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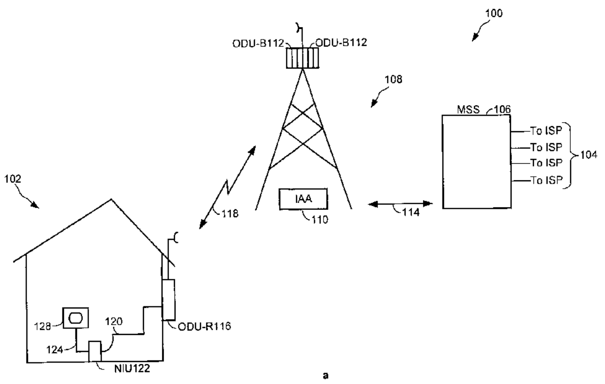
(54) Title: FULL BANDWIDTH WIRELESS INTERNET DELIVERY SYSTEM



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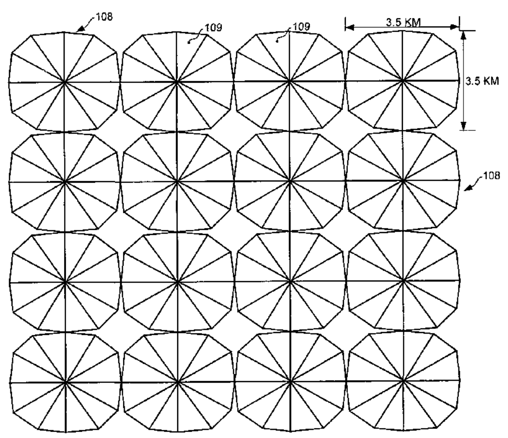

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(57) Abstract: A method and apparatus for connecting a plurality of users (102) to the Internet. The method includes providing a wireless communication link between each user and an Internet backbone router (106) and alternating between the plurality of users allowing each to transmit to the Internet backbone router data signals using a full bandwidth of the wireless communication link but each only when data signals are present and then only for a predefined amount time.

WO 01/62025 A1

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FULL BANDWIDTH WIRELESS INTERNET DELIVERY SYSTEM

BACKGROUND

Internet usage has expanded exponentially in the last five years. The affordability of computers and the availability of Internet Service Providers (ISPs) to deliver inexpensive services to customers through telephone and cable hook-ups have resulted in a growing number of Internet users. With the expansion of E-tailing, more and more users are on-line each day and for longer periods of time. With increased demand, the ISPs have faced the ever-expanding problem of delivering adequate services to each user. More specifically, users are requesting more and more bandwidth to be able to access and download information at faster and faster rates.

Initially most conventional users accessed the Internet through an ISP using a telephone modem. Today, conventional telephone modems provide up to 56Kbytes of data delivery and return up to 53Kbytes of data per second. As users demanded more and better access to the information available on the Internet, other access means were introduced. Users now can select from telephone modems, cable hook-ups (i.e., cable modems), digital subscriber service (DSL) connections, and some wireless communication services to connect to the Internet.

In these conventional systems, users are still limited in the amount of bandwidth that they can access. For example, users connecting to the Internet using conventional modems or cable modems are limited by the transmission rates of their modems as well as Federal Government restrictions. Further, while a DSL connection offers more bandwidth than a conventional telephone or cable modem, customers can be no farther than a fixed distance (typically 3.3 miles) from the closest telephone connection hub in order to be able to receive the DSL service. What is needed is a system for providing large bandwidth access to the Internet for each subscriber where the system includes an inexpensive and convenient connection means so as to maximize the number of subscribers.

SUMMARY

In one aspect the invention provides a method for connecting a plurality of users to the Internet. The method includes providing a wireless communication link between each user and an Internet backbone router and alternating between the plurality of users allowing each to transmit to the Internet backbone router data signals using a full

bandwidth of the wireless communication link but each only when data signals are present and then only for a predefined amount time.

Aspects of the invention can include one or more of the following features. The step of providing a wireless communication link can include transmitting, in a downlink path to all users, a continuous stream of data that includes packets received from the Internet backbone router for transmission to any of the plurality of users. The step of alternating can include generating a token for transmission to a selected one of the plurality of users to signal when uplink communications can commence from the selected user. The step of alternating can include constructing Ethernet frames for transmission in the upstream link to the Internet backbone router. The communication path between the plurality of users and the Internet backbone router can be a hybrid system that includes a wireless portion and a fiber optic portion.

The method can include providing a hub between the user and the Internet backbone router, coupling packets between the plurality of users to the hub using substantially a wireless link and coupling the packets from the hub to the Internet backbone using substantially a fiber optic link. The method can include delivering the token to each of the plurality of users in accordance with a predefined ordering. The method can include delivering the token based on priority of service subscribed to by a given user. The predefined ordering can be a round robin ordering.

The method can include providing an aggregation point for communications from the users in the transmission path between the users and the Internet backbone router. The aggregation point can include links to plural Internet service providers (ISP), each coupled to a respective Internet backbone router. The method can enable each user to select an ISP for coupling its respective packets received at the aggregation point to a selected ISP. The method can include presenting a user interface to each user for selecting an ISP from a predefined list of available ISP's coupled to the aggregation point. The method can include providing billing and statistical services at the aggregation point to track a users use of a particular ISP.

In another aspect, the invention provides a communication system for connecting a plurality of users to the Internet. The system includes a communication link coupling the plurality of users and an Internet backbone router. The communication link includes a wireless portion coupling the users to a hub. The hub is operable to aggregate and distribute packets passed on the communication link between the users and the Internet backbone router. The hub includes means for alternating between the plurality of users allowing each to transmit to the Internet backbone router data signals using a full bandwidth of the wireless portion of the communication link but each only when data signals are present and then only for a predefined amount of time.

Aspects of the invention can include one or more of the following features. The communication system can include a network interface unit including a dedicated DSL head unit or cable modem termination system for coupling a user's Internet access device to the communication link. The communication system of claim 11 wherein the hub includes one or more outdoor antenna unit base stations where each outdoor antenna unit base station is coupled via the communication link to one or more users in a sector of users. The communication system can include, at each user, a remote outdoor unit coupled to the communication link for facilitating the exchange of data between a user and the outdoor antenna unit base station associated with a user's sector.

The outdoor antenna unit base station can generate a token that is distributed to a user in a sector of users to signal a time when uplink communications can proceed from the user using the full bandwidth of the communication link. The outdoor antenna unit base station can be operable to distribute the token in a round robin fashion among the users in a sector of users. The outdoor antenna unit base station can be operable to select a user for distribution of the token and redistribute a token if no data is needed to be uplinked from the selected user. The remote outdoor unit can include a stub antenna and mounts in close proximity to a user's Internet access device. The remote outdoor unit can be attached to a building site for a user. The outdoor antenna unit base station can generate a backpressure signal and communicate the backpressure signal with the hub. The hub can respond to the backpressure signal and drop packets destined to the respective outdoor antenna unit in a downlink communication path to the user.

The outdoor antenna unit base station can communicate with each user in its respective sector of users continuously in the down link communications path over the communications link. The outdoor antenna base unit is located in proximity to the users in its respective sector of users and remotely from the hub. The data packets can be DVB airframes in the wireless portion of the communication link. The data format can be burst packet in an upstream link of the wireless portion of the communication link.

Aspects of the invention can include one or more of the following advantages. A communication system is provided that delivers the full bandwidth of a wide-bandwidth communications link to each individual user for a predefined amount of time. The system systematically allows users to access the full bandwidth of the system to upload data when present, but when a user does not need the bandwidth, other users can be serviced. Users can subscribe to varying levels of service, where each level increases the amount of time that the user will have access to the full bandwidth of the communication system. The system provides downlink communications using conventional Ethernet frames and Ethernet media access control receive procedures, allowing for plural users to listen to all the downstream communications, and specifically decode only those packets that are destined for a particular user. In the data uplink, a modified token based access system is used to deliver the full bandwidth of the communication system to a single user at a time. Since the entire bandwidth is dedicated to an individual user, a data format can be selected that maximizes the amount of data throughput transmitted in the uplink while minimizing the amount of overhead information required to be sent along with the data packets through the communication system. The system provides plural sites that can provide service to a wide area of users. Each individual site can provide service to any user within a predefined radius of the site. These and other advantages will be readily apparent from the detailed description, the attached Figures and the claims presented below.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

FIG. 1A is a schematic block diagram of a system for connecting a user to the Internet.

FIG. 1B shows a schematic diagram of a coverage map for the system of FIG. 1A.

FIG. 2 is a block diagram of a telephone company's switch (MSS).

FIG. 3 is a block diagram of an Internet access aggregator (IAA).

FIG. 4 is a block diagram of an outdoor unit base station (ODU-B).

FIG. 5 is a block diagram of a remote outdoor unit (ODU-R).

FIG. 6 is a block diagram of a network interface unit (NIU).

Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

Referring now to FIG. 1A, a system 100 for coupling a user 102 to the Internet backbone 104 is shown. In one implementation, the system provides a hybrid wireless and fiber architecture in establishing a communication link between the user and the Internet. This architecture is shown in Fig. 1. The system includes a router (MSS) 106, a plurality of sites (BSS) 108 where each site includes an Internet access aggregator (IAA) 110, and a plurality of outdoor unit base stations (ODU-B) 112. Each site 108 is coupled by a communication link 114 to the MSS 106. The system also includes a plurality of remote outdoor units (ODU-R) 116 that are coupled by link 118 to one of the outdoor unit base stations 112. Each ODU-R 116 is coupled by a link 120 to network interface unit (NIU) 122, for example in the user's house. Finally, a communication link 124 couples the NIU 122 to a user's computer/home network 128.

In the implementation shown, communication link 114 is a fiber optics connection using single mode or multi-mode fiber communication means. Other communication linking means can be used including radio frequency (RF) links or conventional hard wire.

In the implementation shown, link 118 is an RF link making use of the MMDS spectrum in the uplink and downlink communication paths between the outdoor unit base stations 112 and the ODU-Rs 116. However, those of ordinary skill in the art will recognize that other communication means can be used depending on the system requirements. Examples of alternative communication links are discussed in greater detail below in the alternative implementations section of this document.

Communication link 124 between the NIU and the customer's computer 128 can be Ethernet, USB, FireWire, DOCSIs (using a distributed or dedicated cable modem termination system technique), XDSL, Home PNA, Home RF or any other standard or non-standard local area and/or wide area network link.

The system includes plural sites 108 that are coupled by plural communication links 114 to MSS 106. In one implementation, each site 108 is configured to cover an area that is 3 ½ kilometers square. In one implementation, each site 108 includes twelve ODU-Bs 112, each covering a 30° sector for the site. Other configurations of ODU-Bs can be used, and the selection of twelve base station antennas should not be construed as limiting.

Referring now to FIG. 1B, a diagram showing a configuration of system 100 for covering a 14 kilometer by 14 kilometer square area is shown. In this system, sixteen sites 108 are included. At each site 108, 12 individual sectors 109 are identified. Each sector has associated with it one or more ODU-Rs 112 for broadcasting and receiving communications from customers (users 102) that reside within an associated sector 109. Each user 102 serviced by system 100 is required to have a local connection to system 100. The local connection includes an ODU-R116, NIU 122, a means for communicating between the NIU 122 and the user's computer and/or other Internet capable appliance (e.g., a communication card, modem) and various communication links there between. Each user 102 can communicate with the Internet backbone 104 making use of the communication link provided by system 100.

Router (MSS)

Referring now to FIG. 2, MSS 106 includes a plurality of cards that are configured to provide a communication link to the Internet backbone. MSS 106 provides switching services including load balancing for transferring packets between users and the Internet. In the implementation shown, a plurality of interface cards 200 are coupled to a chassis 202. In the example shown, the interface cards include two 10/100 Ethernet server cards 204, a dense-wave division multiplexing card 208, a packet over SONET card 210, a SONET card 211 and an ATM card 212. Each of the interface cards provides a means for communicating with the Internet backbone or other communication services, for example, for communicating with a central office switch that in turn communicates with the Internet.

MSS 106 includes one or more control cards 214. Each control card 214 is configured to provide routing services for communication packets that are received from various users connected to system 100 for transmission to and from the Internet. In one implementation, two control cards 214 are used. One control card 214 is designated the primary control card and the second control card is designated a redundant control card. The function and operation of the primary and redundant control cards are identical, with the exception that the redundant control card only operates upon the failure of the primary control card 214. Other configurations of control cards can be used and the use of two control cards (one designated as primary and one redundant) should not be construed as limiting. In one implementation, plural control cards 214 are active concurrently, with each control card carrying a portion of the load in a load balancing configuration.

The "active" control card(s) 214 executes routing protocols for routing packets to and from the Internet. In support of the routing function, control card 214 develops or otherwise accesses a routing table as is known in the art. In one implementation, the routing table associated with the active control card(s) is mirrored in the redundant control card to allow for ease of transfer of control from the primary to the redundant control card. In one implementation, the primary control card 214 copies its routing table to the redundant control card at predefined intervals in order to maintain an up-to-date routing table in the redundant control card. In another implementation, any changes made to the primary control card routing table are mirrored immediately in the redundant control card routing table.

MSS 106 also includes one or more gigabit Ethernet cards 206 mounted in chassis 202. Each gigabit Ethernet card aggregates traffic from one or more sites 108 in system 100 and forwards these to a communications company backbone switch or other service provider via one of the interface cards 200 located in the MSS chassis 202. In one implementation, multiple gigabit Ethernet cards 206 are provided as shown in FIG. 2. Each gigabit Ethernet card can include one or more gigabit Ethernet ports 207. In the implementation shown, dual gigabit Ethernet ports from a single card are coupled to one site 108. Other connection combinations are possible including connecting each port of a dual ported gigabit Ethernet card to a different site 108. In one implementation, a dual ported gigabit Ethernet card 206 is coupled via a fiber optic gigabit Ethernet connection (communication link 114) to IAA 110 providing a maximum of 432 megabits per second throughput. Other throughputs up to a gigabit are possible. In one implementation, the fiber optic connection is a single mode fiber, however, multi-mode fiber communication means can be employed as appropriate.

In addition to routing services, control card 214 can be configured to coordinate the delivery of other services including carrier selection, statistics services and traffic management.

In one implementation, control card 214 includes carrier selection software (not shown). The carrier selection software allows an end-user to designate different carriers (ISPs) to use in accessing the Internet backbone. For example, the MSS 106 may be coupled to plural ISPs via the interface cards 200. The user can advantageously make use of the system to transport data from the user's home/business. No separate dial in to an ISP is required at the user's local computer. Instead, all data, irrespective of the carrier, can be transported through the system, with links to the carrier provided by the interface cards in the MSS. The carrier selection software provides a mapping from IP addresses associated with a carrier to a particular interface card.

Control card 214 can be configured to poll and gather network statistics from various ones of the cards connected to the MSS 106 or the other components of system 100. Control card 214 can be configured to include traffic management software for managing the traffic and flow of information between the Internet backbone and the system users.

Finally, MSS 106 includes a plurality of load sharing power supplies 225. In one implementation, two redundant power supplies 225A and 225B are provided. In this implementation, the power supplies share the load and are configured to be able to support the full load of the router in the event that one of the individual power supplies fail. However, in normal operation, each individual power supply supports a portion of the load.

Internet Access Aggregator (IAA)

Referring now to FIG. 3, each site 108 includes an IAA 110. IAA 110 is a central collection and distribution point in the communications system for a site 108. IAA 110 distributes data received from MSS 106 to an appropriate ODU-Bs 112. Similarly, IAA 110 aggregates traffic received from all the ODU-Bs 112 at a site 108 for forwarding to MSS 106. IAA 110 includes a MSS interface including one or more external interface ports 308, a ODU-B interface including one or more interface cards 302 and interface switch 304.

MSS interface couples data packets between IAA 110 and MSS 106. In one implementation, two external interface ports 308 are provided for interfacing with two gigabit Ethernet ports associated with MSS 106.

ODU-B interface couples data packets between the ODU-Bs for a given site and IAA 110. In one implementation, the ODU-B interface includes a plurality of interface cards 302 (interface cards 302-0 through 302-11 in the example shown). In one implementation, the interface also includes a power interface (not shown) for distributing power from a local power supply in the IAA (not shown) to each of the ODU-Bs 112.

Interface switch 304 provides high speed switching of data packets from the MSS interface to the ODU-Bs 112. Each of the interface cards 302 as well as external ports 308 are coupled to a port of interface switch 304. In one implementation, interface switch

304 is implemented as a hardware ASIC that acts as a layer 2 (L2) switch for traffic between the user and the MSS. Interface switch 304 maintains an L2 forwarding table and automatically switches incoming packets to the right outgoing port.

As packets are received in the upstream path, IAA 110 aggregates the traffic from the ODU-Bs 112 residing at the site 108 (i.e. at the top of the antenna tower) for transfer out a port coupled to the MSS interface. As packets are received on the MSS interface, they are distributed to an appropriate interface card 302 for transfer to an associated ODU-B 112. In one implementation, IAA 110 includes twelve 10/100 megabit per second Ethernet ports (i.e., interface cards 302) and two gigabit Ethernet data ports (i.e., external interface ports 308).

Interface switch 304 includes a high speed switching fabric that can switch packets at rates that far exceed the aggregate maximum packet rate that can be generated by the sum of the ports attached to the switch fabric. As such, interface switch 304 is completely non-blocking. In one implementation, IAA 110 can process back pressure signals generated from the ODU-Bs 112, causing the IAA to randomly, or in a predetermined sequence, discard packets that are destined for a particular ODU-B 112.

Interface switch 304 can be configured to support various priority protocols for the transfer of data packets. In one implementation, interface switch 304 is configured to support the IEEE 802.1P and 802.1Q standards. More specifically, packets (i.e. Ethernet packets) include a tag for designating a priority for the given packet. By allowing for the identification of prioritized packets, certain ones of the packets can be configured to flow through the system faster than other packets. In one implementation, up to four priority queues are included at the output, one for each of voice, video, data and management traffic. These queues can be programmable and sized based on user needs. The priority queues can be used in association with tagging mechanisms that are provided by the customers in order to tag particular data for faster transmission through the system.

