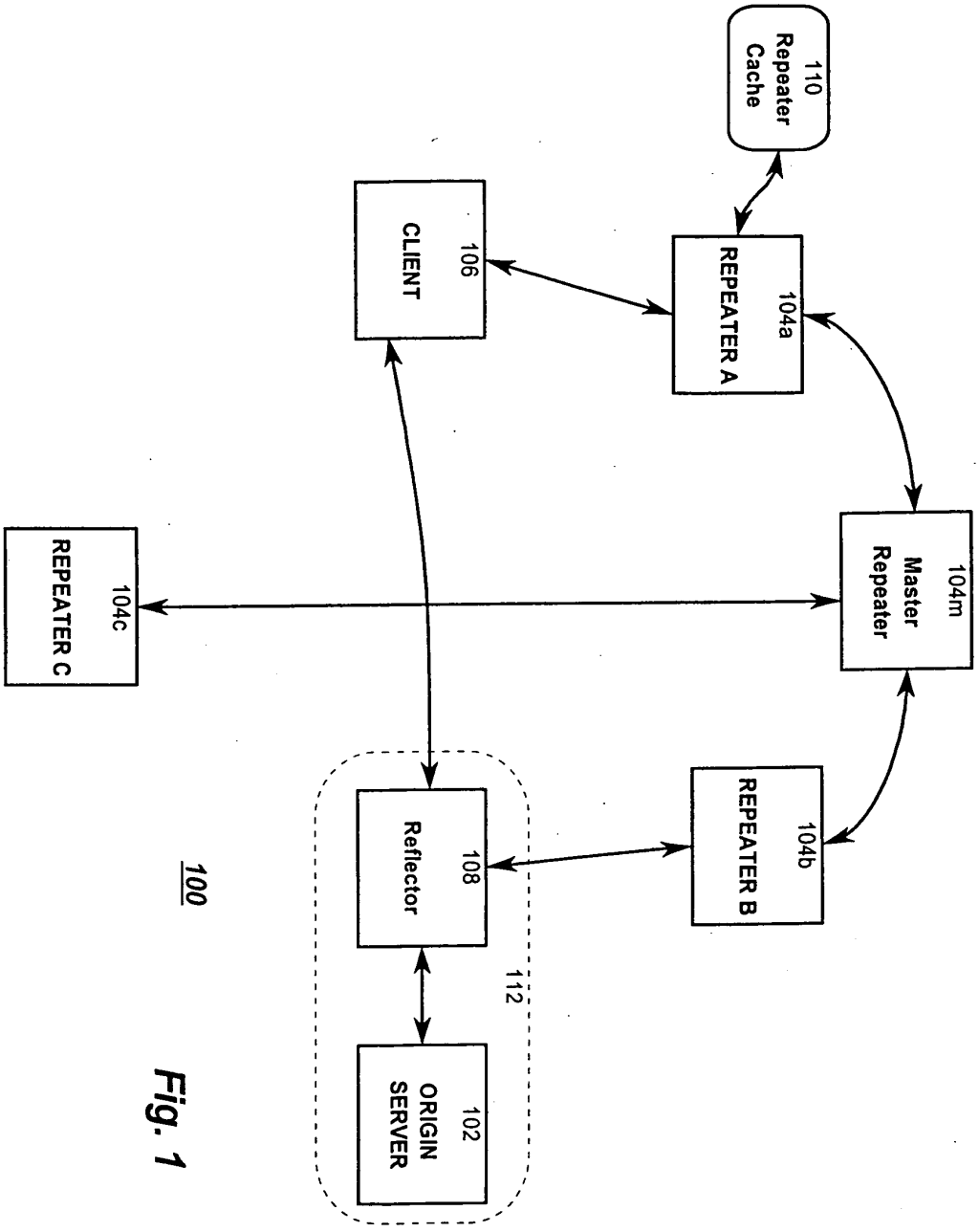

110
Repeater
Cache
106
CLIENT
104a
REPEATER A
104c
REPEATER C
104m
Master
Repeater
108
Reflector
104b
REPEATER B
112
102
ORIGIN
SERVER
100

