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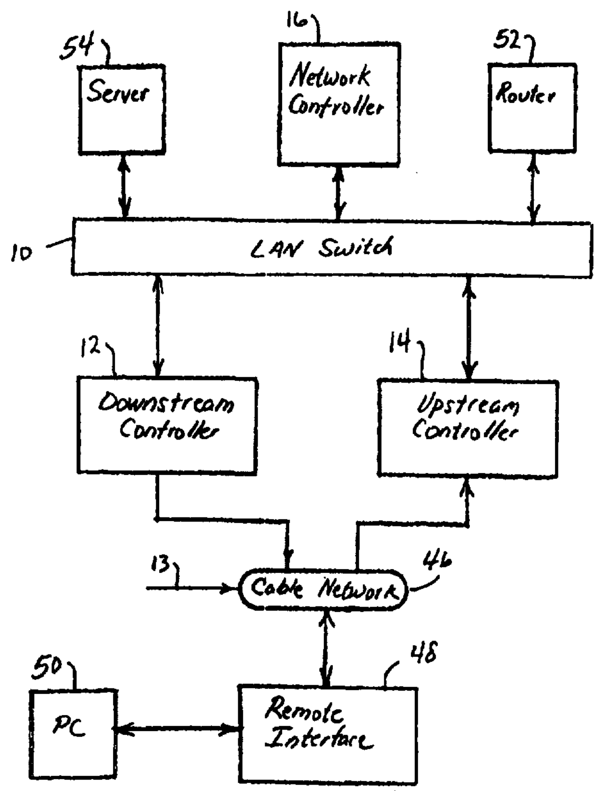
(57) Abstract

An asymmetric network communication system including independently configurable remote devices (48), downstream controllers (12) and upstream controllers (14). Routing tables associated with the controllers (12, 14) and remote devices (48) are maintained in a network manager (16) which define dataflow groups in both the upstream and downstream paths. Configuration parameters in the routing tables configure the system for transfer of digital data through multiple broadband downstream channels and selected return channels over diverse media, including telephone, router (52), wireless and cable. The downstream media include CATV, satellite and wireless broadcasts. A PoP LAN switch (10) provides physical and link layer connections between the network manager (16) and respective upstream and downstream controllers (14, 12). Configuration may be dynamically altered depending on traffic conditions, bandwidth demand and availability, operability of channels and faults detected in the system.



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BROADBAND COMMUNICATION SYSTEM FOR HIGH-SPEED INTERNET ACCESS

CROSS REFERENCE TO RELATED PATENTS AND PATENT APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/025,651 filed Sept. 9, 1996 titled "Broadband Communication System for a High-Speed Internet Access System" and, by virtue of incorporating the subject matter of allowed co-pending application No. 08/378,588 filed January 18, 1996 titled "Hybrid Access System Having Asymmetric Operating, Channel Allocating and Prioritized Polling Schemes" (which is incorporated by reference herein and which, in turn, is a divisional application of application no. 08/426,920 filed April 21, 1995 titled "Asymmetric Hybrid Access System and Method" (now U.S. Patent 5,586,121)), is a continuation-in-part of such prior filed nonprovisional application.

This invention is also related to United States patents 5,347,304 title "Remote Link Adapter for Use in TV Broadcast Data Transmission System" which issued on Sept. 13, 1994 in the name of Eduardo J. Moura and James C. Long for which allowed reissue application 08/340,733 was filed November 16, 1994.

This invention is also related to co-pending application no. 08/899,883 filed July 24, 1997 titled "High-Speed Internet Access System" which claims the benefit of Provisional Application No. 60/022,644 filed July 25, 1996 and which is also incorporated herein by reference.

FIELD OF THE INVENTION

This invention pertains to a arrangement of components and configuration of independently scalable components of an asymmetric network communication system. More specifically, this invention pertains to an arrangement for providing bandwidth management through configurable dataflow groups and configuration control of multiple remote devices and independently scalable upstream and downstream controllers of such an asymmetric network.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the invention, an asymmetric network for providing to a communication between a server and a plurality of remote devices comprises a central routing or switching hub that establishes communication between a network manager and independent upstream and downstream switching or routing devices. The downstream switching/routing device provides multiple high-speed communication channels in pre-configured dataflow groups that convey digital information between a server and remote devices. The upstream routing/switching device provides multiple communication channels that convey digital information from the remote devices to the server also in pre-configured dataflow groups. The network manager also provides a user interface for configuring the respective upstream and downstream controllers, or for diagnosing faults, adding or editing user profiles and/or monitoring communication processes.

In a further aspect of the invention, the remote devices are also configurable at behest of the network manager to assume various communication modes or states of operation including configuration setting, channel assignment, idle, active or other operational states. In addition, the upstream and downstream controllers collect traffic statistics which provide a basis for the network manager to improve bandwidth efficiency and/or to effect corrective action in the event of failed or impaired communications.

These and other aspects of the invention are pointed out with particularity by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a simplified functional block diagram of the inventive asymmetric network system.

Fig. 2 is a detailed functional block diagram of a cable-return asymmetric network system.

Fig. 3 is a detailed functional block diagram of a telephone-return asymmetric network system.

Fig. 4 is a detailed functional block diagram of a router-return asymmetric network system.

Fig. 5 depicts components of the return path of a direct-connection between a remote device and the PoP.

Fig. 6 depicts components of the return path in a router-return asymmetric network system.

Fig. 7 shows an exemplary definition of data flow groups in the upstream and downstream paths of an asymmetric network system.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Fig. 1 shows the invention in simplified form wherein a PoP LAN switch 10 provides link layer or physical interconnection between and among network controller 16, downstream controller 12 and upstream controller 14. Controller 16 maintains routing tables that define upstream and downstream dataflow groups associated with data communications between remote devices 48 (only one shown) that connect in parallel to respective fiber nodes and servers 54 (only one shown) through associated groups of fiber nodes in cable network 46. Remote servers in communication with the Internet may be accessed via router 52 which couples PoP LAN Switch 10. Cable network 46 also carries conventional televisions signals 13 for distribution to the remote interfaces 48. The television signals are branched off the interface 48 and supplied to conventional television sets (not shown). This invention also contemplates use of a wireless broadcast facility in place of cable network 46. Interface 48 provides bi-directional communication of data signals between PC 50 and servers 54 through the asymmetric network. Controller 14 provides medium access control over an upstream control channel and controller 12 provides multiple bands with a TV or other channel for carrying broadband downstream traffic. Details of paths and components in the asymmetric network are subsequently described.

Figure 2 depicts a preferred arrangement of network components of an asymmetric network system 8 wherein a hub 10 interconnects a downstream controller 12, upstream controller 14 and a network manager 16 at the network layer, link or physical layer (using the OSI model). Data from the Internet or a local content server 54 is routed through the hub 10, and is converted from digital Ethernet packets to an intermediate frequency signal and then to radio frequency signals for transmission over a CATV system or other broadcast system. The present commercial embodiment of the network supports up to 2500 subscribers, and due to its modularity, may be configured to support up to 20,000 subscribers in a typical CATV installation or a MMDS or other wireless broadcast facility. Supported communication protocols between the subscriber's remote devices, on one hand, and independent upstream and downstream controllers, on the other hand, include

ATM, IP, TCP, UDP, ARP, RIP and DNS or proprietary protocols. Hub 10 preferably comprises an Ethernet FastSwitch 10/100 Mbps which is an industry standard multi-gated bit backplane switching hub that interfaces modules for Ethernet, fast ethernet, TCP/IP routing, T-1, CSU/DSU and ATM SONET. Hub 10 can also serve as a bridge to provide a single high bandwidth Ethernet fabric (or ATM-based switch) that connects all routing/switching devices, servers and the network manager in the asymmetric network system 8. Communication paths between these respective devices are established at a network layer or lower to permit fast, efficient data transfer and flow control.