As described above, IAA 110 operates to aggregate the communications received on the sector ODU-Bs 112 and forwards communications via the external interface ports 308 to the MSS 106. In addition, IAA 110 evaluates packets that are received from the MSS 106 and forwards the packets to a particular ODU-B 112 that is responsible for the sector 109 where the customer is located.

As described above, interface switch operates as a layer 2 switch evaluating MAC addresses to make forwarding decisions. In one implementation, interface switch 302 supports up to 12,000 MAC addresses. MSS 106 and each customer 102 is assigned a MAC address. In one implementation, particular ranges of MAC addresses are assigned to each sector 109 to ease the route look-up process in the interface switch 304. The addressing of packets is described in greater detail below in association with the Ethernet connection in the downlink from the site 108 to each individual user within a sector 109.

In one implementation, the communication link between IAA 110 and each of the individual ODU-Bs 112 is via an Ethernet communication link. As such, Ethernet frames are provided between the IAA and the ODU-Bs 112.

IAA 110 also includes a processor 305 coupled by a bus 306 to interface switch 304. Processor 305 can be used to gather statistics information, update or enforce routing protocols or other overhead functions.

ODU-B

Referring now to FIG. 4, a block diagram of an ODU-B 112 is shown. ODU-B 112 includes an uplink path 400 and a downlink path 402. In addition, ODU-B 112 includes a tetherless network transport media access controller (TNT-MAC) 406, a transceiver 405 and a microcontroller 408. Associated with the microcontroller 408 may be a flash memory 410 and a dynamic random access memory (DRAM) 412.

Transceiver 405 receives Ethernet frames from IAA 110 and couples the frames to the TNT-MAC 406. TNT-MAC 406 communicates with each user in a sector using a modified round robin communication protocol. In one implementation, a token is passed to arbitrate access to upstream bandwidth within a sector. TNT-MAC 406 selects a user from its respective sector, constructs and sends a token to the selected user to allocate the full bandwidth of the uplink communication channel for the sector to the selected user for a predetermined amount of time. More specifically, TNT-MAC 406 determines a next user in line to transmit data in the uplink and constructs and sends a token to the selected end-user station (ODU-R 116). At a designated time, the token is returned from the ODU-R 116 and another selection and delivery cycle is initiated. In one implementation, TNT-MAC 406 passes the token around in a round-robin fashion according to a list of MAC addresses associated with all of the users in a particular sector. In the event a selected user has no data to uplink, the token can be quickly returned to the ODU-B for distribution to a next selected user.

In another implementation, a different mechanism for providing access to each individual server is provided. For example, each individual user can subscribe to a level (priority) of service. Depending on the subscription, an NIU 122 (a subscriber) is allotted an amount of time for accessing the full bandwidth in the uplink communication path. In one implementation, at least two classes of service are provided for. In one implementation, TNT-MAC 406 allocates bandwidth based on service class as well as based on data class (i.e., audio, video, or other data type).

In one implementation, the TNT-MAC 406 maps Ethernet frames received via transceiver 405 into digital video broadcast (DVB) frames for transmission over the downlink path 402. Similarly, TNT-MAC 406 strips DVB formatting from the packets received on the uplink path 400 for transmission back to an Ethernet switch (IAA 110) at a respective site 108. In this implementation, the DVB framing structure provides the physical media dependent sub-layer and the physical layer.

TNT-MAC can be implemented in hardware using an floating point gate array (FPGA) or alternatively can be embodied in an ASIC.

Microcontroller 408 can be used to configure TNT-MAC 406. In addition, microcontroller 408 can provide statistics and management services for traffic routed through TNT-MAC 406.

i.) downlink path

In the downlink path 402, a modulator 440 is coupled to the input of a mixer circuit 442, which produces an intermediate frequency output. The intermediate frequency output signal is coupled to a second mixer circuit 444 that in turn provides a radio frequency output signal. The radio frequency output signal is coupled to an amplifier 446 that, in turn, provides a radio frequency signal for output to diplexer 430.

In one implementation, mixer circuit 442 includes a radio frequency source 450, an amplifier 452 and a mixer 454. The signal received from modulator 440 is mixed in mixer 454 with the radio frequency signal generated by radio frequency source 450. The output of mixer 454 is coupled to the input of amplifier 452 whose output is coupled to the output of the mixer circuit 442. In one implementation, the output of mixer circuit 442 is coupled to a variable attenuator 460. A feedback circuit 461 monitors the output of amplifier 446 and controls variable attenuator 460 so that the power output at diplexer 430 is maintained at a constant level. In one configuration, the output is set at 15 dBm.

The output of variable attenuator 460 is coupled to the input of mixer circuit 444. In one implementation, mixer circuit 444 includes an amplifier 470, a mixer 472, and a second amplifier 474 coupled to a radio frequency source 476. The radio frequency source 476 provides an input signal that is amplified by amplifier 474 and provided as an input to mixer 472. The intermediate frequency signal that has been attenuated by variable attenuator 460 is provided as an input to amplifier 470. The output of amplifier 470 is provided as a second input to mixer 472. The output of mixer 472 is coupled to the input of amplifier 446. In one implementation, a band pass filter 478 is coupled between the output of the mixer circuit 444 and the input of amplifier 446.

In one implementation, the radio frequency downlink between an ODU-B 112 and the individual ODU-Rs is a single channel of the MMDS spectrum sized to be approximately 6 megahertz in the frequency range from 2503 megahertz to 2681 megahertz. The selection of a particular channel in the frequency range depends on the proximity of other signal sources, interference, and a reuse criterion set based on system requirements.

As described above, the downstream communications between an ODU-B and the ODU-Rs are continuous. That is, frames are broadcast over a sector and are received by all ODU-Rs 116 within the sector. However, only the appropriate customer will access the received data as determined by the MAC addressing of the frames. In one implementation, the downstream communication transmission speed is approximately 28.849 Mb/s, the modulation technique is 64 quadrature amplitude modulation (QAM), and the frame format is DVB airframes. In one implementation, system 100 translates from Ethernet frames to DVB frames prior to downstream transmission. In one implementation, the Ethernet frames include a 48 bit destination address, a 48 bit source address, 32 bits for designation of a virtual local area network, 1500 bits of data and 32 bits of error correction codes. The Ethernet frames are mapped into an airframe that includes one synchronization bit, 187 bytes of data, 1 fragmentation notification bit, and 16 bytes of error correction codes.

In one implementation, a token is passed to a respective party as part of the continuous downstream communication. The token can be a unique bit pattern in the downstream communication path that differentiates it from other downstream data. Alternatively, other authorization means can be used to designate a particular user as the selected user to transmit data in the uplink path.

ii.) uplink path

TNT-MAC 406, in addition to allocating bandwidth and communicating tokens to be transmitted in the downlink path, is also responsible for receiving and forwarding packets transferred through the uplink path. More particularly, uplink path 400 includes a demodulator 420, a receiver 422 including local oscillator 424 that is coupled to diplexer 430.

In the uplink path 400, signals received on diplexer 430 are coupled to the input of mixer circuit 422. The mixer circuit 422 includes amplifiers 482, 484 and 486 as well as a mixer 488 and an image rejection circuit 490. The output diplexer is coupled to the input of amplifier 482. The output of amplifier 482 is provided as an input to the image rejection circuit 490 whose output is in turn coupled to one input of mixer 488. An RF signal source 424 is coupled to the input of amplifier 484 whose output is in turn coupled to a second input of mixer 488. The output of mixer 488 is coupled to the input of amplifier 486 whose output produces an intermediate frequency signal that is provided to demodulator 420. In one implementation, the output is at approximately 44 megahertz.

In the uplink path, users (ODU-R 116) transmit data to a respective ODU-B 112 associated with the user's sector. In one implementation, the radio frequency uplink between an ODU-Rs 116 and the ODU-B is a single channel of the MMDS spectrum sized to be approximately 2 megahertz in the frequency range from 2151 megahertz to 2161 megahertz. The selection of a particular channel in the frequency range depends on the proximity of other signal sources, interference, and a reuse criterion set based on system requirements. In one implementation, each individual ODU-R transmits at a particular fixed frequency and neighboring ODU-Rs (in a different sector) transmit at a different frequency to ensure that there is no overlap of communications between sectors.

In the upstream communication link between the ODU-Rs and the ODU-Bs, communications are "bursty". That is, only the designated local user that received and translated a properly formatted token (or other authorization means) transmits at a given time. In one implementation, the upstream communication transmission speed is approximately 5.832 Mb/s, the modulation technique is 16 QAM with 4 bits per symbol, and the frame format is burst packet format. In one implementation, system 100 translates from Ethernet frames to burst packet frames prior to upstream transmission. In one implementation, the Ethernet frames include a 48 bit destination address, a 48 bit source address, 32 bits for designation of a virtual local area network, 1500 bits of data and 32 bits of error correction codes. The Ethernet frames are mapped into a burst packet physical media dependent frame that includes 128 synchronization bytes, 8172 bytes of data.

ODU-R

Referring now to FIG. 5, a block diagram of an ODU-R 116 is shown. The ODU-R 116 includes a downlink path 502 and an uplink path 500. ODU-R 116 includes a diplexer 530, a TNT-MAC 506, a micro-controller 508, a flash memory 510, DRAM 512 and transceiver 505.

