PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
G06F 13/00

A1

(11) International Publication Number: WO 99/30242

(43) International Publication Date: 17 June 1999 (17.06.99)

(21) International Application Number: PCT/US98/25619

(22) International Filing Date: 3 December 1998 (03.12.98)

(30) Priority Data:
60/067,622 5 December 1997 (05.12.97) US

(71) Applicant: BELL COMMUNICATIONS RESEARCH, INC. [US/US]; 445 South Street, Morristown, NJ 07960-6438 (US).

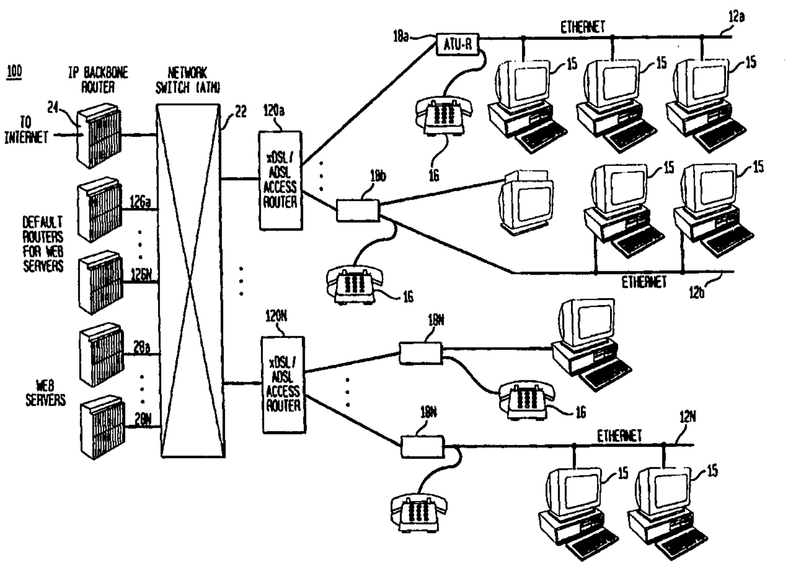
(72) Inventors: GELMAN, Alexander; 158 Pine Grove Road, Smallwood, NY 12778 (US). KHANDELWAL, Rajesh, B.; Apartment #344, 1100 Parsippany Boulevard, Parsippany, NJ 07054 (US).

(74) Agents: YEADON, Loria, B. et al.; c/o International Coordinator, Rm. 1G112R, 445 South Street, Morristown, NJ 07960-6438 (US).

(81) Designated States: AU, CA, CN, ID, JP, KR, MX, SG, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: XDSL-BASED INTERNET ACCESS ROUTER



(57) Abstract

An Internet Protocol based system (100) and method facilitate communication and improve the network performance between remote user terminals (15) and Web servers (28), that are configured by a communication network, including an asynchronous transfer mode (ATM) network (22). The system includes Local Area Networks (LANs) (12), each comprising a plurality of user terminals (15). The system further comprises at least one network switch (22), and at least one digital subscriber line (xDSL) multiplexor and access router (120), each connected between a corresponding LAN and the network switch. Thus, each user communicates directly with its default router obviating the requirement of communicating via the network switch to the default IP edge routers (126). Further, where Quality of Service is required, the xDSL access router serves as the default router for the Web server. XDSL access router helps to reduce the processing load on the Internet edge routers.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

XDSL-BASED INTERNET ACCESS ROUTER

GOVERNMENT INTEREST

This invention was made with United States Government support under Cooperative Agreement No. 70NANB5H1177 awarded by the National Institute of Standards and Technology. The United States Government has certain rights in the invention.

FIELD OF THE INVENTION

The present invention relates generally to an Internet protocol (IP) based system, and more particularly, to an IP based system that facilitates communication and quality of service (QoS) between remote user terminals and Web servers across parts of the Internet that are configured by an asynchronous transfer mode (ATM) network or other communication networks.

BACKGROUND OF THE INVENTION

An asynchronous transfer mode network is a network that can transfer information from one or more sources to one or more destinations. The ATM network can be deployed for configuring parts of the Internet, thus comprising a communication network. The communication network itself may be composed of multiple communicating nodes (e.g., terminals, routers, servers, switches, etc.) that are interconnected to each other by physical communication links (wires, cables, optical fibers, RF channels, etc.). An ATM-equipped node transmits a signal containing a bit stream to an adjacent node via the communication link that connects the two adjacent nodes. The transmitted bit stream is organized into fixed sized packet or “cell” slots for carrying, e.g., 53 byte packets called cells. Illustratively, each cell has a 5 byte header for communicating control information, and a 48 byte payload for communicating a message to be conveyed between nodes. A node allocates a "virtual channel" to each communication, which amongst other things, identifies an adjacent node to which cells of the communication must be transmitted. A sequence of virtual channels of nodes on a path between a source node and a destination node identifies a virtual channel connection.

The source node transmits cells to the destination node via this sequence of virtual channels, i.e., from node to node on the path, in a bucket brigade like fashion. Prior to transmitting the information, the source node segments the information into 48 byte sized messages and appends a 5 byte header to each such message to form a cell. The source node writes a virtual address, such as a virtual channel identifier, which enables each node on the path that receives the cell to determine the outgoing virtual channel on which to transmit the cell. A destination node receiving the cells extracts the messages from the payloads and reassembles the messages (in the appropriate order) into the originally transmitted information.

It is important to note that when communicating between Local Area Networks (LANs) (such as Ethernets) on the Internet which is configured by various links and networks including the ATM network, the data-link layer communications in LAN networks are different than that in the ATM networks. Thus, bridges are utilized to receive information from one network (e.g., LAN) transmitted according to the respective data-link layer and retransmit the information in the other network (e.g., ATM network) according to its respective data-link layer. In other words, bridges decouple the two incompatible data-link layers from each other, yet enable communication between nodes in each of the two networks.