The asymmetric network system 8 provided by the components of Fig. 2 are co-located with an information distribution facility, such as a cable TV headend facility or an MMDS or wireless broadcast facility. The asymmetric network system, however, may be co-located with any type of central data distribution facility.

The network management system 8 may be configured for return-on-cable (Fig. 2), return-on-phone (Fig. 3) or IP router return operation (Fig. 4) for upstream communication. Other return path schemes, e.g., twisted-wire pair, coaxial cable, T1, RF point-to-point or RF broadcast, optical fiber, etc. are envisioned. Shared media for downstream communications with said remote devices include CATV networks, wireless broadcast networks (including MMDS, MDS, ITFS and other FCC approved bands), direct broadcast satellite networks, over-the air broadcasts, coaxial cable, optical fiber and the like. Protocols for upstream and downstream communications include IP, ATM, proprietary and other protocols.

In the present commercial embodiment, switching/routing hub 10 comprises a multi-giga bit backplane switching hub that accommodates twenty-five 10 Mbps Ethernet ports and one high-speed expansion module delivering eight 100 Mbps Ethernet ports. A second high-speed expansion slot thereof is configurable to interface with 100baseFX, FDDI or ATM.

The network manager 16, which comprises a Sun Microsystems Sparc5 installation, operates to configure the mode of operation of downstream controller 12, the upstream controller 14 and remote interface device 48 (e.g., client cable modem). Remote interface 48 may accommodate plural PC devices 50 respectively identified via subnet addresses. Remote interface device 48 is pre-configured to register a specific downstream frequency upon shipment to a customer site. In addition, the network manager 16 serves as a user interface for the upstream and downstream controllers 12,14. In addition to issuing configuration commands to the remote interface device 48, the network manager also effects trickle loading of the cable modems' network operating software (NOS). In this fashion, network operating software at the remote devices 48 may be kept current to reflect changes or upgrades to network operating software.

NETWORK MANAGEMENT SYSTEM

The network manager 16 includes routing tables for all subscribers (e.g., PCs 50) within its domain. Network operating software continues to maintain an update of the routing tables for incoming and outgoing traffic according to dynamic traffic and other operational conditions within the asymmetric network system. The primary task to be performed by the network manager 16 is to route and modulate/demodulate data. In addition, the network manager is responsible for all upstream and downstream variable parameters, such as, control of Ethernet host communications and overall dataflow. Control, in part, is exercised through the upstream and downstream controllers.

The signal carrying digital data must be upconverted for transportation over the cable network system 46, and demodulated at the remote site 48. Likewise, data sent upstream from remote site 48 must be modulated into RF signals when transmitted over a coaxial cable system 46 or 47 (Figs. 1, 2 and 3), or modulated into analog signals for transmission over a PSTN (Fig. 3).

Data that is transmitted over a common physical hardware, e.g., within the same virtual headend, and at the same frequency is characterized as belonging to a dataflow group. Each subscriber PC 50, upon establishing an account, is assigned to a downstream dataflow group as well as an upstream dataflow group. For each PoP that includes an asymmetric network system, at least one downstream and one upstream dataflow group must be defined. Additional dataflow groups can be designed depending on the desired dataflow design and the number of cable/wireless plant and upstream transmission options supported. Each dataflow group corresponds to a fiber node group.

Typically, one fiber node in a cable plant serves a neighborhood of 300 to 500 users. Fiber nodes transmitting downstream data on the same frequency are grouped together and are defined as a downstream fiber node group. Multiple downstream frequencies can be assigned to a group of fiber nodes. Associations are made by assigning the downstream fiber node group to a downstream dataflow group. Dataflow groups effectively characterized the flow of data on the downstream and upstream paths from router to fiber node and back again. Data flow groups are used to facilitate the assignment of configuration parameters to a number of logical entities. Based on the assignments made, such as the downstream frequency, values are assigned in configuring remote devices 48 upon initial account setup. All downstream paths are routed over the fiber/coaxial cable TV network to obtain maximum transmission speeds possible.

A Virtual Headend is a logical entity comprised of one or more upstream or downstream controllers, as well as, the cable or wireless headend equipment located at the PoP. Configuration parameters for each virtual headend include channel plan type, identity of downstream controllers, identity of upstream controllers and a parameter indicating whether or not to time-stamp all messages. Channel plans include HRC, IRC and standard. These determine the set of downstream frequencies which the cable headend can transmit. Downstream frequencies are associated with channels within a frequency plan. Specification of the channel plan type provides a means for auto-computing the downstream frequencies from selected channel and subchannels based on common lookup tables. The channel plan selected is used automatically to compute the downstream carrier frequency from the specified channel number for each downstream dataflow group.

Physical fiber node groups (Fig. 7) are used to transmit and/or receive RF data. Parameters that define their attributes include fiber node name, minimum transmit level, maximum transmit level and normal transmit level. The same physical fiber node is used throughout both upstream and downstream data over a two-way cable system. Typically, one fiber node serves a neighborhood of 300 to 500 subscribers, as illustrated in Fig. 7. For each group of fiber nodes 60-70 (Fig. 7) used to transmit data on the same downstream frequency, the downstream fiber node group is defined. The physical fiber nodes transmitting downstream at the same frequency are assigned to a particular group. Multiple downstream frequencies can be transmitted by one or more fiber nodes. This is accomplished by assigning the fiber node to more than one downstream fiber node group and then assigning more than one "downstream dataflow group" to each of the several "downstream fiber note groups".

A hybrid installation protocol operating in network manager 16 automatically configures remote interface devices 48. Typically, remote device 48 is configured to receive downstream broadcast on a specific downstream frequency. This frequency corresponds to the downstream frequency assigned to frequency set for the downstream dataflow flow group to which the subscriber is assigned. In general, the remote devices 48 are pre-configured prior to shipment or installation at the user's site. Through a user interface to the network controller 16, a system administrator assigns specific downstream upstream dataflow groups to respective subscribers. Such assignment initiates a broadcast polling for specified accounts or subscribers. During initial setup by the system administrator, configuration files based on subscriber supplied data are stored in PoP file directories along with other information. Typical setup templates defining parameters for respective subscribers include an account name, an IP address, a local Ethernet address, an IN channel Ethernet address, a network server IP address, downstream frequency and IP addresses of nodes for remote interface devices 48.

DOWNSTREAM CONTROLLER

The downstream controller 12 comprises a rack-mounted PCI-bus microcomputer running under a UNIX operating system. It functions to route or switch high-speed data from a server 54 to PC devices 50. By routing, we mean to include switching and bridging, as well. Routing may be achieved by conveying an information packet to a destination in accordance with an address, such as an ATM, IP or Ethernet address, or in accordance with a switching path that is defined by an ATM or other protocol. Server 54 includes local servers as well as remote servers, i.e., servers located at a site remote from the facility of switching hub 10. In the preferred commercial embodiment, downstream controller 12 provides dataflow groups each comprising three 10 Mbps data channels in the downstream direction. Each such data channel occupies approximately 2 MHz of bandwidth so that the three channels themselves occupy an entire television channel of approximately 6 MHz. Under the European standard, the dataflow groups may comprise four 2 MHz channels each having a capacity of 10 Mbps for a total bandwidth consumption of one 8 MHz TV channel. Preferably, the downstream controller uses dual serial interface cards 12c and 12d that respectively supply corresponding modulators 12a and 12b.