TNT-MAC 506 is similar to the TNT-MAC 406 (FIG .4) provided in the ODU-B and includes circuitry for understanding the authorization means (e.g., token) generated by the ODU-B. Where a token is used, the token can designate a time (start and duration) when the user (customer) associated with the particular ODU-R 116 can transmit data on the uplink portion 500 of the communications path to the ODU-B 112. In one implementation, the user is provided with the entire bandwidth of the uplink communication portion of the communication path to the ODU-B 112 for a fixed duration of time that may vary according to the user's access class for transmission. In one implementation, in the downlink communications path 502, TNT-MAC 506 recovers/un-maps data from the DVB standard to Ethernet format frames for communication along the Ethernet link to NIU 122. When a token is received, TNT-MAC 506 commences uplinking signals from the NIU 122 to be received by the associated ODU-B 112.

i.) downlink

In the downlink path 502, a diplexer 530 receives signals and transfers them to a mixer circuit 522, whose output is provided to a demodulator 520. In one implementation, the mixer circuit 522 includes amplifiers 582, 584 and 586 and mixer

588. A radio frequency signal source 524 is coupled to the first input of amplifier 584 whose output is coupled to one input of mixer 588. The output of diplexer 530 (i.e., the received signal) is coupled to the input of amplifier 582 whose output is coupled to an image rejection circuit 590. The output of image rejection circuit 590 is coupled to a second input of mixer 588. The output of mixer 588 (the down converted signal) is coupled to the input of amplifier 586 whose output is coupled to the input of demodulator 520. In one implementation, a variable gain amplifier 521 is provided at the output of the mixer circuit 522 between the mixer circuit and the demodulator 520. The gain of the variable gain amplifier 521 is controlled by an output provided by demodulator 520. The output of demodulator 520 is coupled to TNT-MAC 506. In one implementation, TNT-MAC 506 recovers the Ethernet frames from the received DVB formatted stream prior to passing the data to the NIU 122.

ii.) uplink

Signals received from NIU 122 via transceiver 505 can be transformed in TNT-MAC 506 (Ethernet frames to DVB air frames) prior to passage to modulator 540. In the uplink path 500, modulator 540 receives signals from TNT-MAC 506 for transmission through an amplifier 542 whose output is coupled to an upconvert circuit 544. The upconvert circuit 544 includes amplifiers 570 and 574 as well as mixer 572. A source 576 provides an RF output that is coupled to the input of amplifier 570 whose output in turn is coupled to one input of mixer 572. The output of amplifier 542 is coupled to the input of amplifier 574 in the upconvert circuit 544. The output of amplifier 574 is coupled to the second input of mixer 572. The output of mixer 572 is coupled to a power amplifier 546 whose output is then in turn coupled to diplexer 530. In one implementation, a bandpass filter 578 is coupled between the upconvert circuit 544 and the power amplifier 546.

Network interface unit

Referring now to FIG. 6, network interface unit (NIU) 122 is shown. NIU 122 includes a processor 600 coupled by a bus 602 to a plurality of plug-in cards 604. One or more plug in cards can be used to access the ODU-R 116. Other plug in cards can be used to communicate with the MSS as part of an initialization process. Finally, one or more other cards (typically one) can be used for communicating with the end user's personal computer or network. In one implementation, NIU 122 includes a four-port switch fabric 606 that is coupled to bus 602. Four port switch fabric 606 can include two

10/100 Ethernet connections 608-0 and 608-1 and a USB connection. In one implementation, one of the Ethernet connections 608-0 is coupled to the output of the local ODU-R 116 and provides a path to the system 100. The second Ethernet connection 608-1 can be used to communicate to a user's personal computer (PC) 128. Alternatively, a USB interface 610 can be included. The USB interface can be used for communicating with the particular user's PC.

In one implementation, NIU 122 includes a cable head end 612 for cable modem communications. The cable modem may be included within the user's PC and the NIU can be configured to include a cable modem head end circuitry for cable modem termination. In one implementation, the cable head end can be dedicated to support a single user 102.

In one implementation, a digital subscriber line (DSL) modem is included in the user's PC for communicating with NIU 122. NIU 122 can be configured to include a DSL access multiplexor (not shown) for communicating with the DSL modem in the user's PC. Where dedicated cable modems or DSL system implementations are selected, NIU 122 can convert signals received from these services to a format that is suitable for transmission over the hybrid wireless and fiber system described above.

NIU 122 can include an optional hard drive 612 for caching video and other information as required. NIU 122 can also include a conventional dial up modem 614 for communicating with MSS 106 directly or with a configuration server/database during initialization. In one implementation, modem 614 is only used for initial configuration. At initialization, MSS 106 transfers necessary information such as user identifier (ID), password, MAC address, IP address, account number and service class specification. When the user completes the initialization process including an authentication processes, MSS 106 provides the MSS's IP address and MAC address to the NIU 122 for use in formatting frames of data to be sent to the MSS, via the hybrid wireless and fiber communication system.

In one implementation, the data frames passed between the NIU 122 and the ODU-R 16 are Ethernet frames. More specifically, Internet protocol (IP) packets received on an interface card coupled to the user's PC are formatted by the IP stack in the PC to produce data frames (e.g., Ethernet frames) for transmission to a local ODU-R 116. Data frames received from the ODU-R are linked directly to the user's PC using an appropriate interface card. Depending on the interface, the format of the packets received from ODU-R can be converted to produce the necessary IP packets for transfer to the user's PC.

In operation, the user accesses the Internet in a conventional manner. That is, the user opens a browser that links to an ISP. The linking is performed through system 100. In one implementation, every subscriber is assigned a default ISP for Internet access and mail.

In one implementation, the user can select an ISP to connect to through the MSS 106. The user can be prompted for a selection. In one implementation, a default ISP selection is made based on the user's level of service. In another implementation, a graphical user interface can be presented that includes one or more icons, each representing an available ISP that can be linked to using system 100. In each case, the session TCP port numbers and IP addresses generated by the user will be mapped to the ISP port at the MSS. System 100 can include a billing routine for monitoring usage of each service (ISP) used.

Assuming that the user has an IP address of "A", and desires to link to a website ("W") with an IP address of "B", the process invoked is as follows. MSS 106 is the next hop in the transmission path between the source (user A) and destination (IP address B). IAA 110 is a transparent bridge in the transmission path between the user and the MSS.

More specifically, at initialization each NIU 122 and MSS share the following information: MAC address of the network interface card inside the user's PC, ISP selection, User/Account Information and User ID/Password. The MSS 106, after authenticating the user, provides its IP address (e.g., a DHCP server connected to the MSS at the central office).

For the user, the default gateway IP address is that of MSS. The NIU 122 can acquire the MAC address of the MSS by executing an address resolution protocol (ARP). NIU 122 has the complete IP stack and assumes that the Domain Name Server (DNS) is at the central office connected to the MSS.

For the purposes of example, assume that the user's PC has IP address of "A" and a MAC address of "M-A"; the destination website has a IP address of "B" and a MAC address of "M-B"; and finally, that the MSS 106 has IP address of "C" and a MAC address "M-C".

A request is generated for the selected ISP to retrieve data from the desired web site. The request is of the form of an IP packet and is transmitted to the NIU 122. The

NIU constructs Ethernet frames that include the appropriate layer 2 and layer 3 headers to complete the routing of the request through the system. The layer 3 and layer 2 headers will have the following structure as it leaves a user's PC destined to the website (W).

Destination IP	Source IP	
B	A	← Layer 3

Destination MAC	Source MAC	
M-C	M-A	← Layer 2

The request (packet) is transferred to the local ODU-R for transmission to the MSS. When the ODU-R receives the authorization to transmit, the packet is forwarded via the IAA in the sector's BSS 110 to the MSS 106.

Once the packet arrives at the MSS 106, the destination MAC address is updated to reflect that of the website (W) as follows:

Destination IP	Source IP	
B	A	← Layer 3

Destination MAC	Source MAC	
M-B	M-A	← Layer 2

The swapping of the destination MAC address takes place at the MSS 106. As described above, IAA 110 in its respective BSS (site 108) is a simple layer 2 switch and is transparent to the end user or the MSS. Note that the above example assumes that the website is resident on a host machine/server that is co-located with the MSS in the service provider's central office building. The connection between the MSS and the web server can then be made by a local area network.

When data is to be returned to the user from the website W, the process is as follows. Packets flowing from the website to the end user will have the addresses swapped as follows.

From website (W) to PC via the MSS, packets are directed to A using the layer 3 header, but routed through to the MSS using the layer 2 header data as follows:

Destination IP	Source IP	
A	B	← Layer 3

Destination MAC	Source MAC	
M-C	M-B	← Layer 2

Once the packet arrives at the MSS, the destination MAC address is updated to reflect that of the user's PC as follows:

Destination IP	Source IP	
A	B	← Layer 3

Destination MAC	Source MAC	
M-A	M-B	← Layer 2

Thereafter, the packets are forwarded to an appropriate BSS (site 108). At the IAA for the BSS, the packet is distributed to the appropriate ODU-B associated with the sector where the user resides. The ODU-B transmits the packet over the sector in the downlink path. The user's ODU-R receives the packet, and recognizes the MAC address for the user. The packet is transferred to the NIU 122, where it is linked through an interface card back to the user's PC.

Alternative Implementations

The system above has been described in terms of particular implementations. Other implementations are possible.