At the network layer, all of the nodes may communicate using the same protocol, e.g., the Internet protocol (IP). Like the Ethernet protocol, each node that can serve as a source or destination node is assigned an IP identifier, or IP address. Information is transmitted from a source node to a destination node in a bit stream that is organized into packets. As previously stated, each packet has a header and a payload. The IP address of the source node is written in a source field of the packet header, and the IP address of the destination node is written in a destination field of the packet header. The data is then written in the payload. The packet is then transmitted according to the appropriate data-link layer protocol for the network (e.g., formed into Media Access Control (MAC) frames, divided into ATM cells, etc.) and then transmitted to its respective destination node. IP provides a routing function for routing a packet from node to node in a sequence of nodes until the packet arrives at its destinations using routing tables.

Such communications networks are becoming increasingly important vehicles for delivering video, audio and other data to and from remote user terminals. For example, such networks are used to support video-on-demand, near video-on-demand, and pay-per-view applications. However, problems are evident in terms of adequate bandwidth.

Typically, wideband (1-10 Mb/s) access technologies are relatively expensive and specialized (such as T1 lines), such that their use has been primarily by large institutional customers, such as large corporations, universities, and government agencies. However, a number of new network access technologies are now moving from the research labs into general availability. For example, some network providers have started to deploy hybrid fiber coax access lines, as well as cable modems. Further, trials and limited deployments of a variety of Digital Subscriber Line (xDSL) (e.g., Asymmetrical Digital Subscriber Lines -

ADSL) technologies are also ongoing. All of this activity is intended to bring broadband networks to the mass market. The ATM network, as previously described, is intended to "bridge the gap" in providing wideband transmission rates to a remote user in an Internet environment.

A conventional IP based system is shown in FIG 1. System 10 includes groups 12a, 12b through 12N of remote user terminals 15, where each group is part of an Ethernet or other LAN system. Each group 12a, 12b through 12N is connected to a respective Ethernet bridge, illustratively an Asymmetrical Digital Subscriber Line (ADSL) termination unit - remote side (as opposed to a central office side) ATU-R 18a, 18b through 18N, respectively, for providing an Ethernet bridge between the LAN system and the respective default IP router. ATU-Rs 18a, 18b, 18c through 18N are also connected to respective telephones 16a, 16b, 16c through 16N.

System 10 further includes a plurality of ADSL based Digital Subscriber Line Access Multiplexors (DSLAM) 20a through 20N, each of which is connected to a plurality of ATU-Rs. Each DSLAM provides basic transport and multiplexing functions between each respective ATU-R 18 and an ATM switch 22. ATM switch 22 is further connected to a plurality of Web servers 28a through 28N, IP edge routers 26a through 26N and IP backbone router 24 for connection to the Internet. The function of each will be described below.

First, we describe the ADSL technology. ADSL was motivated by the goal of achieving wideband transmission rates over existing copper loops. The concept has achieved a growing acceptance by the telecommunications industry and resulted in a standardization effort.

The main idea behind ADSL is that overlapping parts of the spectrum should be present only for signals that are propagating in the same direction within a single bundle of copper wire pairs. This approach reduces the effect of near-end and far-end crosstalk, and hence makes wideband transmission rates feasible for reasonably large loop lengths (up to 18,000 ft). Several characteristics of traditional ADSL systems are specifically tailored to their intended application in residential local loops. These include the asymmetry of bandwidth and the support for life-line telephony as an inseparable component. Note that ADSL technology is suitable for Internet access service. For example, a 10baseT (10bT) interface is located at the ATU-R for personal computer protocols.

A DSLAM is utilized in the IP based system to support ATM bearer service for IP applications. In an ATM bearer service scenario, the interface on the user side is configured as an ATM user to network interface over an ADSL. On the ATM network (trunk) side, the interface is configured as an network to network interface over a synchronous optical network (SONET) transport. Typically, DSLAMs are located in the central office; however they can also be remote such that they are connected over significant distances by single mode fiber links.

DSLAMs support life-line telephony and an asymmetric high/low speed data channel. The DSLAM upstream data channels typically support data rates of 9.6 - 156 kb/s. The downstream bit rate is either fixed or distance-dependent. For some early commercial products, a 2.3 Mb/s rate was specified for distances of no more than 3 km and about 4 Mb/s can be supported over loops shorter than 4 km.

The number of subscriber lines per OC-3c trunk is a function of the QoS, which is required from the ATM bearer service to support the target set of applications. Each OC-3c interface on the ATM network side of the DSLAM provides a line rate of 155.52 Mb/s, giving an effective ATM cell rate close to 150 Mb/s, which leaves an effective bit rate of about 135 Mb/s. If, for example, a non-blocking streaming service is supported for video applications of a constant bit rate of 2.5 Mb/s, then a DSLAM can be configured to support 48 ADSL lines (2.5 Mb/s x 48 = 120 Mb/s). Note that DSLAMs have been designed to provide access to a broadband backbone, characterized by the ATM transport service on the top of the SONET broadband digital hierarchy.

As described above, ADSL-based DSLAMs provide subscriber line multiplexing functionality for Internet Protocol based system. As shown in FIG 1, DSLAMs 20 crossconnect the user terminals 15 or Ethernet 12 to the IP edge routers 26, via ATM switch 22.

A conventional router suffers performance degradation due to processing overloads since it typically support a large population of users. Accordingly, it is common for the router administrators to turn off some important functions (e.g., packet filtering, RSVP, etc.) to improve the router performance.

FIG 2 illustrates the protocol stack for the system of FIG 1. As shown, protocol stack 30 from the user terminals (or PCs) 15 includes a network layer, a data link layer and the physical or PHY layer. The network layer comprises the IP which includes the destination and source addresses, the data link layer comprises the link layer control (LLC) and media access control (MAC) which includes information pertaining to when to transmit and how to construct the frame, and the PHY comprises the 10bT which represents a 10MHz NRZI signal.

Protocol stack 32 from the ATU-Rs 18 consists of ADSL layer (physical and data link), ATM, and AAL on the DSLAM side and 10bT and MAC layer on the user side. Protocol Stack 38 at the IP Router includes the SONET, ATM, AAL, and LLC on the ADSL (user) side and SONET, ATM, and AAL on the network side. Protocol stack 34 from the DSLAM comprises ATM and ADSL on the user side and ATM and SONET on the network side. The ATM switch 22 maintains the layer protocols. Protocol stack 38 provides simulation of the Ethernet bridge on the user side by injecting the LLC-layer.