Fig. 1

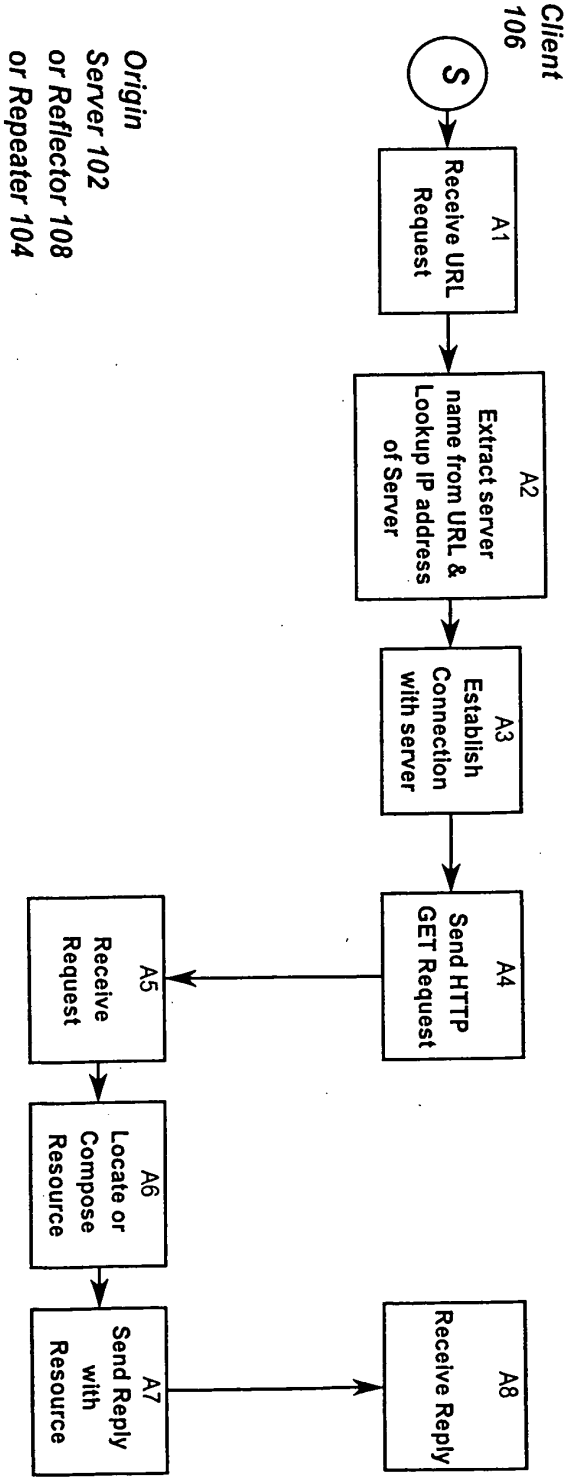

Client 106
Origin Server 102 or Reflector 108 or Repeater 104
S
A1 Receive URL Request
A2 Extract server name from URL & Lookup IP address of Server
A3 Establish Connection with server
A4 Send HTTP GET Request
A5 Receive Request
A6 Locate or Compose Resource
A7 Send Reply with Resource
A8 Receive Reply