For example, in one implementation, the ODU-B can be remotely located from the BSS (site 108). As described above, each ODU-B supports a sector for a site (BSS). In this configuration, an ODU-B can be configured to support, and be in proximity with, a nano-cell. The nano-cell is similar to a sector in that plural users in a defined geographical area are supported by the nano-cell. However, by moving the ODU-B closer to the respective users, no outdoor antenna unit may be required at the individual user's house. As such, the NIU can be configured to include a stub antenna or other antenna means for receiving communications from the local ODU-B. In this configuration, the functionality of the ODU–R may be incorporated into the NIU. Alternatively, the functionality of the NIU and ODU-R can be implemented in a single network interface card that couples directly to a user's PC. The nano-cell configuration relieves line of sight issues that may arise when using a conventional antenna tower because of the geography of a particular sector. In addition, the relocation of the ODU-B moves the arbitration of bandwidth closer to the actual users, speeding delivery and return of data and tokens. In one implementation, the size of a nano-cell is approximately 250 square meters.

The link between the ODU-B and the IAA in a respective BSS can be by fiber, hard wire, wireless, point to point or other communication means. Spread spectrum communication techniques can be used in the communication link between the ODU-B and the modified NIU.

In another implementation, one or more repeaters can be included in the transmission path between the ODU-B and ODU-Rs for ones of the users in a given sector. Repeaters can be used to boost signal levels and assist in delivering signal data to areas of a sector that might otherwise be unserviced due to geographical or other considerations.

In another implementation, the NIU can operate as a router and can perform network address translation (NAT). In this configuration, the user's PC would list the NIU as the default gateway to the Internet and would pass all web/Internet requests through the NIU. The NIU in turn would translate the IP source address into the IP address that was assigned to the user site by the service provider.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

WHAT IS CLAIMED:

1. A method for connecting a plurality of users to the Internet comprising:

providing a wireless communication link between each user and an Internet backbone router; and

alternating between the plurality of users allowing each to transmit to the Internet backbone router data signals using a full bandwidth of the wireless communication link but each only when data signals are present and then only for a predefined amount time.

2. The method of claim 1 where the step of providing a wireless communication link includes transmitting in a downlink path to all users a continuous stream of data that includes packets received from the Internet backbone router for transmission to any of the plurality of users.

3. The method of claim 2 wherein the step of alternating includes generating a token for transmission to a selected one of the plurality of users to signal when uplink communications can commence from the selected user.

4. The method of claim 1 wherein the step of alternating includes constructing Ethernet frames for transmission in the upstream link to the Internet backbone router.

5. The method of claim 1 wherein the communication path between the plurality of users and the Internet backbone router is a hybrid system that includes a wireless portion and a fiber optic portion.

6. The method of claim 5 further comprising:

a. providing a hub, between the user and the Internet backbone router;

b. coupling packets between the plurality of users to the hub using substantially a wireless link; and

c. coupling the packets from the hub to the Internet backbone using substantially a fiber optic link.

7. The method of claim 3 including delivering the token to each of the plurality of users in accordance with a predefined ordering.

8. The method of claim 5 further including delivering the token based on priority of service subscribed to by a given user.

9. The method of claim 5 where the predefined ordering is a round robin ordering.

10. The method of claim 1 further including

a. providing an aggregation point for communications from the users in the transmission path between the users and the Internet backbone router, the aggregation point including links to plural internet service providers (ISP), each coupled to a respective Internet backbone router;

b. enabling each user to select an ISP for coupling its respective packets received at the aggregation point to a selected ISP.

11. The method of claim 10 further including presenting a user interface to each user for selecting an ISP from a predefined list of available ISP's coupled to the aggregation point.

12. The method of claim 11 further including providing billing and statistical services at the aggregation point to track a users use of a particular ISP.

13. A communication system for connecting a plurality of users to the Internet comprising:

a communication link coupling the plurality of users and an Internet backbone router, the communication link including a wireless portion coupling the users to a hub, the hub for aggregating and distributing data packets passed on the communication link between the users and the Internet backbone router, the hub including means for alternating between the plurality of users allowing each to transmit to the Internet backbone router data signals using a full bandwidth of the wireless portion of the communication link but each only when data signals are present and then only for a predefined amount time.

14. The communication system of claim 13 further comprising a network interface unit including a dedicated DSL head unit for coupling a user's Internet access device to the communication link.

15. The communication system of claim 13 further comprising a network interface unit including a dedicated cable modem termination system for coupling a user's Internet access device to the communication link.

16. The communication system of claim 13 wherein the hub includes one or more outdoor antenna unit base stations where each outdoor antenna unit base station is coupled via the communication link to one or more users in a sector of users.

17. The communication system of claim 16 further comprising:

at each user, a remote outdoor unit coupled to the communication link for facilitating the exchange of data between a user and the outdoor antenna unit base station associated with a user's sector.

18. The communication system of claim 17 wherein each outdoor antenna unit base station generates a token that is distributed to a user in a sector of users to signal a time when uplink communications can proceed from the user using the full bandwidth of the communication link.

19. The communication system of claim 18 wherein the outdoor antenna unit base station is operable to distribute the token in a round robin fashion among the users in a sector of users.

20. The communication system of claim 17 wherein the outdoor antenna unit base station is operable to select a user for distribution of the token and redistribute a token if no data is needed to be uplinked from the selected user.

21. The communication system of claim 17 where the remote outdoor unit includes a stub antenna and mounts in close proximity to a user's Internet access device.

22. The communication system of claim 17 wherein the remote outdoor unit is attached to a building site for a user.

23. The communication system of claim 16 wherein the outdoor antenna unit base station is operable to generate a backpressure signal and communicate the backpressure signal with the hub, and wherein the hub is operable to respond to the backpressure signal and drop packets destined to the respective outdoor antenna unit in a downlink communication path to the user.

24. The communication system of claim 16 wherein the outdoor antenna unit base station communicates with each user in its respective sector of users continuously in the down link communications path over the communications link.

25. The communication system of claim 16 wherein the outdoor antenna base units is located in proximity to the users in its respective sector of users and remotely from the hub.

26. The communication system of claim 13 wherein the data packets are DVB airframes in the wireless portion of the communication link.

27. The communication system of claim 13 wherein the data format is burst packet in an upstream link of the wireless portion of the communication link.