The serial interface (SIF) cards 12c and 12d receive high-speed serial bit streams of data from an interface card 12e, e.g., a PRO/100 LAN card that is commercially available from Intel. The serial interface card 12e interfaces the downstream controller 12 and routing/switching hub 10. It also provides three channels to the 64QAM modulation cards of 10 Mbps each. The network manager 16 may effect assignment of the same or three different downstream frequencies to each SIF having downstream channel. The modulators 12a and 12b are marketed by General Instruments under the trade name Digicypher and provide 64QAM modulation in the downstream path. These 64QAM modulation cards generate three channels of 10 Mbps each in the downstream path wherein each channel occupies 2 MHz of bandwidth.

The downstream path also includes an upconverter 44 that is commercially available from the General Instruments/Jerrold. Upconverter 44 functions to translate intermediate frequency signals to channel frequencies of a standard television broadcast. A combiner 45 combines the high-speed R. F. data signal which carries digital data with standard television signals 39. Combiner 45 then forwards the combined signal to diplex filter 43. The diplex filter 43 separates the operating frequencies of upstream (5-42 MHz) from downstream (50-750 MHz) channels in a bi-directional cable network.. The downstream controller 12 preferably connects with hub 10 at the data link layer.

Remote Device Configuration

Once the node number and unique IP is known, the hybrid installation protocol engages an "address allocation and management" scheme which allocates IP addresses to the remote interface device 48, and then, associates that IP address with a unique ID of the remote device. Once configured, remote device 48 tunes to a specific downstream frequency and awaits transmission of a poll message on the downstream channel having its specific user ID. At the PC device 50, remote device 48 is configured with a downstream frequency which is the downstream frequency assigned to the interface device 48. This frequency corresponds to the downstream frequency assigned by the downstream dataflow group. When remote device 48 "hears" its own ID through the RF cable connection (or wireless broadcast reception), it notes the IP address and forces a return ICMP message from the remote device 48 which contains the factory set user ID. Remote device 48 waits for the next poll before actually sending or transmitting on the upstream channel. Thus, this message can only be transmitted if a physical upstream connection has been established. Upon verifying that the user ID is valid for the specific remote device 48, the hybrid installation protocol via a hasdb demon sends the configuration files to the remote device 48 which contain the IP address assignments made for that remote device. The remote device configuration process continues until it instructs the PoP to stop transmitting. Thereafter, the remote device then reboots itself and starts using the new newly assigned IP address. Also, remote device 48 instructs the PoP that it has been fully configured. Then, the hasdb demon terminates the configuration download process.

At this point, asymmetric network communication may be initiated between the remote PC device 50 and server 54 (or other devices). When PC 50 begins sending traffic through its Ethernet port, remote device 48 registers the transmission and attempts an upstream connection by automatically dialing up (any case other telephone return system) or optionally logging onto a dial-up router.

UPSTREAM CONTROLLER

In a preferred arrangement, the upstream controller 14 also comprises a rack-mounted PCI-bus microcomputer running under a UNIX operating system. It too is configurable by the network manager 16. When utilized in a return-on-phone arrangement, controller 14 includes add-in cards to receive analog telephone signals for generating digitized data packets. Controller 14 is preferably designed to receive up to 64 return-on-phone lines, but may include any number according to design choice. In operation, controller 14 routes or switches upstream data packets sent from the remote subscriber devices 48, and collects and stores upstream traffic statistical data. In addition to providing multiple upstream data channels, controller 14 also provides a separate control channel in the upstream link that is utilized by the remote devices 48 for establishing media access on a polling or contention basis.

The upstream controller 14, in the preferred structure, includes a set 14a of 4VSB (vestigial sideband) two-channel demodulation cards. The 4VSB demodulation cards demodulate RF signals to create digital data. These cards plug into a passive backplane of the upstream controller 14 which transmits digital data to hub 10 at 10 Mbps. As shown in Fig. 2, demodulators cards connect directly to the Ethernet Fast Switch 10. The demodulator cards support data rates of up to 100 Mbps. A 12-way splitter 53 channelizes RF signals generated by the remote devices 48 which are transmitted upstream through cable network 46, through the diplex filter 43 and which are passed on to the upconverter block 55. Remote interface devices 48 include an R. F. modem to convert upstream data from the PC device 50 to analog form in order for transmission upstream to the cable plant or information distribution plant. Cable network 46 provides two-way asymmetric communication. The upstream controller 14 also preferably connects with the hub 10 at the data link layer.

Fig. 3, a telephone return network, depicts components comparable to those of Fig. 2 wherein like numerals represent like components. The asymmetric network system of Fig. 3, however, has a telephone return network for providing upstream communications with the server. Unlike the two-way on cable system of Fig. 2, the telephone return system provides one-way communication downstream between the cable headend and remote interface device 48. A diplex filter is not utilized for separating upstream and downstream frequencies. The upstream controller 15 of the telephone return system differs as well in that controller 15 includes a bank of MP8P telephone modem demodulation cards 15a that receive modem signals from the telephone network 39. The modulation cards translate the analog signals from the telephone return modem 49 to digital data signals.

The upstream controller 15 monitors usage of each of the MP8P cards and routes data appropriately based on the extracted Ethernet packets and IP addresses. A telephone modem 49, which typically operates at 28.8 Kbps under V.32bis, is operative in conjunction with the remote interface device 48 for establishing upstream communications with a cable TV headend system. Telephone modem 49 may be integrally formed with remote device 48, or may be configured and operate separate and apart from the interface device 48, in which case, network operating software in PC device 50 coordinates the operation of the respective remote devices 48 and modem device 49 to control information flow in the upstream and downstream directions.

Fig. 4 depicts components of a router return system which are comparable to those of Fig. 3 wherein like numerals represent like components. Here, the return path includes a bridge or router 51 connected directly to an Ethernet switch linking the local PC workstations 50 to a local remote interface device 48. In this case, PC devices 50, each having unique IP addresses or other identifiers, are connected via local area network such as an Ethernet hub 51, which in turn, interconnects with remote interface device 48 via a standard 10BaseT interface. Return signals from PC device 50 are routed through the hub 51 to a standard router 56, such as an IP router, and are then forwarded to an upstream network 55 which includes a switched 56Kb ISDN or frame relay network. The upstream network 55 forwards return signals to a network router 57 which interconnects the switching/routing hub 10. Optionally, the upstream network 55 may forward return signals to other wide area networks or the Internet via connection 58. Advantageously, a router return network allows a few high-speed users to be assigned to a high-speed cable modem while leaving the connection of remainder of the users unchanged.

The upstream controller performs several functions including demodulating channels from the RF data stream delivered on the return channel; extracting 802.3 packets encapsulated in the data link layer for each channel, routing packets from the demodulators to the hub10; maintaining routing tables containing RIPs (routing information protocols); generate polling, credit and diagnostic packets that are sent to the downstream controller for downstream transmission; and generating and maintaining traffic statistics, error accounts and executing diagnostic routines.