Fig. 2

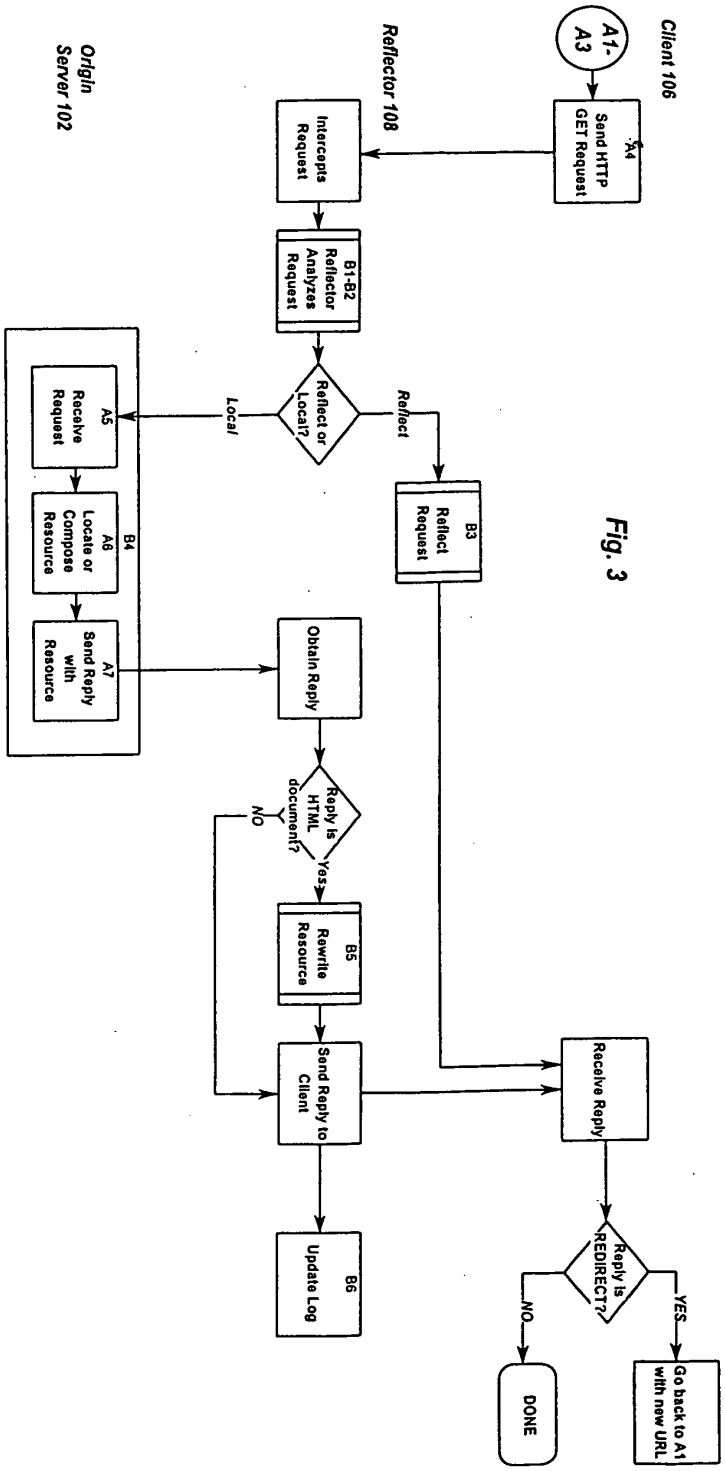

Client 106
Reflector 108
Origin Server 102
A1-A3
A4 Send HTTP GET Request
Intercepts Request
B1-B2 Reflector Analyzes Request
Reflect or Local?
Local
Reflect
A5 Receive Request
A6 Locate or Compose Resource
B4
A7 Send Reply with Resource
B3 Reflect Request
Obtain Reply
Reply is HTML document?
NO
YES
B5 Rewrite Resource
Send Reply to Client
Receive Reply
Reply is REDIRECT?
NO
YES
DONE
Go back to A1 with new URL
B6 Update Log

Fig. 3

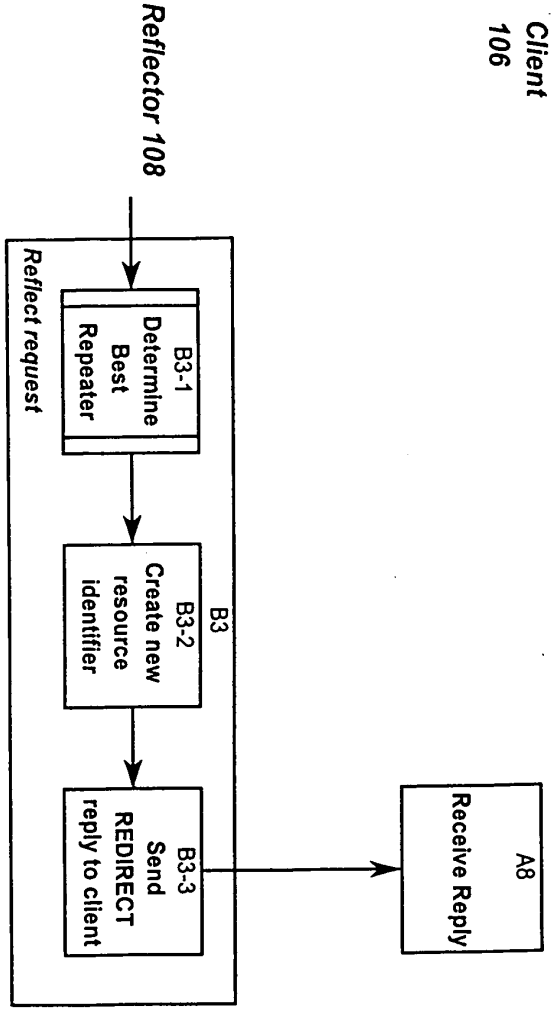

Client 106
Reflector 108
Reflect request
B3
B3-1 Determine Best Repeater
B3-2 Create new resource identifier
B3-3 Send REDIRECT reply to client
A8 Receive Reply