An example of the operation of the conventional Internet based system 10 is as follows. Consider that Web server 28a wishes to communicate with user terminal 15 that resides on LAN 12b. Now, depending on which IP edge routers are assigned to Web server 28a and to this terminal, there will be at least two passes of the data packets through the ATM switch 22. Consider a best case scenario in which Web server 28a and terminal 15 on LAN 12b are both assigned to IP edge router 26N. Thus, the minimum path between Web server 28a and terminal 15 on LAN 12b must include a link from Web server 28a to IP edge router 26N through ATM switch 22. Then a link must be established from IP edge router 26N, through ATM switch 22, to LAN 12b, via DSLAM 20a. This path passes twice through ATM switch 22, thus contributing to traffic. Of course, if the Web server and terminal were assigned to different IP edge routers, then a minimum of three passes through ATM switch 22 are necessary, since an additional link would also have to be established from the IP edge router assigned to the terminal and the IP edge router assigned to the Web server via the ATM switch 22.

Note that under the architecture of FIG 1, the DSLAMs functionality are limited to providing transport and multiplexing functions. The IP edge routers, in addition to the IP routing mechanism, provide the Ethernet bridging capability in order to be able to address the user's LANs. Accordingly, the system of FIG 1 suffers from a number of performance deficiencies.

Specifically, the IP edge routers become bottlenecks due to the large amount of processing that they have to perform on in-bound and on out-bound packets. It becomes difficult to support QoS in the routers since the bandwidth and processing resources are in a deficit. Consider if a user requires a stream of video information to be transmitted from a Web server, then this stream needs to follow a path from the Web server to an appropriate edge router, take one or more hops between the Web server's edge router and the edge router to which the user is assigned, and then follow a path from the edge router assigned to the user to the user terminal. Only then will the stream of video information reach the user's LAN.

Another disadvantage is that the Address Resolution Protocol (ARP) mechanism requires the router to broadcast the address to be resolved on the LANs. Thus, since the router simulates the LAN bridge, the ARP must be transmitted over the ATM network. Accordingly, additional traffic is added on the ATM network.

It is therefore an object of the present invention to overcome the deficiencies evident in the prior art.

SUMMARY OF THE INVENTION

An aspect of our present invention is an Internet protocol based system and method for facilitating communication and improving communications between remote user terminals and Web servers across parts of the Internet configured by a communications network, such as an ATM network.

The system includes a plurality of LAN networks, such as Ethernet LANs, each comprising a plurality of user terminals or PCs. The system further includes a network switch, illustratively an ATM switch, and at least one digital subscriber line (xDSL) access router, each connected between a corresponding LAN and the network switch. The xDSL (e.g. ADSL) access routers function both as a router and a digital subscriber line multiplexor. Thus, each user terminal can communicate directly with its default router, and vice-versa, obviating the requirement of communicating with its default router via the ATM switch and reducing traffic in the ATM network.

In addition, the IP based system further comprises at least one bridge, such as an ADSL termination unit (ATU-R), each coupled between a respective LAN and a respective xDSL access router. Further, the IP based system further comprises an IP backbone router for connecting the ATM-configured network to the rest of the Internet.

Because each xDSL access router of our inventive IP based system supports a relatively small number of customers (from a few tens to a few hundreds), *vis-a-vis* an IP edge router, the xDSL access router can process traffic more efficiently and with far less risk of overload. In contrast, a conventional router suffers performance degradation due to processing overloads since they support much greater populations of users. Accordingly, it is common for the router administrators to turn off some important functions (e.g., packet filtering, RSVP, etc.) to improve the router performance.

In special situations, when uncompromised QoS is required (e.g., for Video On Demand Applications) the xDSL access router could serve as the default router for specialized Web servers, thus allowing direct connections from user terminals to the Web servers for better support of the IP QoS by utilizing any kind of the QoS mechanism (e.g. based on RSVP protocol) which typical servers do not utilize due to traffic constraints.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description, given by way of example and not intended to limit the present invention solely thereto, will best be understood in conjunction with the accompanying drawings, where similar elements will be represented by the same reference symbol, in which:

FIG 1 schematically illustrates a conventional IP based system;

FIG 2 illustrates the protocol stack for the system of FIG 1;

FIG 3 schematically illustrates the inventive IP based system having xDSL-based access routers in accordance with an aspect of the present invention;

FIG 4 illustratively depicts an embodiment of our inventive access router in accordance with an aspect of the present invention; and

FIG 5 illustrates the protocol stack for the system of FIG 3 in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Our inventive IP based system 100 is shown in FIG 3. System 100 illustratively shows an ATM network; however, it should be understood that any communications network may be utilized as desired. By way of illustration and not limitation, such communication networks may include digital cross-connect network based on T1 (E1) or DS3 (E3), frame relay and ATM, or any combination thereof. The present invention applies to the Internet as well as IP based Intranet. Similar to system 10 of FIG 1, system 100 includes groups 12a, 12b through 12N of remote user terminals 15, where each group is part of an Ethernet or other LAN system. Each group 12a, 12b through 12N is connected to a respective Ethernet bridge, illustratively an ADSL termination unit - remote side (as opposed to a central office side), ATU-R 18a, 18b, 18N, for providing an Ethernet bridge between the LAN system and respective default router.

ATU-Rs 18a, 18b, 18c through 18N are also connected to respective telephones 16a, 16b, 16c through 16N. However, instead of utilizing a plurality of ADSL based DSLAMs as in system 10, system 100 utilizes xDSL (e.g., ADSL) access routers 120a through 120N that are connected between the ATM switch 22 and respective ATU-Rs. Further, in accordance with an aspect of our invention, IP edge routers are no longer utilized as default routers for the user terminals, and user terminals can communicate directly with its default router without going through the ATM switch. Edge routers may continue to serve as default routers for Web servers.