The upstream protocol is a media access protocol for upstream CATV channels (or channels of other types of media). The preferred protocol provides for use of control messages embedded in the downstream channel transmissions along with a single upstream control channel to assign the remaining upstream channels on a demand basis. The network manager 16 effects simple polling operations to detect changes in the remote devices 48. Polling is initiated by the upstream controller which sends a message for downstream transmission via UDP datagrams.

Upstream dataflow corresponds to the flow data from the remote interface devices 48 to the PoP located at the headend or central data distribution facility.

While the downstream data is transmitted over the coaxial TV or broadcast network, upstream data may be routed back to the PoP in one of several ways including cable, RF transmission, telephone, direct connect or router. Each type of return path corresponds to a predefined upstream type. The dataflow path of each type is different, thereby requiring different parameters characterized in the PoP's routing tables by specified routing and other path-specified information. Upstream channels are allocated among remote devices 48 in a logical fiber node. Each upstream channel is assigned to a particular frequency (or time slot). This means that once a frequency (or time-slot) is occupied by a remote device 48 on a physical fiber node, then this frequency (or time-slot) becomes unavailable to other remote devices 48 on the same physical fiber node if that remote device is assigned to the same upstream dataflow group.

Upstream fiber node groups 82 (Fig. 7) are defined and labeled for each group of fiber nodes used for transmitting data on the same set of upstream frequencies. An upstream fiber node group is comprised of a group of fiber nodes, all of which transmit a set of upstream frequencies to the same interface of an upstream controller 14,15. For a cable return system, the upstream dataflow group is characterized by parameters including upstream type (e.g. cable), channel bandwidth (in kHz), Ethernet interface used upstream, upstream fiber node group frequency (in MHz) and interface indexes. Multiple upstream frequencies from several upstream fiber node groups can be combined and transmitted to a single upstream controller subject to a set of constraints. Multiple upstream frequencies from a fiber node can also be routed to different upstream controllers. Multiple upstream controllers can connect to the same fiber node group, but each one must have a distinct set of frequencies. Associations are made between upstream fiber node groups and upstream dataflow groups.

Each upstream channel is software configurable to operate at data rates ranging from 128 Kbps to 2.048 Mbps. Configuration is controlled via software selectable modulation parameters. The channel bandwidth can also be set to 100, 300 or 600 Khz which corresponds to 128, 512 and 1024 Kbps. The channel bandwidth parameter controls the total bandwidth or speed of the upstream dataflow. The Ethernet Interface Used Upstream parameter corresponds to the PRO 100 LAN interface card used throughout the digital data output from the 4VSB demodulators to the switching hub 10. The Upstream Fiber Node Group parameter is defined and labeled for each group of fiber nodes used for transmitting data on the same set of upstream frequencies. An upstream fiber node group is comprised of a group of fiber nodes, all of which transmit a set of upstream frequencies to the same interface on the upstream controller 14,15. The Frequencies parameter is pre-defined for each upstream dataflow group. The actual number of frequencies that can be processed by the upstream controller will be directly proportional to the number called 4VSB demodulators cards installed in the upstream controller 14, 15. Each card can process two signals. Failure or degradation of an upstream channel is determined by monitoring the bit error rate and signal levels at the upstream controller 14,15 and reporting status to the network manager 16. Upon detection of a failure or unacceptable degradation, a remote device session is moved to another available upstream channel frequency (or time slot) on that fiber node. The bad channel is regularly monitored for usability and recorded in a channel quality database of the network manager 16. The bad channel is made available for reassignment to another remote device 48 when it passes acceptable bit error rate and signal level criteria.

The network manager 16 also maintains a database for characterizing the return-on-telephone upstream dataflow groups. The upstream dataflow group is characterized by parameters including upstream Type (telephony return), Ethernet upstream interface, and an upstream fiber node group.

An upstream dataflow group for a direct connect return (Fig. 5) is only used for connecting a PC of a remote interface device to the PoP for purposes of troubleshooting or diagnosing system problems. In a direct connect configuration, PC 50 connects directly to PoP LAN Switch 10. The dataflow group thereof is characterized by upstream type, Ethernet upstream interface and an upstream fiber node group.

A router-return system (Fig. 6) does not require upstream controller. A direct route from PC device 50 to the server is established through the PC's remote interface 48 to the user's local router 90, and thence through the Internet cloud 92 to PoP router 52. In this situation, the dataflow group is characterized by parameters including upstream type, Ethernet upstream interface and upstream fiber node group. The upstream controller-generated messages travel downstream on a standard Ethernet-like IN channel. Once a data channel has been assigned to a remote device 48, the subscriber sends data upstream without mediation.

Upstream channels are allocated among subscribers in a logical fiber node. Each upstream channel is assigned to a particular frequency (or time slot). The usability of upstream frequency changes over time due to interference caused by extraneous energy sources. The upstream controllers 14, 15 mitigate this interference by adjusting the signal level at which the remote devices transmit and by performing background checks when a frequency is not in use. Subscriber polling is initiated by the upstream controller and/or downstream controller to determine the activity status of the upstream dataflow. The upstream controller determines when a subscriber is responding based on whether or not it receives a response within a specified time. After being polled on a downstream channel, the value specified must be greater than 24 milliseconds; typical values range between forty and sixty milliseconds.

When the PoP does not receive a valid response from a remote subscriber being polled within a specified time-out period, the PoP considers that subscriber to be non-responsive and ceases to send polling messages thereto. In the event that no upstream activity is detected after a specified number of seconds, the subscriber device 48 can be forced to release the channel. A Subscriber Active Transmit Time Period defined by the "heartbeat rate" or rate at which each client in the active state is to send active, unsolicited messages to indicate to the PoP that it is still alive and in an active state.

In the return-on-cable system, parameters characterizing subscriber polling include maximum number of upstream subscribers (default 500), polling rate (40 poles per second), polls per interval (5), minimum time between polls to subscriber (250 milliseconds), subscriber response timeout (20 milliseconds), subscriber no-polled response timeout (100 milliseconds), maximum failed subscriber responses (3), average subscriber heartbeat interval (2 seconds), subscriber' s in active timeout (five seconds), upstream controller inactive time-out for subscriber (six seconds) and status log interval (ten minutes).

Upstream frequencies are specified in units of 100 Hz. For each upstream dataflow group, the frequency value set must be unique within the allowed frequency spectrum and be separated by at least 300 kHz. For example, if an upstream dataflow group has the frequency assignment of 116000 MHz come in the nearest neighboring channel allowed for a second frequency assignment for the dataflow group is either 113000 MHz or 11900 to MHz. The same frequency values are allowed to be used again for different upstream dataflow groups. Given the maximum/minimum frequency limits and the 300 kHz delta constraint, approximately forty upstream frequencies can be defined.

The PoP will execute a valid round-robin cycle of tuning into each frequency (or time slot) that has been assigned to the fiber nodes transmitting to the upstream controller. If such specified frequencies (or time slots) are found to be non-functional due to noise or other problems, they are marked accordingly. The upstream controller no longer tunes to these frequencies, and initiates the transmission of messages to the remote devices 48 to cease transmission on these unusable frequencies.

We set forth the above embodiments as being illustrative, but not limiting, of the invention and embrace all variations as may come to those skilled in the art based on the teachings herein.