Fig. 4

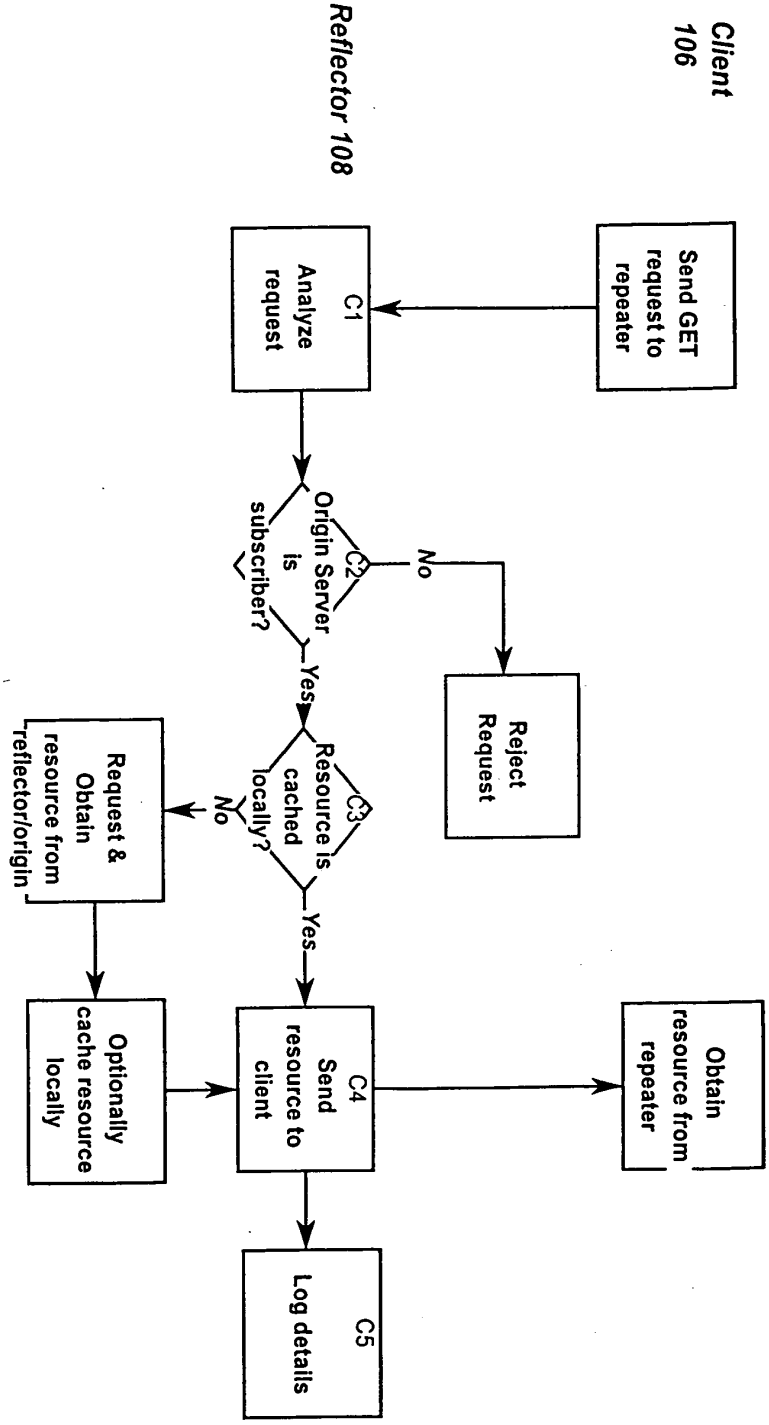

Client 106
Reflector 108
Send GET request to repeater
C1 Analyze request
Origin Server is subscriber?
C2
No
Yes
Reject Request
Resource is cached locally?
C3
No
Yes
Request & Obtain resource from reflector/origin
Optionally cache resource locally
C4 Send resource to client
Obtain resource from repeater
C5 Log details