FIG 4 depicts an illustrative embodiment of our inventive xDSL access router 120, which comprises a bank of xDSL line cards 121a through 121N, a system controller 122, at least one ATM/SONET line card 123, a data/control bus 125, and a telephony splitter 126. The ATU-Rs 18 are connected to the xDSL access router 120 via the bank of xDSL line cards 121, which multiplexes and demultiplexes the packets received from and addressed to, respectively, the ATU-Rs 18. The ATM/SONET line card 123 serves as an interface between the ATM switch 22 and the xDSL access router 120. The xDSL line cards and the ATM/SONET line cards communicate via data/control bus 125. The system controller 122 manages the operation of the access router 120 and provides control signaling to its components. The routing and Ethernet bridging functions may reside in the system processor 122, but may also be partially implemented in a distributed fashion in the line cards. As shown in FIG 4, telephony service is being passively coupled to and split from the data service in the telephony splitter 126 of the xDSL access router 120.

FIG 5 illustrates the protocol stack for the system of FIG 3. Similar to FIG 2, protocol stack 30 from the user terminals (or PCs) 12 includes a network layer (IP), a Data Link layer, and the physical or PHY layer. The network layer comprises the IP which includes the destination and source addresses, the data link layer comprises the link layer control (LLC) and MAC which includes information pertaining to when to transmit and how to construct the frame, and the PHY comprises the 10bT which represents a 10MHz NRZI signal. Further, protocol stack 32 from the ATU-Rs 18 comprises an Ethernet bridge, Mac layer, and the physical layer on the user side and an adaption layer (AAL), ATM layer and AAL on the network side.

Protocol stack 134 from the ADSL access router 120 supports AAL, ATM, and SONET (SDH) on the network side and LLC, AAL, ATM, and ADSL on the user side (i.e., the ADSL access router serves as a simulated bridge on the user side). Such router functions were previously performed by the IP edge routers 26 of FIG 1.

As shown in protocol stack 36, the ATM switch 22 maintains the layer protocols. Lastly, protocol stack 138 from the backbone router 24 maintains the protocol layer it receives for scenarios of all-ATM network configurations. In case of heterogeneous networks, including, illustratively, combinations of ATM/SONET and ATM/DS3, protocol conversion would be appropriate.

An example of the operation of the Internet based system 100 is as follows. Consider the case in which uncompromised QoS is required (such as for Video On Demand application). For this case, the xDSL access router would serve as the default router for the Web server delivering this application as well. Therefore, if Web server 28a wishes to communicate with user terminal 15 residing on LAN 12b, a direct link from Web server 28a can be made to LAN 12b. Accordingly, only one pass through ATM switch 22 occurs.

Further, xDSL access router 120a routes data from the Web server 28a directly to LAN 12b (and vice-versa). In another illustrative embodiment where QoS requirement is not as strict, the data from the Web server 28a could flow via the Web server's default router directly to the xDSL access router 120b and then to the user terminal 15 on LAN network 12b.

Our inventive IP based system eliminates the utilization of IP edge routers as default router for user terminals by combining the routing functions thereof with the xDSL access multiplexors. Thus, the Ethernet bridging functions are simulated in the xDSL access routers. Accordingly, since the Ethernet bridging functions occur outside the ATM network, the ARP mechanism does not contribute to the traffic on the ATM network.

The advantages of the xDSL access router of the inventive IP based system includes the benefit, unlike the conventional IP edge routers, of supporting a relatively small number of customers (from a few tens to a few hundreds). Thus, the xDSL access router can process traffic more efficiently and without overload. In contrast, a conventional router suffers performance degradation due to processing overloads as they must support a far greater number of users. Another advantage is that, in cases in which uncompromised QoS is required, the xDSL access router allows direct connections between a user terminal and a Web server, without multiple passes through the ATM switch. This provides greater efficiency as well as better support of the IP QoS by means utilizing any kind of QoS mechanism (e.g., based the RSVP protocol, or a completely proprietary protocol). In addition, by combining the multiplexing and routing functions as described herein, the overall system cost is significantly reduced.

Finally, note that the above discussion is just a preferred embodiment of the invention and is only provided as an illustrative description of the invention. Numerous alternative embodiments may be devised by those skilled in the art without departing from the spirit and scope of the following claims.

CLAIMS

What is claimed is:

1. An Internet protocol (IP) based system for facilitating communication and improving network and service performance between remote user terminals and Web servers across a communications network, comprising:

at least one group of at least one user terminal;

a network switch; and

at least one digital subscriber line (xDSL) access router, each connected between a corresponding one of said at least one group of user terminals and said network switch, said xDSL access router being configured to function as a router and a digital subscriber line multiplexor.

2. The system of Claim 1, wherein each said user terminal communicates, via the corresponding xDSL access router, with a Web server, and vice-versa, obviating need for IP edge routers to as default router for user terminals, thereby reducing network traffic through said network switch.

3. The system of claim 2, further comprising at least one bridge, each coupled between a respective at least one group of said user terminals and said at least one xDSL access router.

4. The system of claim 2, further comprising at least one asymmetrical digital subscriber line (ADSL) termination unit-remote (ATU-R), each coupled between a respective at least one group of said user terminals and said at least one ADSL (or xDSL) access router.

5. The system of claim 2, wherein said network being configured as an asynchronous transfer mode (ATM) network and said switch being configured as an ATM switch.

6. The system of claim 5, further comprising an IP backbone router for connecting said ATM-configured network with the rest of the Internet.

7. The system of claim 5, wherein each said xDSL access router being configured to support at least one of ATM adaption layer (AAL), link layer control (LLC), asymmetrical digital subscriber line (ADSL), ATM, synchronous optical network (SONET), synchronous digital hierarchy (SDH), T1, E1, DS3, and frame relay protocols.

8. The system of claim 12, wherein each said xDSL access router being configured to support quality-of-service (QoS) layers and QoS signaling mechanisms.

9. The system of claim 2, further comprising at least one default router corresponding to said Web servers, such that each of said user terminals communicates, via the corresponding xDSL access router and the corresponding default router, with a Web server, and vice-versa.

10. The system of claim 9, wherein said at least one Web server's default router being said at least one xDSL access router.