CLAIMS

1. An arrangement of components for an asymmetric communication system operative for establishing two-way communication between a server and plural remote user stations, said arrangement comprising:

a routing hub having a network or lower layer path for providing communications with said server;

a network manager in communication with said routing hub at a network or lower communication layer, said network manager including routing tables for defining dataflow groups associated with respective downstream and upstream paths;

a downstream controller in communication with said routing hub at a network layer or lower communication layer, said downstream controller being operative for transferring data to said plural remote user stations in accordance with a high-speed forward channel protocol in assigned dataflow groups of a shared medium;

an upstream controller in communication with said routing hub at a network layer or lower communication layer, said upstream controller being operative for transferring return data to said server in accordance with a return channel protocol in an assigned dataflow group of a return channel of said network; and

said downstream controller and said upstream controller being configurable by said network manager to control the flow of data through multiple channels provided by said downstream and upstream controllers.

2. The arrangement as recited in claim 1 wherein said routing hub comprises at least one of an ATM switching network and an Ethernet switch.

3. The arrangement as recited in claim 1 wherein said shared medium comprises at least one of a CATV network, an Ethernet network, a wireless broadcast network, a direct satellite broadcast network, an optical fiber network, a hybrid fiber coaxial network and a coaxial cable network and said return channel resides in a medium including at least one to a PSTN network, a router return network, a return channel of a CATV network, a return channel of a wireless broadcast network, a return channel of a direct broadcast satellite network, a return channel of an optical fiber network, a return channel of a hybrid fiber coaxial network and a return channel of a cable network.

4. The arrangement as recited in claim 3 further comprising an Internet router in communication with said routing hub for providing communication with at least one of an Internet, a wide area network and other high-speed networks.

5. The arrangement as recited in claim 1 wherein said downstream controller comprises plural high-speed downstream channels, and said network manager controls the selection of channels assigned to respective remote user stations for receiving high-speed downstream transmissions.

6. The arrangement as resided in claim 1 wherein said downstream controller is further operative for collecting and storing downstream traffic statistics relative to use and consumption of bandwidth by respective ones of said plural remote user stations.

7. The arrangement as recited in claim 6 wherein said network manager is further operable for managing an assignment of downstream channels to said remote devices respectively in accordance with statistical information collected and stored by said downstream controller.

8. The arrangement as recited in claim 7 wherein said network manager is further operative for assigning downstream bandwidth through respective ones of said plural remote user stations in accordance with a class of service assigned to said respective ones of said plural remote user stations.

9. The arrangement as recited in claim 1 wherein said upstream controller is further operative for collecting and storing upstream traffic statistics relative to use and consumption of bandwidth by respective ones of said remote user stations.

10. The arrangement as recited in claim 1 wherein said upstream controller is further operative for monitoring and storing quality of information signals transmitted by said remote user stations.

11. The arrangement as recited in claim 9 wherein said network manager is responsive to upstream traffic statistics to effect reconfiguration of at least one of said upstream controller and one of plural remote user stations thereby to increase bandwidth utilization.

12. The arrangement as recited in claim 10 wherein said network manager is responsive to set quality of information signals monitored by said upstream controller for taking corrective action in the event that quality falls below a predetermined level.

13. The arrangement as recited in claim 1 wherein said upstream controller

includes at least one control channel and plural data channels, said controll channel enabling said plural remote user stations to request access to at least one of said plural data channels.

14. The arrangement as recited in claim 12 wherein said quality of information signals includes a periodic heart beat of respective ones of said plural remote user stations, said network manager being responsive to automatically switch an upstream channel assignment of a remote user station upon cessation of reception of a periodic heartbeat thereof.

15. The arrangement as recited in claim 1 wherein said forward channel protocol of said downstream controller is operative in accordance with an ATM protocol.

16. The arrangement as recited in claim 15 wherein said return channel protocol is also operative in accordance with an ATM protocol.

17. The arrangement as recited in claim 1 wherein said forward channel protocol of said downstream controller is operative in accordance with an IP protocol.

18. The arrangement as recited in claim 17 wherein said return channel protocol is also operative in accordance with an IP protocol.

19. The arrangement as recited in claim 1 wherein at least one of said plural remote user stations includes at least one of a personal computer equipped with asymmetric communication capabilities, an Ethernet network device equipped with asymmetric communication capabilities, a routing device equipped with asymmetric communication capabilities, a switching device equipped with asymmetric communication capabilities, a bridging device equipped with asymmetric communication capabilities, an RF modem utilized in and asymmetric network configuration, a cable modem including a telephony return channel used in an asymmetric network configuration, a cable modem utilizing a CATV network for upstream and downstream communications, a wireless modem utilizing wireless forward and return communication channels, a wireless modem utilizing independent forward and return transmissions channels that operate according to different asymmetric transmission protocols, a wireless modem utilizing independent forward and return transmission channels that operates according to different modulation schemes, and a network device equipped with asymmetric communication capabilities.

20. The arrangement as recited in claim 1 wherein at least one of said remote

user stations is operative for responding to configuration commands initiated by said network manager.

21. The arrangement as recited in claim 20 wherein said remote user station includes network operating software, and said remote user station responds to commands initiated by said network manager to trickle load updated network operating software.

22. An asymmetric network system that is operative for establishing bi-directional communication between a server and at least one remote interface device, said system comprising:

a switching hub including a path for communicating with said server;

a network manager in communication with said switching hub at a network layer or lower communication layer;

an independent downstream controller in communication with said switching hub at a network layer or lower communication layer, said downstream controller being operative for transferring data to said plural remote user stations in accordance with a high-speed forward channel protocol over a shared medium;

an independent upstream controller in communication with said switching hub at a network layer or lower communication layer, said upstream controller being operative for transferring return data to said server in accordance with a return channel protocol over a return channel; and

said remote interface device, downstream controller and said upstream controller being configurable by said network manager to control the flow of data between said server and said remote interface device through multiple channels provided by said downstream and upstream controllers.

23. The system as recited in claim 22 wherein said remote interface device includes multiple states of operation and said network manager effects control of the state of operation of said remote device.

24. The system as recited in claim 23 wherein said multiple states of operation includes at least one of a transmit power setting state, an idle state, an active state.

25. The system as recited in claim 22 including multiple paths defined by said downstream controller and multiple paths defined by said upstream controller.

26. The system as recited and claim 25 wherein the speed of operation of data flow differs between at least one of each of said multiple downstream and upstream

paths.

27. The system as recited in claim 26 wherein said network manager effects a selection of speed of data flow in said upstream and downstream paths.

28. The system has recited in claim 27 wherein said selection of speed is determined in accordance with the type of data flowing between said remote device and said server.

29. A method for providing two-way communication between a server and plural remote user stations in any asymmetric network including a routing hub, a network manager, a downstream controller and an upstream controller, said method comprising:

establishing routing tables that define dataflow groups associated with respective downstream and upstream communication paths through respective fiber node groups of a CATV network;

configuring said downstream controller, said upstream controller and remote devices to establish communication between said remote device and said server in accordance with assigned data flow groups for upstream and downstream communication;

transferring data to said plural remote user stations in accordance with a high-speed forward channel protocol in assigned dataflow groups of a shared medium; and

transferring return data to said server in accordance with a return channel protocol in an assigned dataflow group of a return channel of said network.