Fig. 5

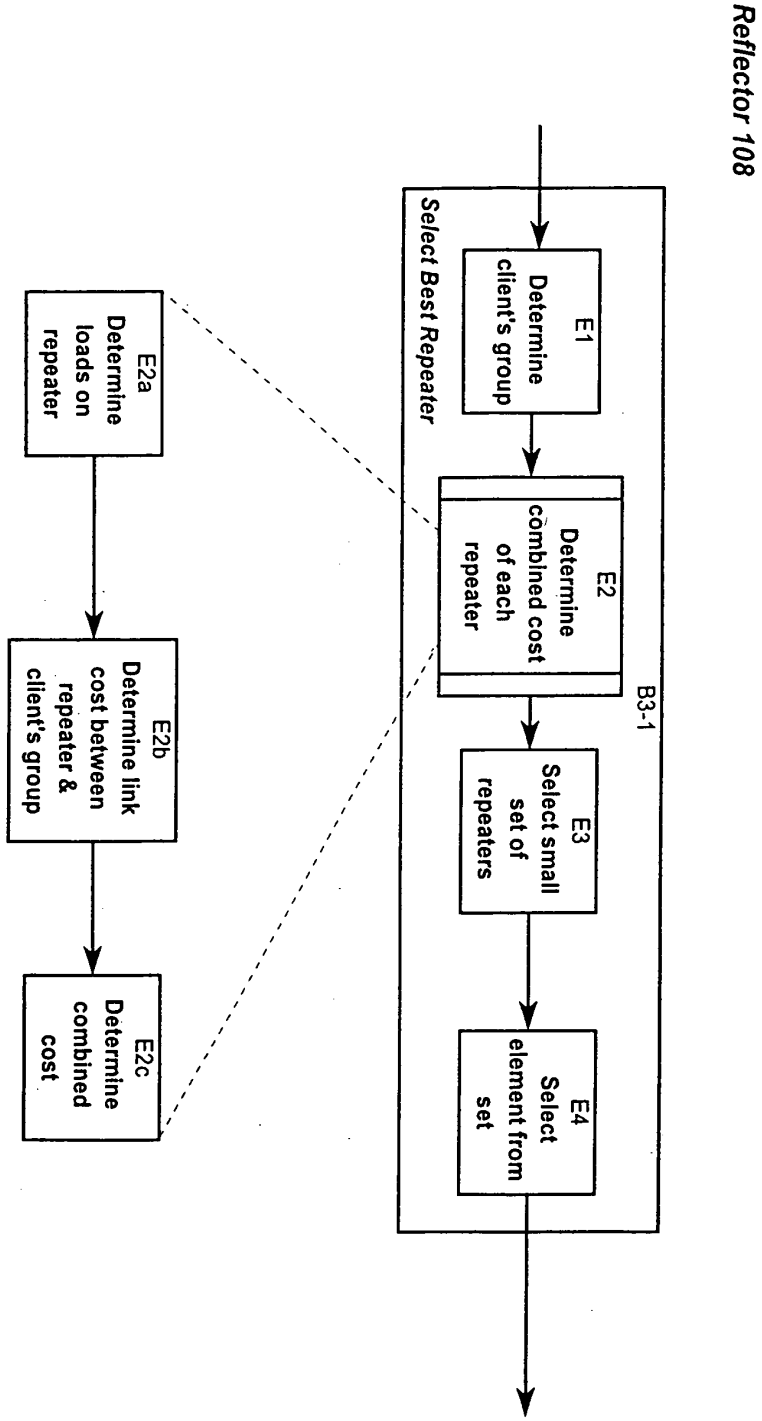

Reflector 108
Select Best Repeater
E1
Determine client's group
E2
Determine combined cost of each repeater
E3
Select small set of repeaters
E4
Select element from set
B3-1
E2a
Determine loads on repeater
E2b
Determine link cost between repeater & client's group
E2c
Determine combined cost

Fig. 6

FOR UTILITY/DESIGN
CIP/PCT NATIONAL/PLANT
ORIGINAL/SUBSTITUTE/SUPPLEMENTAL
DECLARATIONS

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

CUSHMAN
FORM

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the INVENTION ENTITLED OPTIMIZED NETWORK RESOURCE LOCATION

the specification of which (CHECK applicable BOX(ES))

X → ☐ is attached hereto.