11. The system of claim 2, wherein each said xDSL access router being an asymmetrical digital subscriber line (ADSL) router.

12. The system of claim 2, wherein each said xDSL access router being configured to provide Ethernet bridging capabilities between said Web servers and said at least one user terminal.

13. A method for facilitating communication and improving network and service performance over an Internet protocol (IP) based system between remote user terminals and Web servers across a communications network, comprising the steps of:

transmitting data from a user terminal, in at least one group of at least one user terminal, to a corresponding digital subscriber line (xDSL) access router, said xDSL access router being configured to function as a router and a digital subscriber line multiplexor, transmitting at least a portion of said data from said xDSL access router to a selected Web server, via a network switch, the selected Web server being based on address information included in said data,

wherein each said user terminal communicates, via the corresponding xDSL access router, with a Web server, and vice-versa, obviating the requirement of each user terminal communicating via IP edge routers, thereby reducing network traffic through said network switch.

14. The method of claim 13, wherein said step of transmitting from a user terminal to a corresponding xDSL access router transmits said data to said xDSL access router via a corresponding bridge.

15. The method of claim 13, wherein said step of transmitting from a user terminal to a corresponding xDSL access router transmits said data to said xDSL access router via a corresponding asymmetrical digital subscription line (ADSL) termination unit-remote (ATU-R).

16. The method of claim 14, further comprising the step of connecting said network switch to the Internet via an IP backbone router.

17. The method of claim 13, wherein each said xDSL access router being figured to support at least one of ATM adaption layer (AAL), link layer control (LLC), asymmetrical digital subscriber line (ADSL), ATM, synchronous optical network (SONET), synchronous digital hierarchy (SDH), T1, E1, T3, DS3 and frame relay protocols.

18. The method of claim 13, wherein each said xDSL access router being configured to support quality-of-service (QoS) layers and QoS signaling mechanisms.

19. The method of claim 13, wherein said network being configured as an asynchronous transfer mode (ATM) network and said switch being configured as an ATM switch.

20. The method of claim 13, further comprising at least one default router corresponding to said Web servers, such that each of said user terminals communicates, via the corresponding xDSL access router and the corresponding default router, with a Web server, and vice-versa.

21. The method of claim 20, wherein said at least one default router being said at least one xDSL access router.

22. The method of claim 21, wherein each said xDSL access router being an asymmetrical digital subscriber line (ADSL) router.