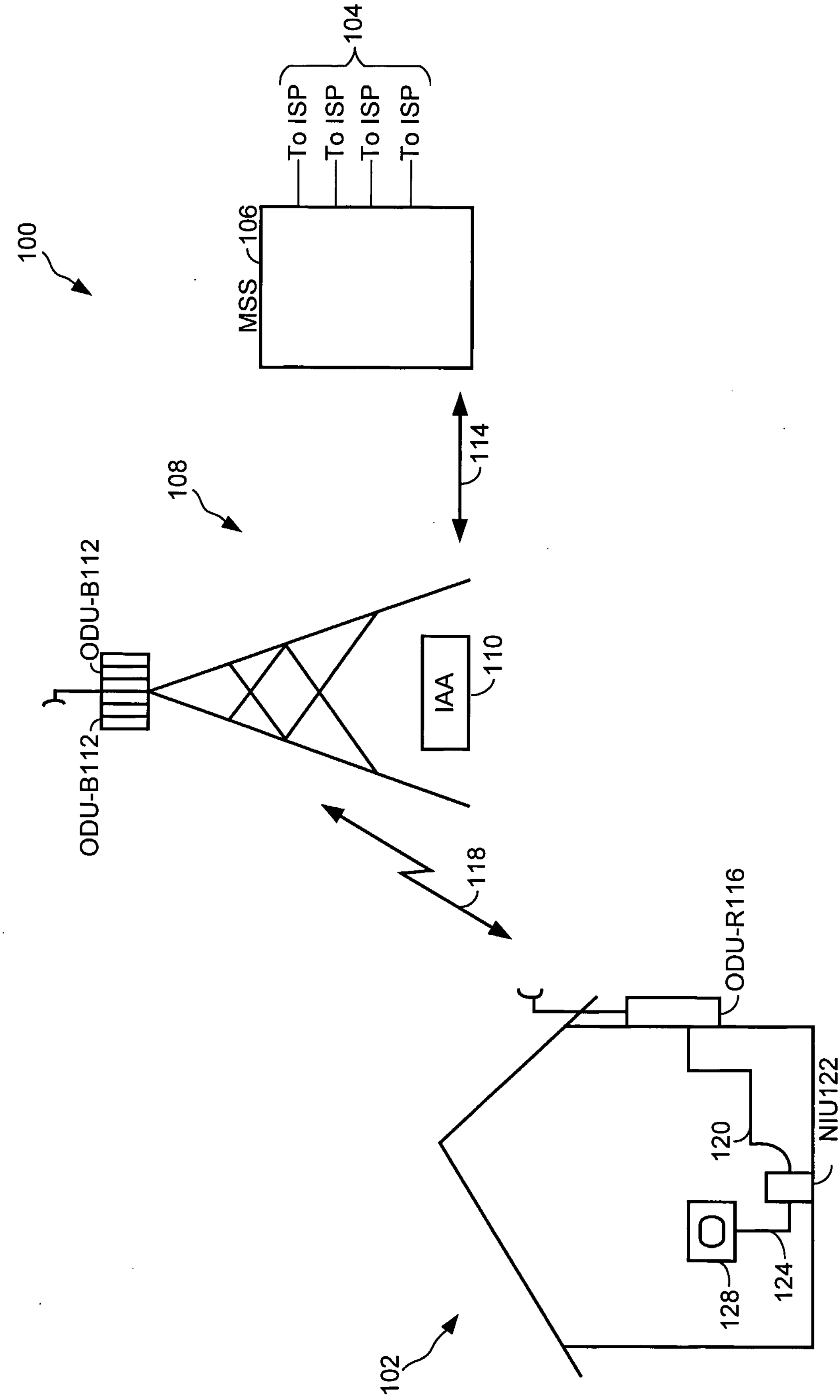

100
To ISP
To ISP
To ISP
To ISP
104
MSS
106
108
114
ODU-B112
ODU-B112
IAA
110
118
ODU-R116
NIU122
120
124
128
102

Fig.1a

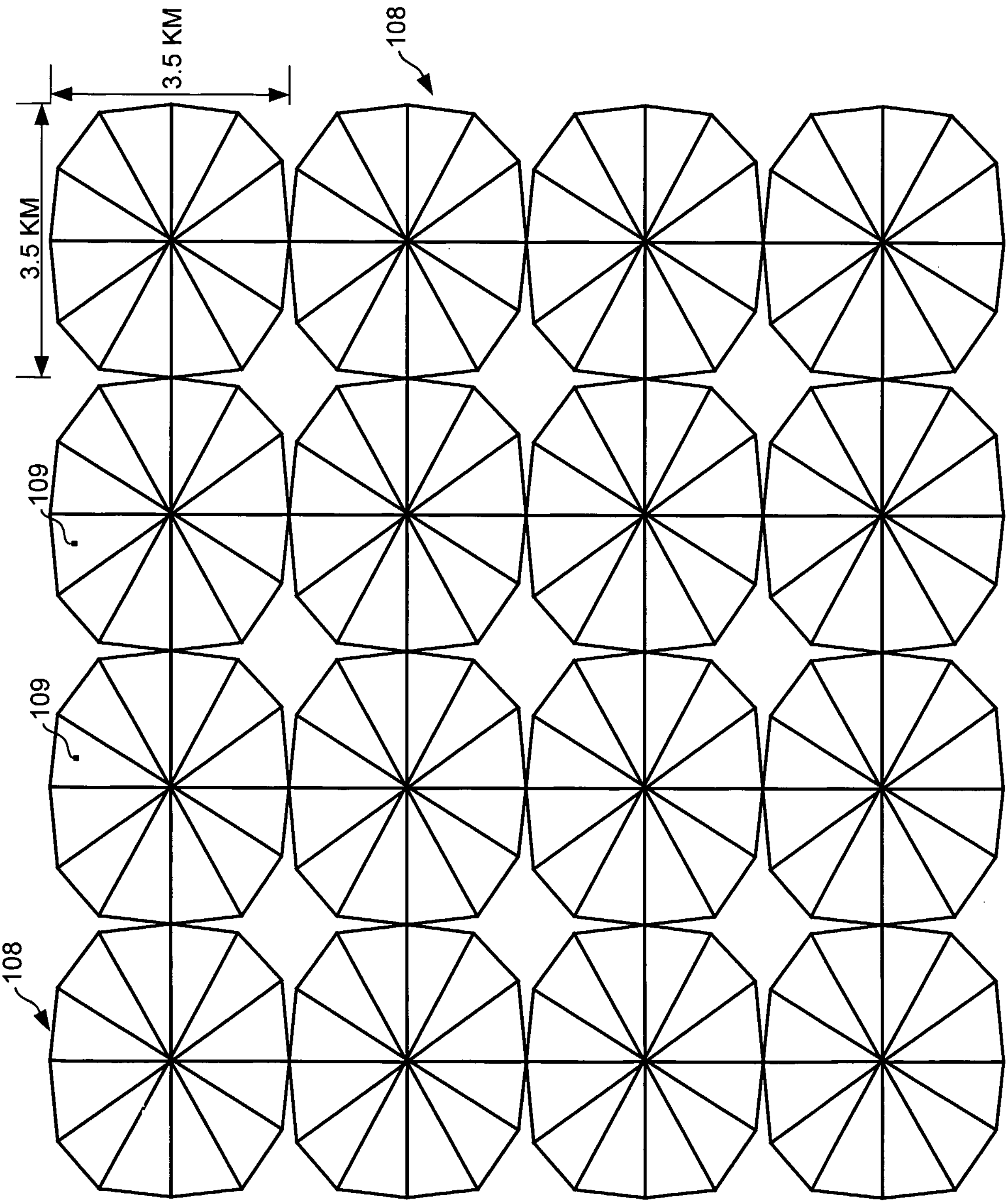


Fig.1b

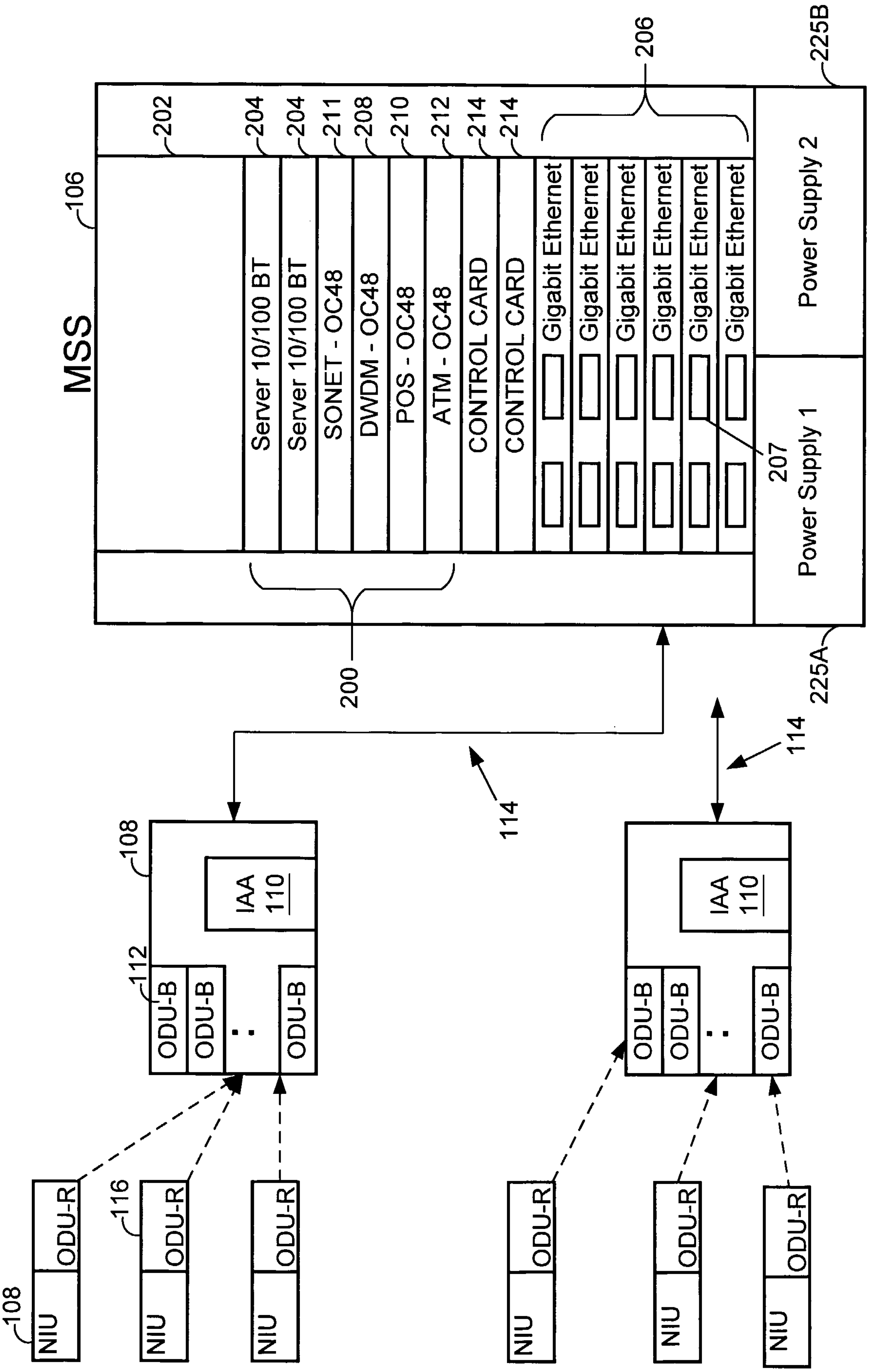
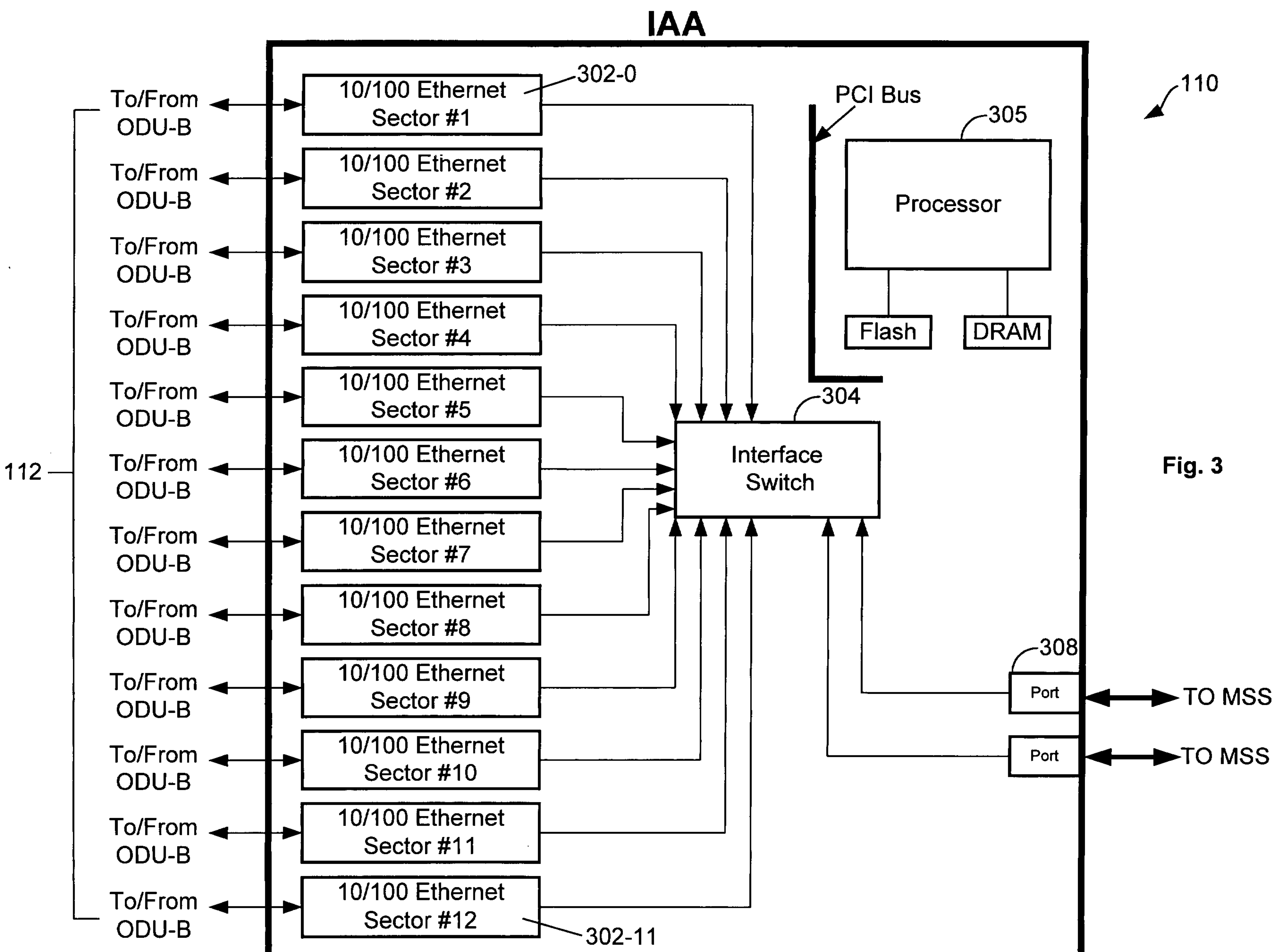