BOX(ES) → ☒ was filed on February 10, 1998 as U.S. Application No. /

→ → ☐ was filed as PCT International Application No. PCT/ / on

and (if applicable to U.S. or PCT application) was amended on

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate filed by me or my assignee disclosing the subject matter claimed in this application and having a filing date (1) before that of the application on which priority is claimed, or (2) if no priority claimed, before the filing date of this application:

PRIOR FOREIGN APPLICATION(S) Number	Country	Day/MONTH/Year Filed	Date first Laid-open or Published	Date Patented or Granted	Priority Claimed Yes	No

I hereby claim domestic priority benefit under 35 U.S.C. 119/120/365 of the indicated United States applications listed below and PCT international applications listed above or below and, if this is a continuation-in-part (CIP) application, insofar as the subject matter disclosed and claimed in this application is in addition to that disclosed in such prior applications, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of each such prior application and the national or PCT international filing date of this application:

PRIOR U.S. PROVISIONAL, NONPROVISIONAL AND/OR PCT APPLICATION(S) Application No. (series code/serial no.)	Day/MONTH/Year Filed	Status pending, abandoned, patented	Priority Claimed Yes	No

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

And I hereby appoint Pillsbury Madison & Sutro LLP, Intellectual Property Group, 1100 New York Avenue, N.W., Ninth Floor, East Tower, Washington, D.C. 20005-3918, telephone number (202) 861-3000 (to whom all communications are to be directed), and the below-named persons (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent, and I hereby authorize them to delete names/numbers below of persons no longer with their firm and to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct the above Firm and/or a below attorney in writing to the contrary.

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Edgar H. Martin	20534	Peter W. Gowdey	25872	Lynn E. Eccleston	35861	Roger R. Wise	31204
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(FOR ADDITIONAL INVENTORS, check box ☒ to attach PAT 116-2 same information for each re signature, name, date, citizenship, residence and address.)

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DECLARATION AND POWER OF ATTORNEY
(continued)
ADDITIONAL INVENTORS

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Post Office Address	981 Via Colinas, Westlake Village, CA		
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(4) INVENTOR'S SIGNATURE: James A. Balter Date: 9 March 1998

	James	A.	BALTER
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(5) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address			
(include Zip Code)			

(6) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address			
(include Zip Code)			

(7) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address			
(include Zip Code)			

(8) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address			
(include Zip Code)			

(9) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address			
(include Zip Code)			

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PATENT APPLICATION FEE DETERMINATION RECORD
Effective December 8, 2004

11/065412

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	1	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	1 minus 20=	*
INDEPENDENT CLAIMS	1 minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	150.00	OR	BASIC FEE	300.00
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL		OR	TOTAL	

CLAIMS AS AMENDED - PART II

AMENDMENT A	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

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

FORM PTO-875 (Rev. 10/04) Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION SERIAL NO. _____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

03/01/2005 AKELECH1 00000048 11065412

01 FC:1011	300.00	OP
02 FC:1111	500.00	OP
03 FC:1311	200.00	OP
04 FC:1253	1020.00	OP

PTO-1556
(5/87)

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application. No.	:	Unassigned
Applicant	:	David A. Farber
Filed	:	02/23/2005
TC/A.U.	:	Unassigned
Examiner	:	Unassigned
Docket No.	:	6233P001DC3
Customer No.	:	8791

Commissioner for Patents
PO Box 1450
Alexandria VA 22313-1450

PRELIMIANRY AMENDMENT

Sir:

Prior to examination of this application, please amend the above-identified application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims, which begins on page 3 of this paper.

Remarks/Arguments begin on page 4 of this paper.

Amendments to the Claim of Priority:

Please add the following paragraph on page 1, line 2:

This application is a continuation of Application No. 09/612,598 filed 07/07/2000, now abandoned which is a divisional of Application No. 09/021,506 filed 02/10/1998, now U.S. Patent 6,185,598.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1-24. (Canceled)

25. (Original) A system operative in a computer network in which users of client machines connect to a first server, the system comprising:

a routine for modifying at least one embedded object URL of a web page to include a host name prepended to a domain name and path;

a set of repeater servers, distinct from the first server, for hosting at least some of the embedded objects of web pages that are normally hosted by the first server; and

a repeater selector mechanism constructed and adapted to identify, for a particular client machine, an appropriate repeater server from the set of repeater servers;

wherein in response to requests for the web page, generated by the client machines, the web page including the modified embedded object URL is served from the first server and the embedded object identified by the modified embedded object URL is served from a given one of the repeater servers as identified by the repeater selector mechanism.