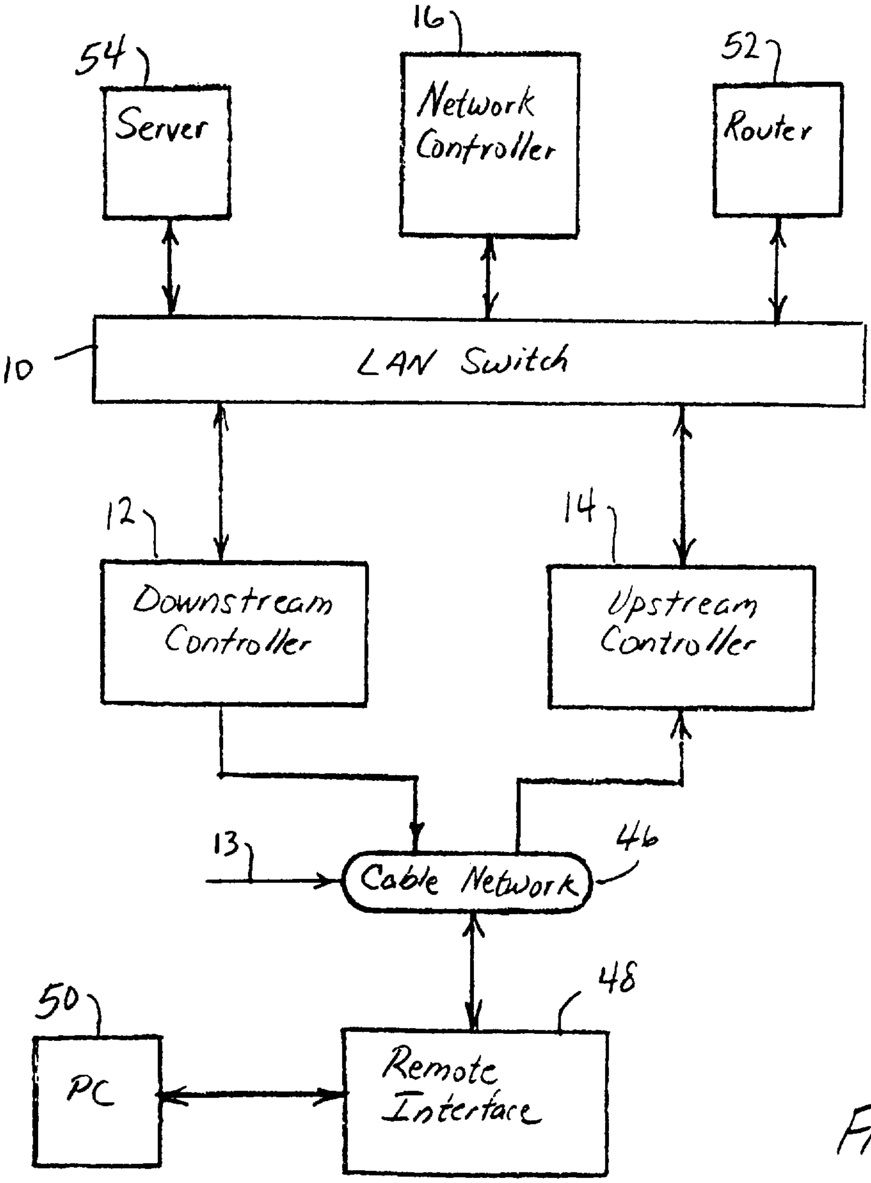

54
Server
16
Network Controller
52
Router
10
LAN Switch
12
Downstream Controller
14
Upstream Controller
13
Cable Network
46
48
50
PC
Remote Interface