MSS
106
202
204
204
211
208
210
212
214
214
206
225B
Server 10/100 BT
Server 10/100 BT
SONET - OC48
DWDM - OC48
POS - OC48
ATM - OC48
CONTROL CARD
CONTROL CARD
Gigabit Ethernet
Gigabit Ethernet
Gigabit Ethernet
Gigabit Ethernet
Gigabit Ethernet
Gigabit Ethernet
207
Power Supply 1
Power Supply 2
200
225A
114
114
108
112
ODU-B
ODU-B
ODU-B
IAA
110
ODU-B
ODU-B
ODU-B
IAA
110
108
116
NIU
ODU-R
NIU
ODU-R
NIU
ODU-R
NIU
ODU-R
NIU
ODU-R
NIU
ODU-R

Fig. 2


IAA
110
PCI Bus
305
Processor
Flash
DRAM
302-0
10/100 Ethernet Sector #1
10/100 Ethernet Sector #2
10/100 Ethernet Sector #3
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10/100 Ethernet Sector #5
10/100 Ethernet Sector #6
10/100 Ethernet Sector #7
10/100 Ethernet Sector #8
10/100 Ethernet Sector #9
10/100 Ethernet Sector #10
10/100 Ethernet Sector #11
10/100 Ethernet Sector #12
302-11
304
Interface Switch
308
Port
Port
TO MSS
TO MSS
To/From ODU-B
To/From ODU-B
To/From ODU-B
To/From ODU-B
To/From ODU-B
To/From ODU-B
To/From ODU-B
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To/From ODU-B
To/From ODU-B
To/From ODU-B
112

Fig. 3

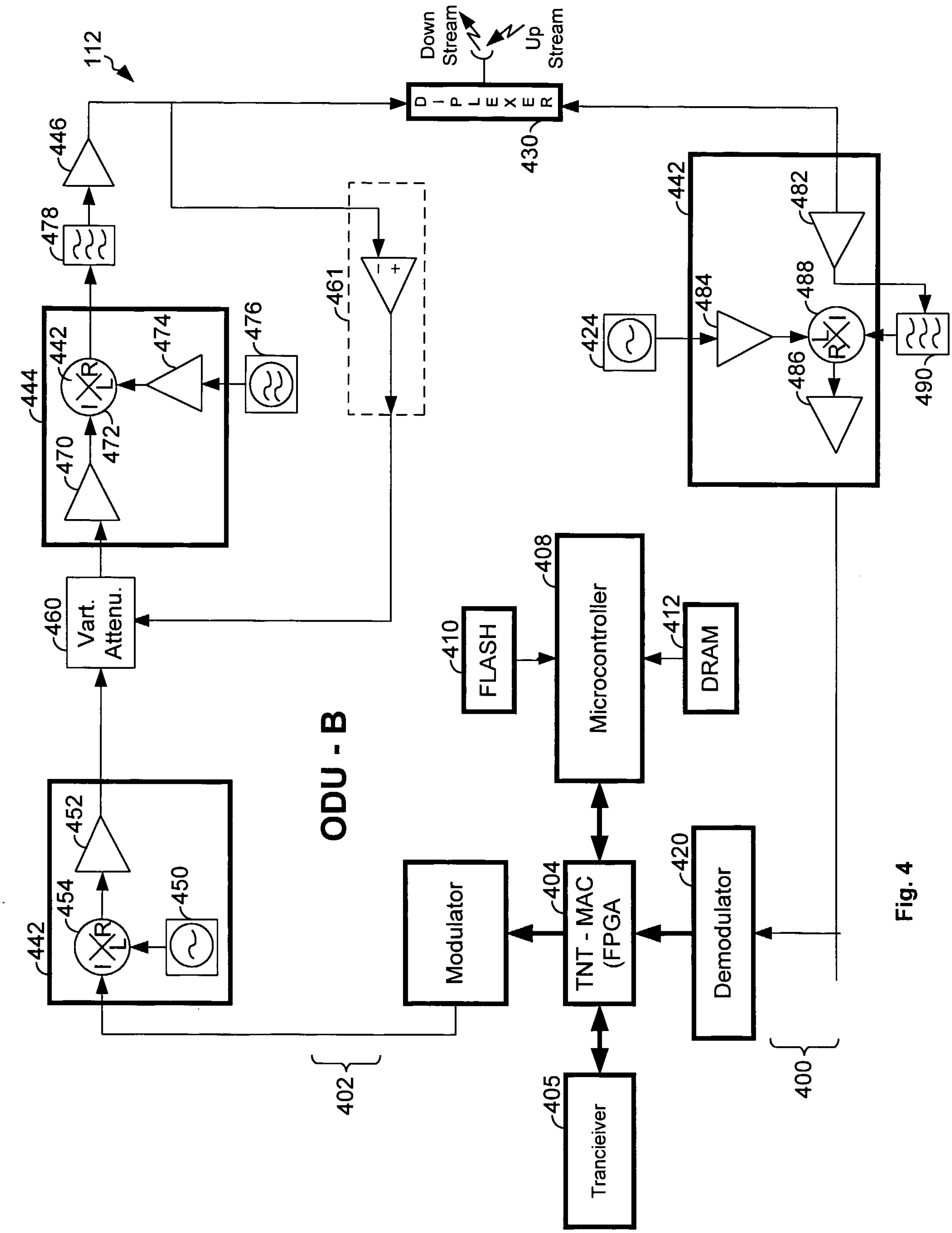
112
Down Stream
Up Stream
D I P L E X E R
430
446
478
444
442
470
472
474
476
I R L
461
- +
460
Vart. Attenu.
442
452
454
450
ODU - B
410
FLASH
408
Microcontroller
412
DRAM
Modulator
404
TNT - MAC (FPGA
420
Demodulator
405
Tranceiver
402
400
442
482
484
424
488
486
490