REMARKS/ARGUMENTS

By this amendment, claims 1-24 have been cancelled without prejudice and new claim 25 has been added.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: 2/23/2005

By _____
William W. Schaal
Reg. No. 39,018
Tel.: (714) 557-3800 (Pacific Coast)

12400 Wilshire Boulevard, Seventh Floor
Los Angeles, California 90025

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Susan McFarlane

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	
DAVID A. FARBER, ET AL.	Art Group:
Application No.: Unassigned	Examiner:
Filed: February 23, 2005	
For: **Optimized Network Resource Location**	

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.97

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In accordance with the duty of disclosure, enclosed is a copy of IDS Citation Form PTO/SB/08 or PTO-1449, together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed). This IDS and IDS Citation Form are being submitted concurrently with the Continuation Application. It is respectfully requested that the cited references be considered and that the enclosed copy of PTO/SB/08 be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s). Some or all of the references listed on the enclosed PTO/SB/08 were previously identified in the parent application (Application No. 09/612,598, filed July 7, 2000) and copies of the references were furnished at that time. Accordingly, per 37 CFR §1.98(d)(1) additional copies of those references are not submitted herewith.

The submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made in the subject application and is not to be construed as an admission that the information cited in this statement is material to patentability.

Please charge any fees due to Deposit Account 02-2666. A duplicate copy of the Fee Transmittal (PTO/SB/17) is enclosed for this purpose.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: February 23, 2005

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Susan McFarlane — *02-23-05*

Susan McFarlane — *Date*

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Application Number	
Filing Date	February 23, 2005
First Named Inventor	Farber
Group Art Unit	
Examiner Name	

Sheet 1 of 7

Attorney Docket No: 6233P001DC3

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Application Number	
Filing Date	February 23, 2005
First Named Inventor	Farber
Group Art Unit	
Examiner Name	

Sheet 2 of 7

Attorney Docket No: 6233P001DC3

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Application Number	
Filing Date	February 23, 2005
First Named Inventor	Farber
Group Art Unit	
Examiner Name	

Sheet 3 of 7

Attorney Docket No: 6233P001DC3

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Application Number	
Filing Date	February 23, 2005
First Named Inventor	Farber
Group Art Unit	
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Sheet 4 of 7

Attorney Docket No: 6233P001DC3

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OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
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		"Cache Director Systems Technology Overview", http:/www.cisco.com/warp/public/751/cache/cds ds.htm, Cisco System, Inc.,(1997),1-3	
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EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional) [2] Applicant is to place a check mark here if English language Translation is attached

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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known

Application Number	
Filing Date	February 23, 2005
First Named Inventor	Farber
Group Art Unit	
Examiner Name	

Sheet 5 of 7

Attorney Docket No: 6233P001DC3

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	
	Filing Date	February 23, 2005
	First Named Inventor	Farber
	Group Art Unit	
	Examiner Name	
Sheet 6 of 7	Attorney Docket No: 6233P001DC3	

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T[2]**
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EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)
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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	
	Filing Date	February 23, 2005
	First Named Inventor	Farber
	Group Art Unit	
	Examiner Name	
Sheet 7 of 7	Attorney Docket No: 6233P001DC3	

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
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		Science, (November 1994),214-225	
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EXAMINER **DATE CONSIDERED**

Substitute Disclosure Statement Form (PTO-1449)
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16805 U.S.PTO 022305

113013 U.S.PTO 11/06542 022305

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	6233P001DC3
First Inventor	David A. Farber, et al.
Title	Optimized Network Resource Location
Express Mail Label No.	EV589924728US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

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

1. ☒ Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original and a duplicate for fee processing)*
2. ☐ Applicant claims small entity status. See 37 CFR 1.27.
3. ☒ Specification *[Total Pages 55]* *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. ☒ Drawing(s) *(35 U.S.C. 113)* *[Total Sheets 6]*
5. Oath or Declaration (signed) *[Total Pages 2]*
   a. ☐ Newly executed (original or copy)
   b. ☒ Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 18 completed)*
      i. ☐ DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☐ Application Data Sheet. See 37 CFR 1.76
7. ☐ CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ paper
   c. ☐ Statements verifying identity of above copies
9. ☐ Assignment Papers (cover sheet & document(s))
10. ☐ 37 C.F.R. § 3.73(b) Statement *(when there is an assignee)* ☐ Power of Attorney
11. ☐ English Translation Document *(if applicable)*
12. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
13. ☒ Preliminary Amendment ☐ Application Amended to Reflect Claim of Priority
14. ☒ Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. ☐ Nonpublication Request under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. ☒ Other: Request for Extension of Time