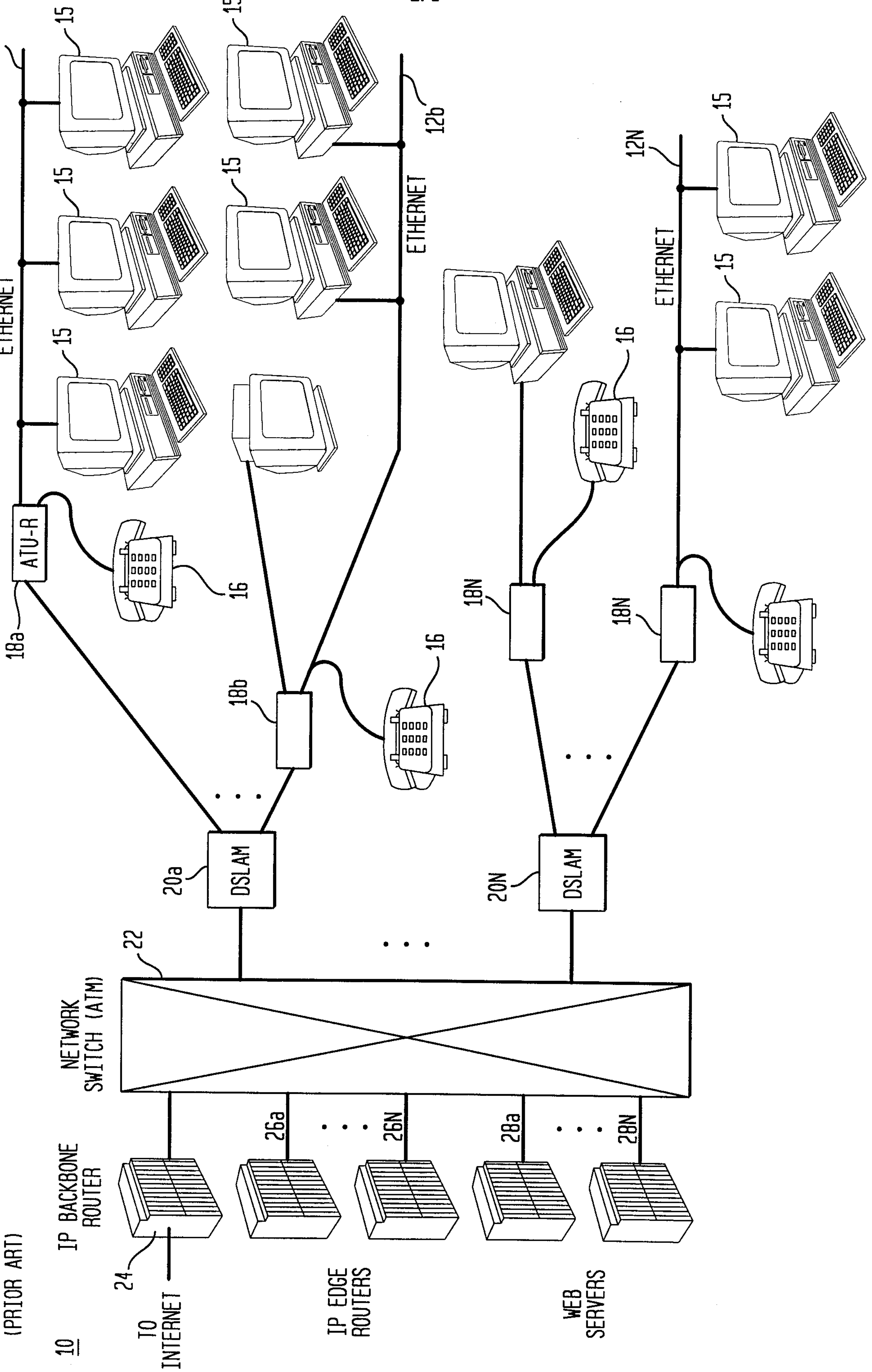
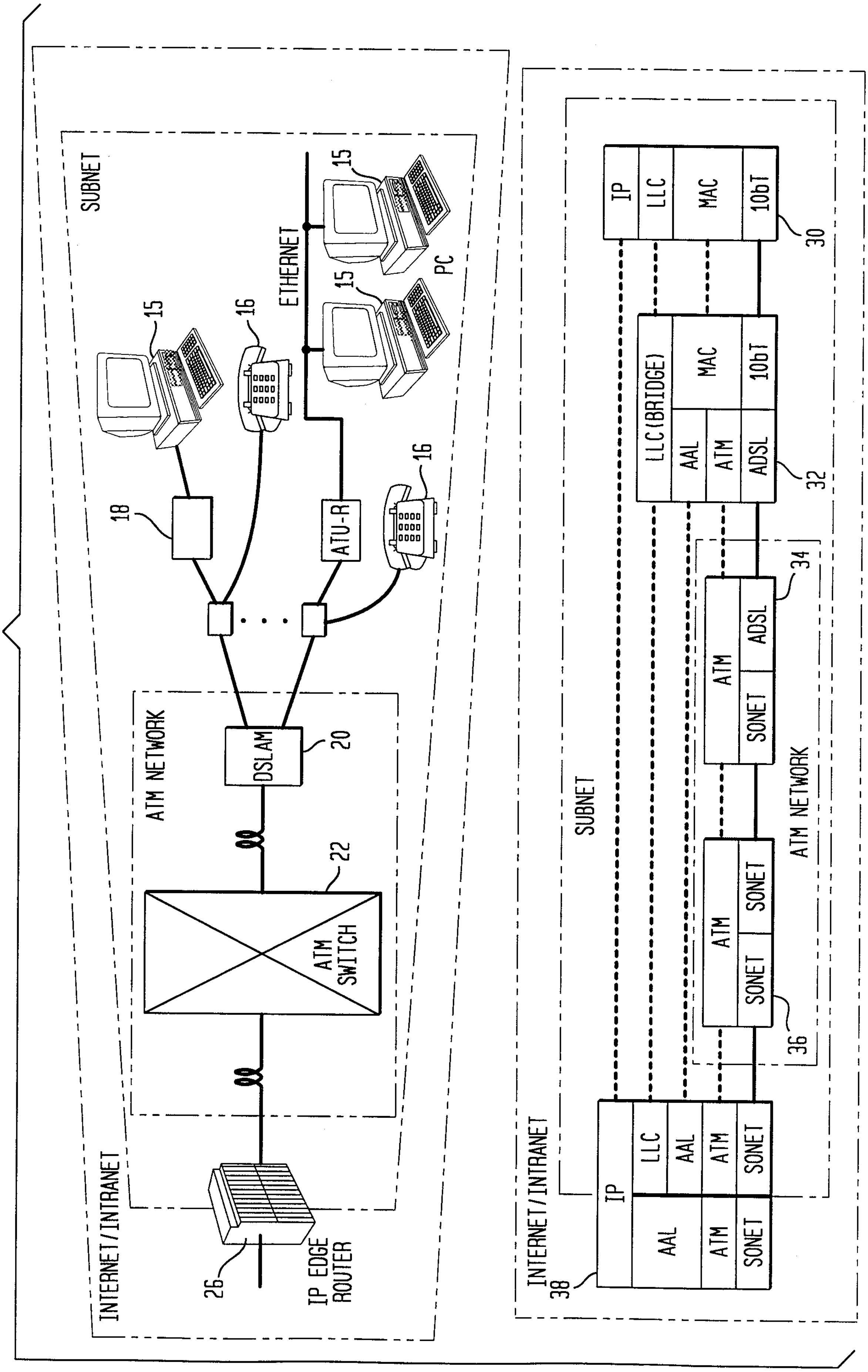


FIG. 1
(PRIOR ART)

FIG. 2
(PRIOR ART)