Fig. 4

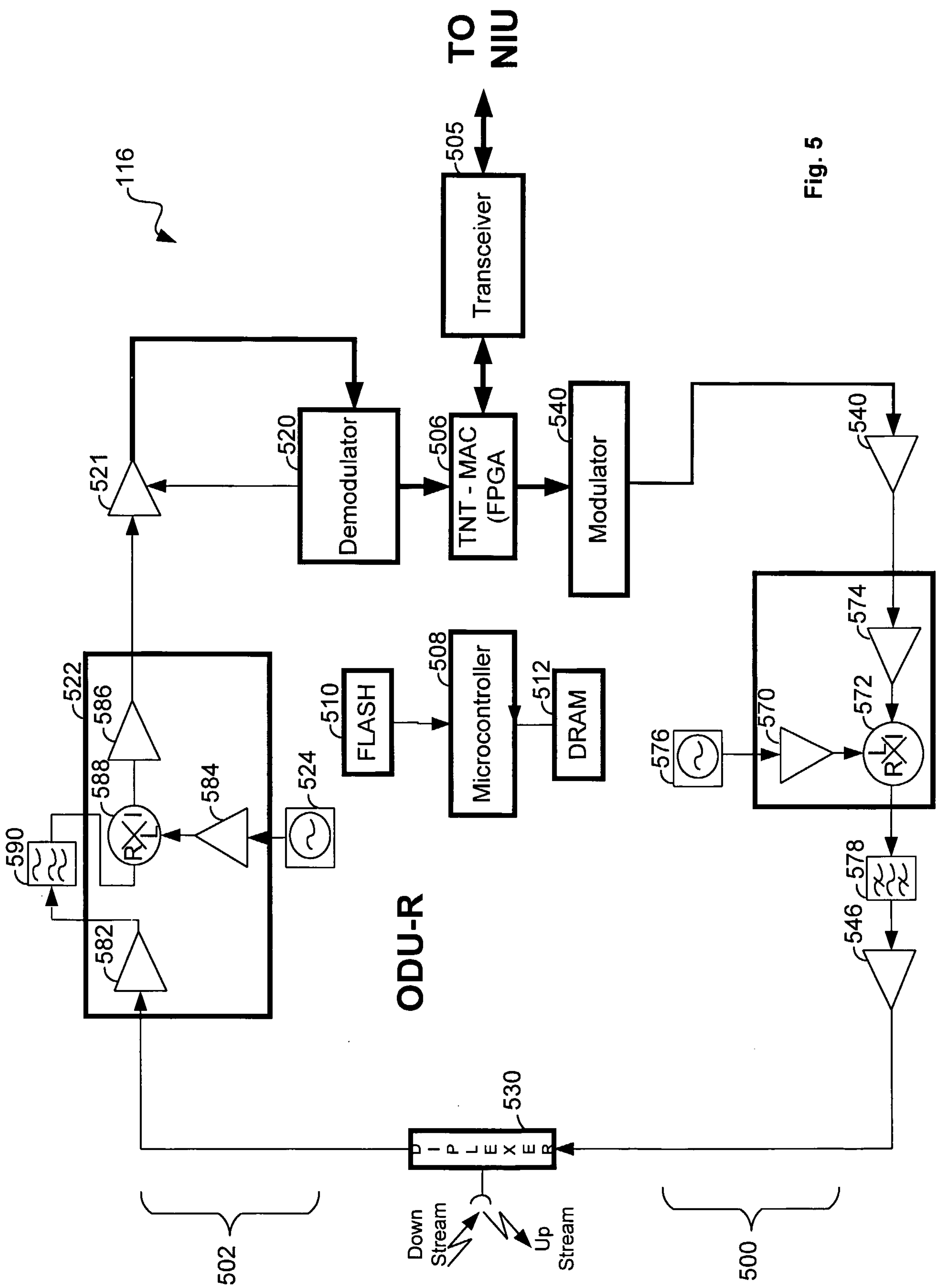
TO NIU
116
505
Transceiver
506
TNT - MAC (FPGA
520
Demodulator
540
Modulator
521
522
586
588
590
584
524
510
FLASH
508
Microcontroller
512
DRAM
576
570
572
574
578
546
582
ODU-R
530
DIPLEXER
Down Stream
Up Stream
502
500

Fig. 5

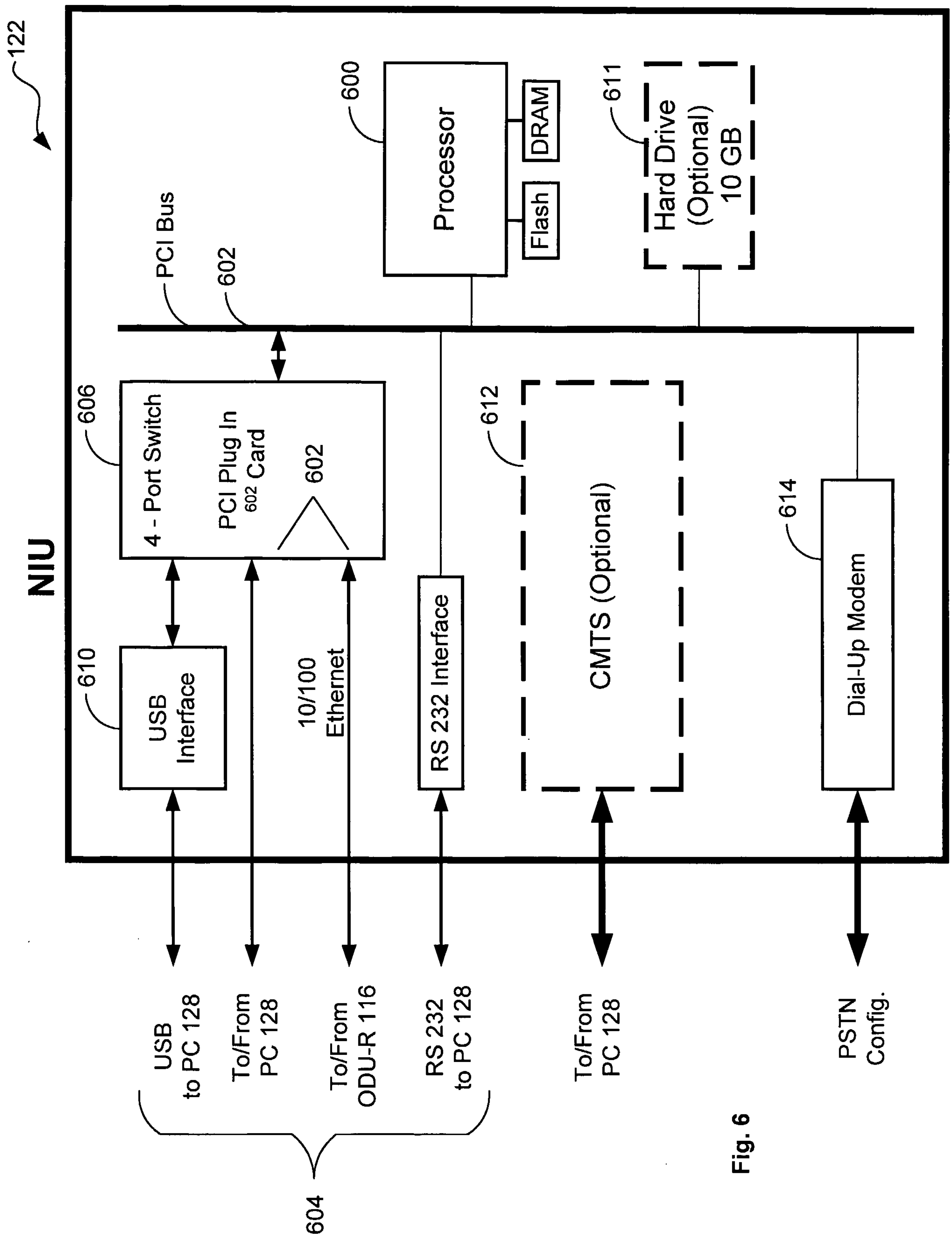
122
NIU
PCI Bus
602
600
Processor
Flash
DRAM
611
Hard Drive
(Optional)
10 GB
606
4 - Port Switch
PCI Plug In
602 Card
602
610
USB
Interface
10/100
Ethernet
RS 232 Interface
612
CMTS (Optional)
614
Dial-Up Modem
USB
to PC 128
To/From
PC 128
To/From
ODU-R 116
RS 232
to PC 128
To/From
PC 128
PSTN
Config.
604

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/05158

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04Q 7/24; HO4L 12/43
US CL : 370/338, 461
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. : 370/338, 401, 458, 459, 460, 461, 450, 487, 490

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)

EAST
search terms: token, wireless

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US 6,108,314 A (JONES ET AL) 22 August 2000, Fig. 1, col. 2, lines 53-59, col. 4, lines 12-14, 36-38.	1-7,9,13,16-22,24,25,27
Y,P	US 6,034,966 A (OTA) 07 March 2000, Fig. 10, col. 8, lines 47-50, col. 5, lines 35-37, 48-53.	1-7,9,13,16-22,24,25,27
Y	US 5,301,333 A (LEE) 05 April 1994, col. 3, lines 15-25.	8
Y	US 6,067,319 A (COPELAND) 23 May 2000, col. 2, lines 8-12, col. 4, lines 44-55.	26

☐ 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

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"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

26 MARCH 2001

Date of mailing of the international search report

14 JUN 2001

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