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: 09/612,598

Prior application Information: Examiner _____ *Group/Art Unit:* _____

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

☒ *Customer Number* **08791** *or* ☐ *Correspondence address below*

Name	Blakely, Sokoloff, Taylor & Zafman LLP				
Address	12400 Wilshire Boulevard, 7th Floor				
City	Los Angeles	State	California	Zip Code	90025
Country		Telephone	(714) 557-3800	Fax	(714) 557-3347

Name (Print/Type)	William W. Schaal	Registration No. (Attorney/Agent)	39,018
Signature		Date	02/23/05

Based on PTO/SB/05 (04-04) as modified by Blakely, Sokoloff, Taylor & Zafman (wtr) 06/04/2004.
SEND TO: Mail Stop Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

153

16805 U.S. PTO
022305

Effective 12/08/2004
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818)

FEE TRANSMITTAL for FY 2005

☐ Applicant claims small entity status. See 37 CFR 1.27.

TOTAL AMOUNT OF PAYMENT	($)	2,020.00

Complete if Known	
Application Number	Unassigned
Filing Date	February 23, 2005
First Named Inventor	David A. Farber
Examiner Name	
Art Unit	
Attorney Docket No.	6233P001DC3

METHOD OF PAYMENT *(check all that apply)*

☒ Check ☐ Credit card ☐ Money Order ☐ None ☐ Other (please identify): _____

☒ Deposit Account Deposit Account Number: 02-2666 Deposit Account Name: Blakely, Sokoloff, Taylor & Zafman LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☒ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, except for the filing fee

☒ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR §§ 1.16, 1.17, 1.18 and 1.20. ☒ Credit any overpayments

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
		Small Entity		Small Entity		Small Entity	
Application Type	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee(s) Paid ($)
Utility	300	150	500	250	200	100	1,000.00
Design	200	100	100	50	130	65	
Plant	200	100	300	150	160	80	
Reissue	300	150	500	250	600	300	
Provisional	200	100	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description

Each claim over 20 or, for Reissues, each claim over 20 and more than in the original patent

Each independent claim over 3 or, Reissues, each independent claim more than in the original patent

Multiple independent claims

Total Claims		Extra Claims		Fee ($)		Fee Paid
4	- 20 or HP =	0	X	50.00	=	$0.00

HP = highest number of total claims paid for, if greater than 20

Indep. Claims		Extra Claims		Fee ($)		Fee Paid
2	- 3 or HP =	0	X	200.00	=	$0.00

HP = highest number of independent claims paid for, if greater than 3

Multiple Dependent Claims	
Fee ($)	Fee Paid

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets of sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets	Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)		Fee Paid ($)
61	- 100 = -39	/ 50 =		(round up to a whole number) X		=	

4. OTHER FEE(S)

	Fees Paid ($)
Non-English Specification, $130 fee (no small entity discount)	
Other: Extension of Time (3) Three Month	1,020.00
Recording of a patent assignment	

5. TOTAL AMOUNT OF PAYMENT ($) 2,020.00

SUBMITTED BY				Complete (if applicable)	
Name (Print/Type)	William W. Schaal	Registration No. (Attorney/Agent)	39,018	Telephone	(714) 557-3800
Signature				Date	02/23/05

Based on PTO/SB/17 (10-02) as modified by Blakely, Sokoloff, Taylor & Zafman (wlr) 02/10/2004.
SEND TO: Mail Stop Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

Docket No.: 6233P001DC3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:

DAVID A. FARBER, ET AL.

Application No.: Unassigned

Filed: February 23, 2005

For: **Optimized Network Resource Location**

Art Group:

Examiner:

PETITION FOR EXTENSION OF TIME PURSUANT TO 37 C.F.R. § 1.136(a)

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

Sir:

In accordance with 37 C.F. R. § 1.136(a), Applicants for the above-identified application respectfully Petition the Commissioner for a three (3) month extension of time, extending the period for response to February 23, 2005, from the Final Office Action dated August 23, 2004. The petition filing fee of $1,020.00 and a Request for filing a 1.53(b) continuation are attached.

If it should be determined that a longer extension of time is required to prevent this application from being abandoned, please charge any additional fees to Deposit Account No. 02-2666. A copy of the Fee Transmittal is enclosed for deposit account charging purposes.

Respectfully submitted,

Blakely, Sokoloff, Taylor & Zafman LLP

Date: February 23, 2005

William W. Schaal, Reg. No. 39,018

12400 Wilshire Boulevard, 7th Floor
Los Angeles, CA 90025
Telephone: (714) 557-3800

CERTIFICATE OF MAILING/TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Susan McFarlane *02-23-05*
Date