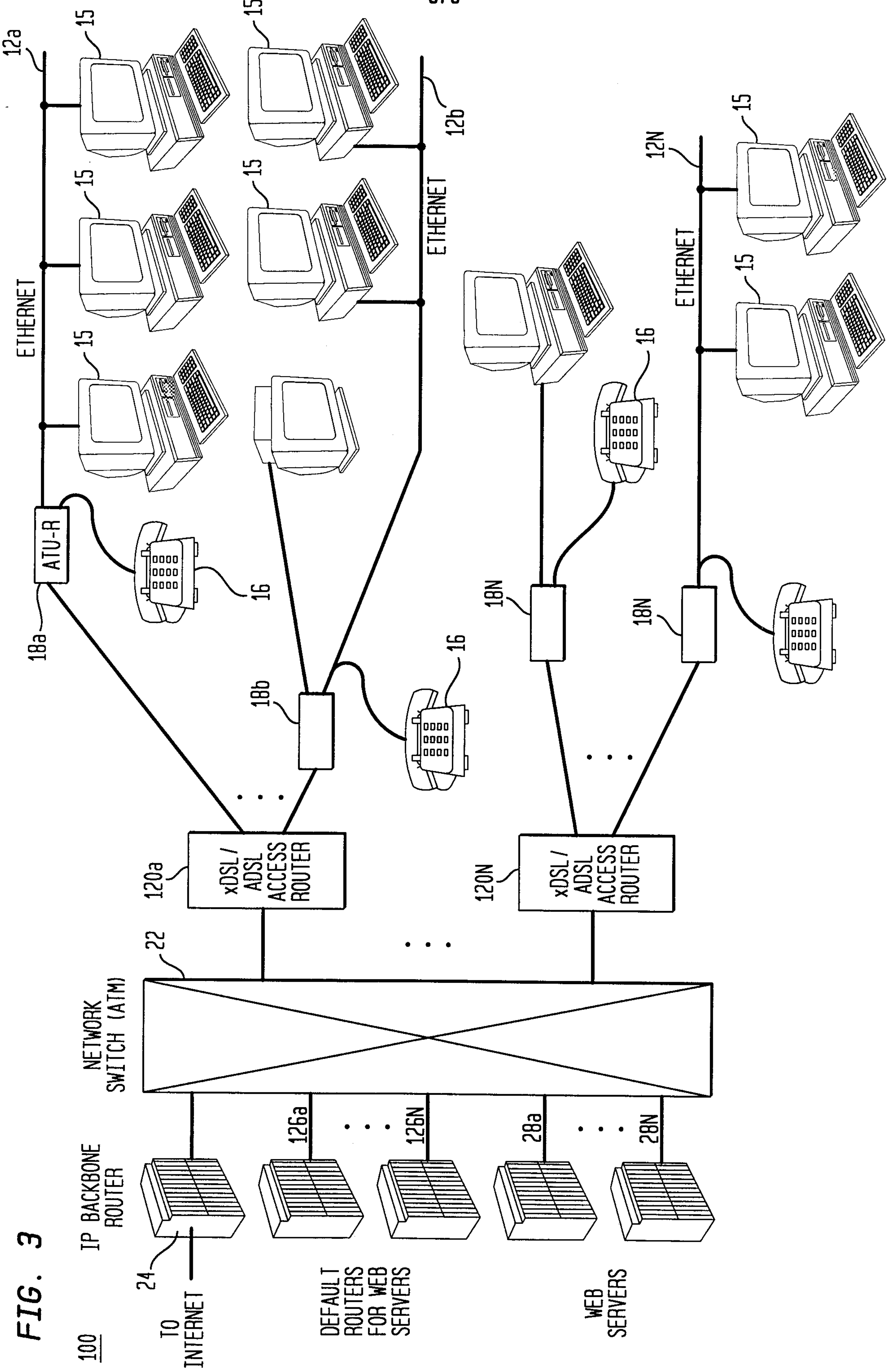

100
TO INTERNET
24
IP BACKBONE ROUTER
DEFAULT ROUTERS FOR WEB SERVERS
126a
126N
WEB SERVERS
28a
28N
NETWORK SWITCH (ATM)
22
120a
xDSL/ ADSL ACCESS ROUTER
120N
xDSL/ ADSL ACCESS ROUTER
18a
ATU-R
16
18b
16
18N
18N
16
ETHERNET
12a
15
15
15
15
15
ETHERNET
12b
12N
ETHERNET
15
15

FIG. 3

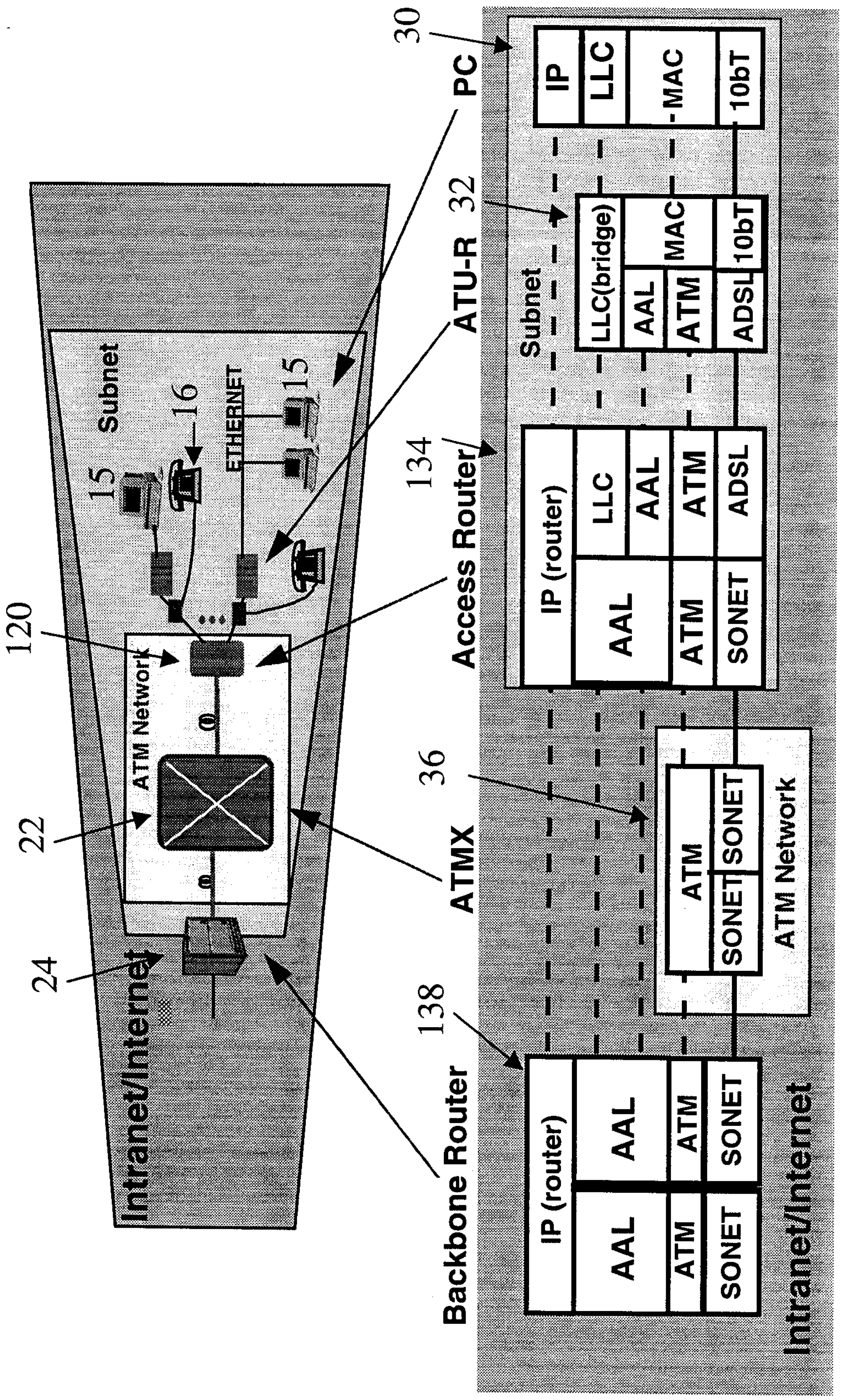

Intranet/Internet
24
22
120
ATM Network
Subnet
15
16
ETHERNET
15
Backbone Router
ATMX
Access Router
ATU-R
PC
138
36
134
32
30
IP (router)
AAL
ATM
SONET
AAL
ATM
SONET
SONET
ATM
SONET
ATM Network
IP (router)
AAL
ATM
SONET
LLC
AAL
ATM
ADSL
Subnet
LLC(bridge)
AAL
ATM
ADSL
MAC
10bT
IP
LLC
MAC
10bT
Intranet/Internet

Figure 4

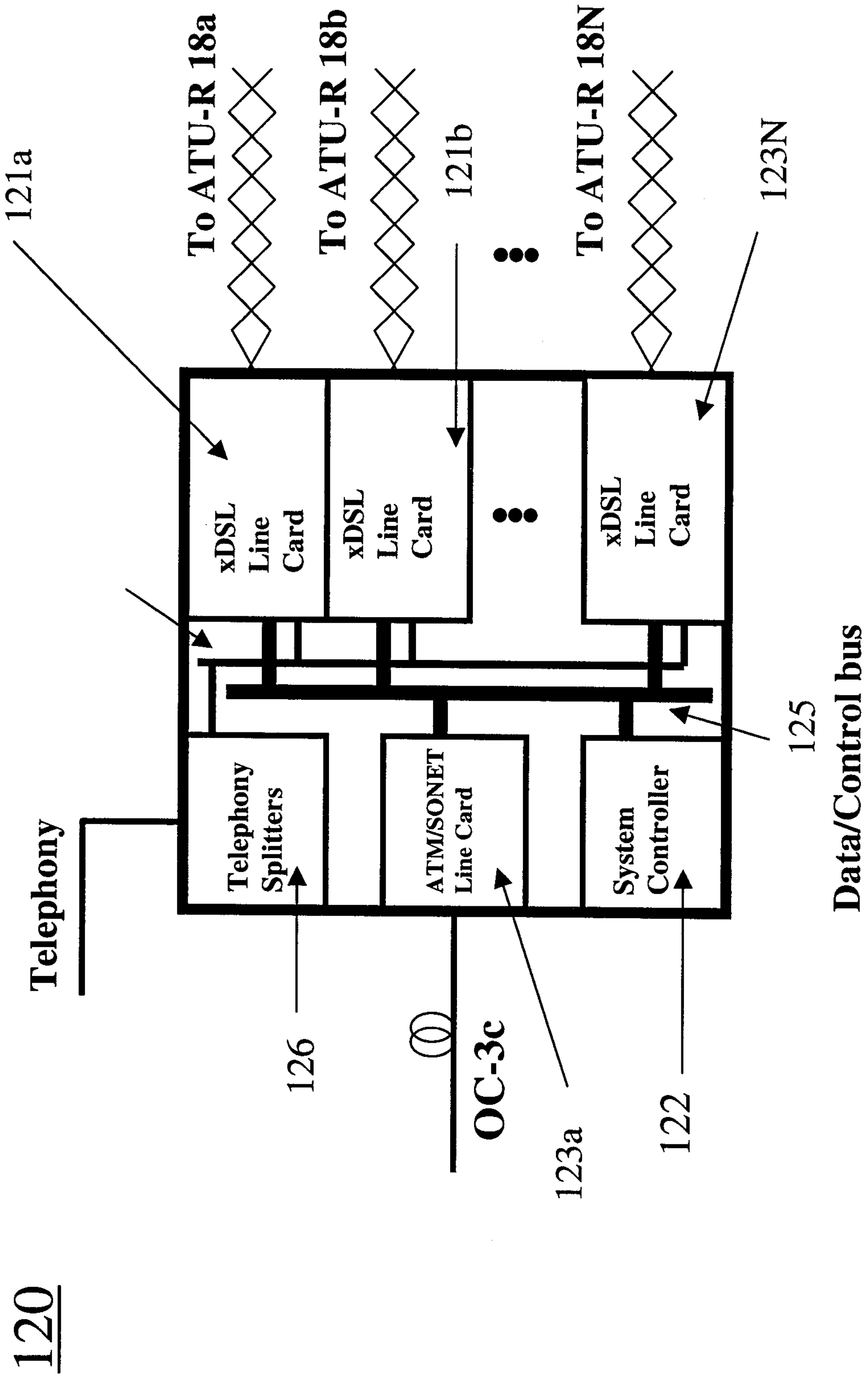

120
Telephony
Telephony Splitters
126
OC-3c
ATM/SONET Line Card
123a
System Controller
122
Data/Control bus
125
xDSL Line Card
xDSL Line Card
xDSL Line Card
121a
121b
123N
To ATU-R 18a
To ATU-R 18b
To ATU-R 18N

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/25619

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :G06F 13/00
US CL :709/218, 238
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 709/218, 238

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
APS
search terms: ADSL, XDSL, DSL, handshaking, ATM, QOS, wideband transmission rate, router

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,673,265 A (GUPTA et al.) 30 September 1997, col. 4-7, 30-32	1, 3-8, 13, 15-19
Y	US 5,666,487 A (GOODMAN et al.) 09 September 1997, col. 9-10, 12-13 and fig. 1,6	1-6, 8-12, 13-16, 18-22
Y	US 5,619,650 A (BACH et al.) 08 April 1997, col. 6-7 and abstract	1-3, 13-15
Y	US 5,608,447 A (FARRY et al.) 04 March 1997, col. 9-12, fig. 11,12, and abstract	1, 2, 5-7, 9-14, 16, 17, 19, 20, 22
Y	US 5,583,863 A (DARR, JR. et al.) 10 December 1996, col. 15-16, 19-20, fig. 2, and abstract	1-3, 5, 6, 13-15, 19, 21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"B" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
19 JANUARY 1999

Date of mailing of the international search report
20 APR 1999

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
JASON D. CARDONE
Joni Hill
Telephone No. (703) 305-3800