Fig. 1

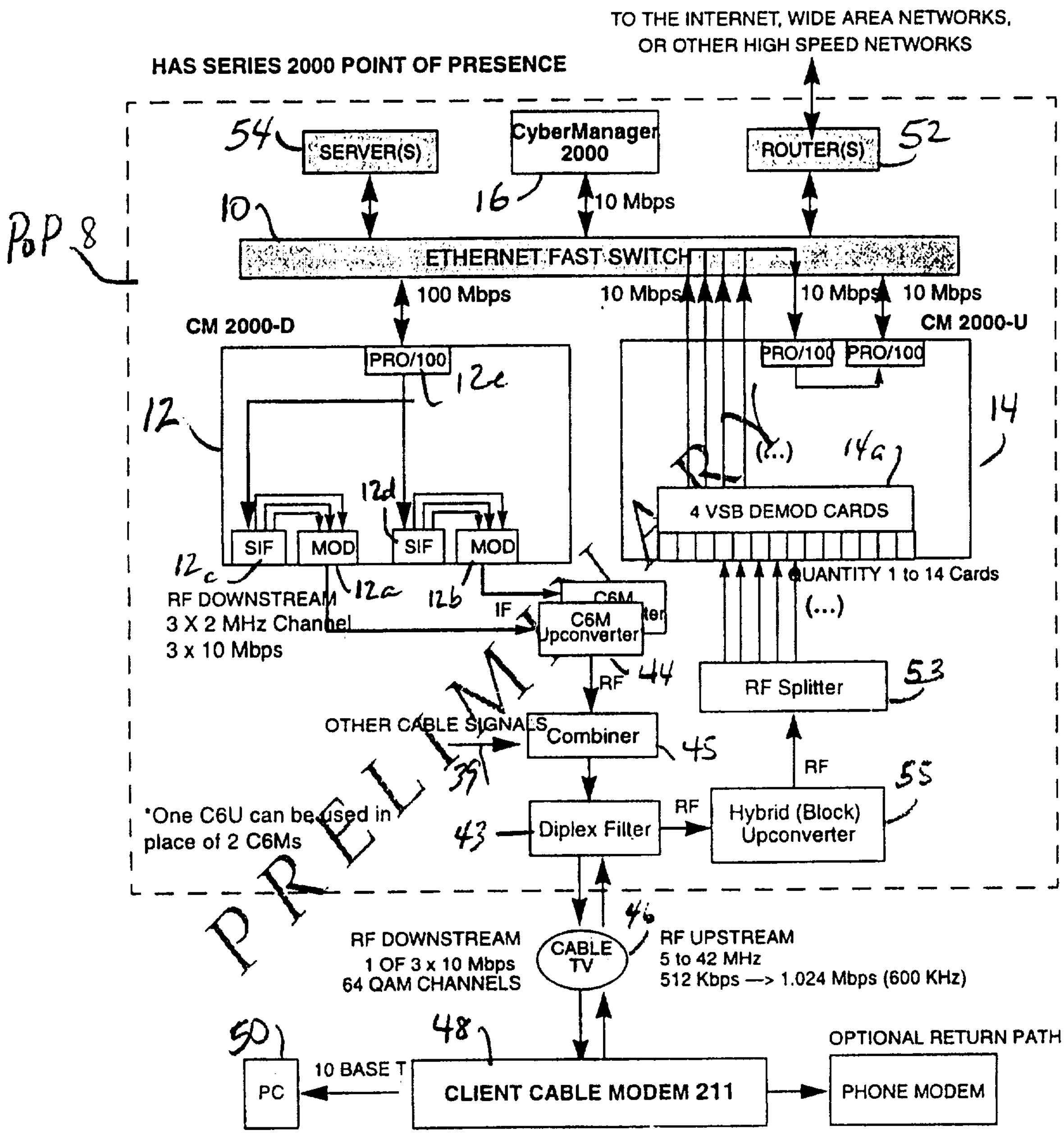


Figure 2-1 ***HAS Series 2000, Cable Return — Main System Components***

Fig 2

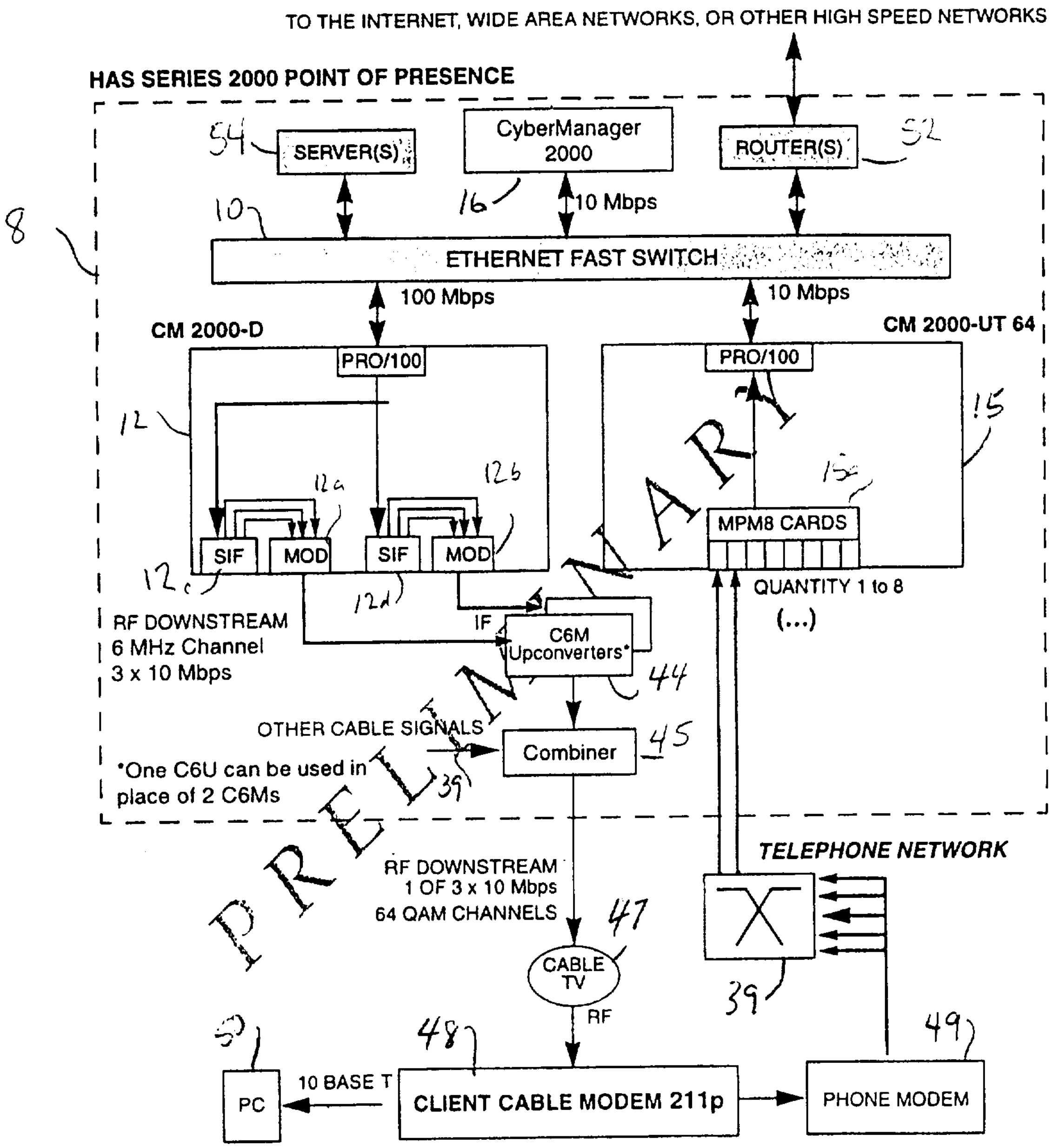


Figure 2-2 HAS Series 2000, Phone Return — Main System Components

Fig. 3

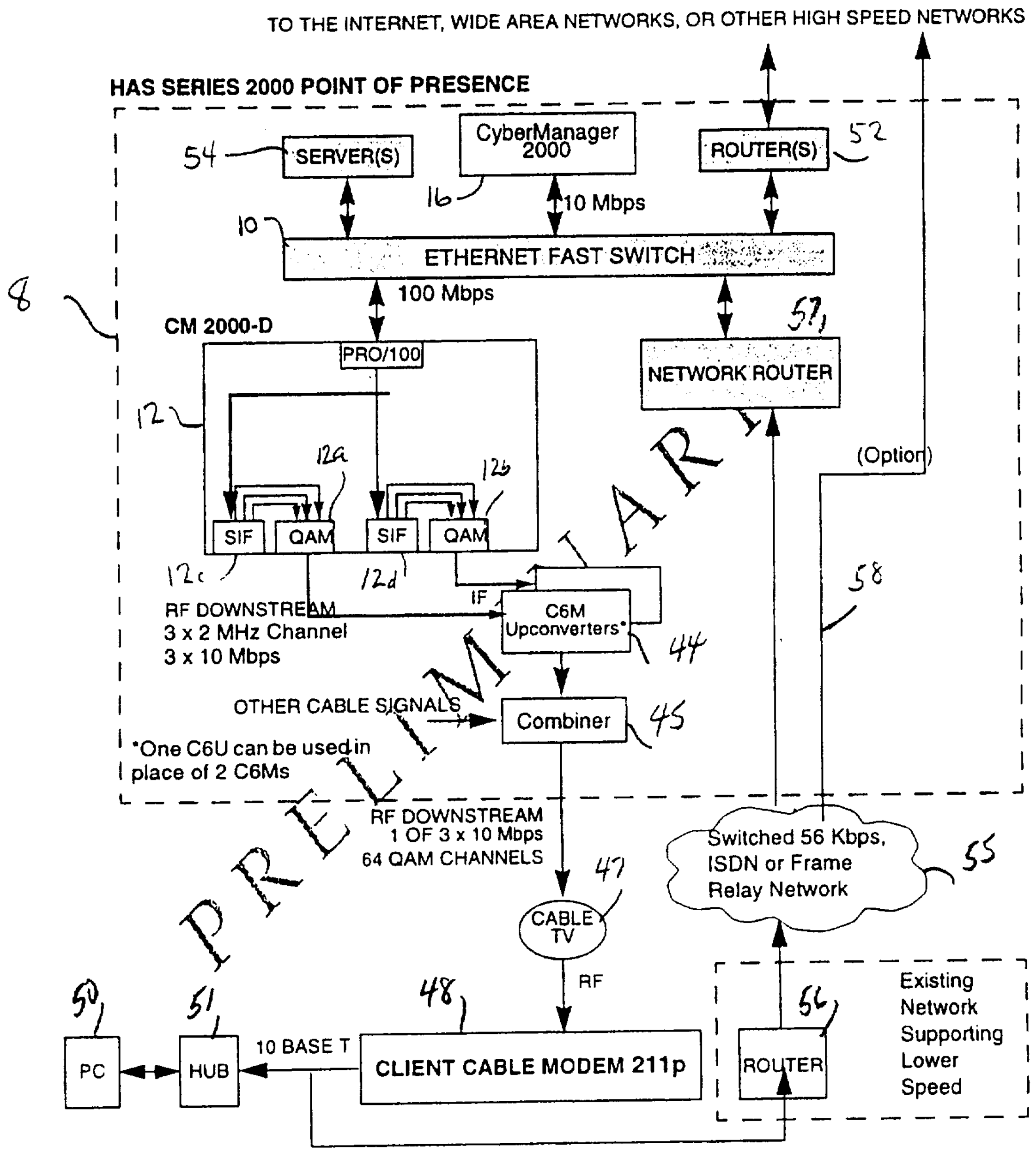


Figure 2-3 HAS Series 2000, Router Return — Main System Components

Fig. 4

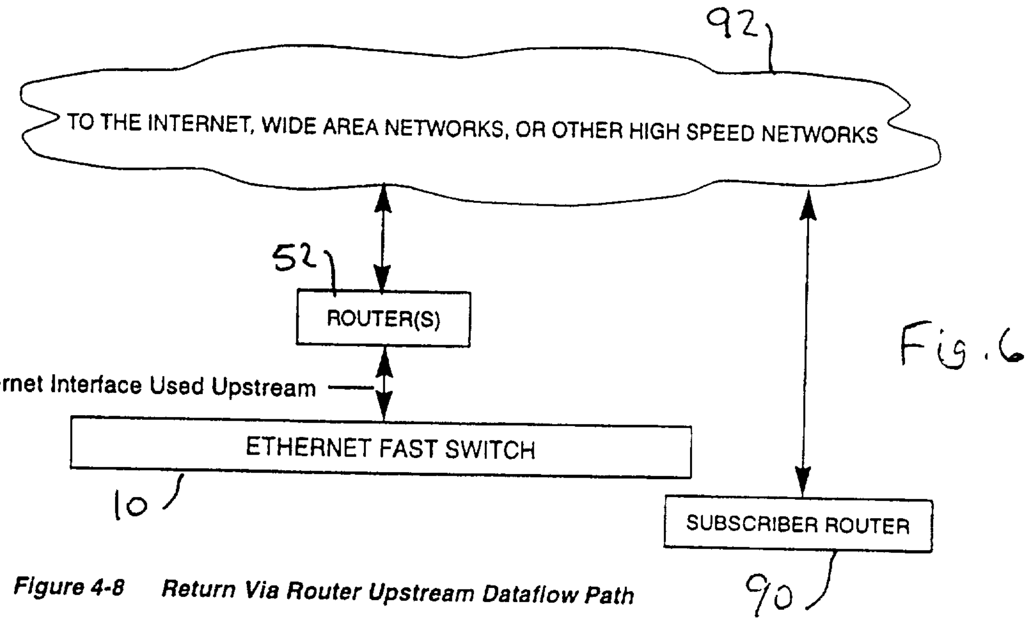


Figure 4-8 Return Via Router Upstream Dataflow Path

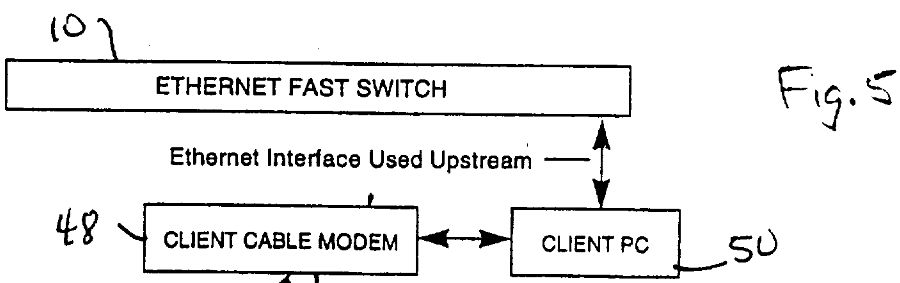
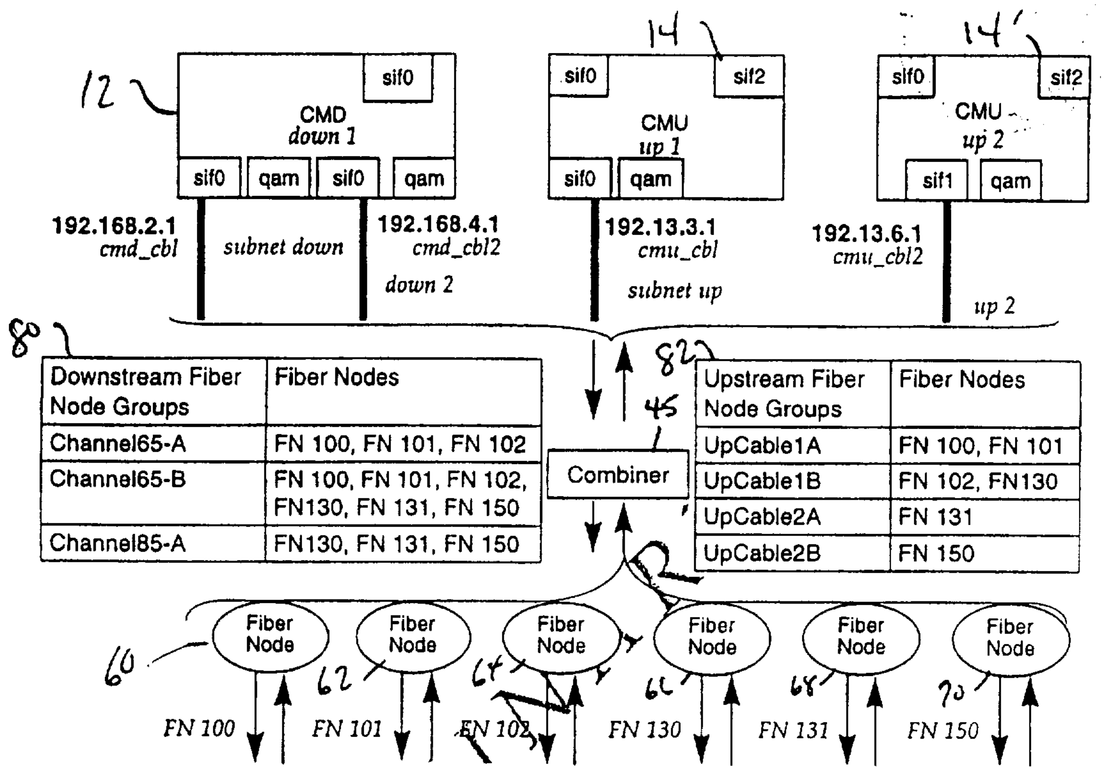


Figure 4-7 Return Via Direct Connect Upstream Dataflow Path



Downstream Fiber Node Groups	Fiber Nodes
Channel65-A	FN 100, FN 101, FN 102
Channel65-B	FN 100, FN 101, FN 102, FN130, FN 131, FN 150
Channel85-A	FN130, FN 131, FN 150

Upstream Fiber Node Groups	Fiber Nodes
UpCable1A	FN 100, FN 101
UpCable1B	FN 102, FN130
UpCable2A	FN 131
UpCable2B	FN 150

Downstream Dataflow Gp	Downstream Interface	Channel	Channel Offset (MHz)	Freq. (mHz)	Downstream Fiber Node Gp
DwnFlow65A	cmd_cbl	65	0.00	507.262	Channel65-A
DwnFlow85A	cmd_cbl2	85	0.00	121.25	Channel85-A
DwnFlow65B	cmd_cbl	65	0.0	507.262	Channel65-B

Upstream Dataflow Gp	Upstream Type	Ethernet Interface	Upstream Fiber Node Group	Frequencies (MHz)
UpFlow1A	Cable	cmu_cbl	UpCable1A	5, 11, 28, 32, 34
UpFlow1B	Cable	cmu_cbl	UpCable1B	40, 44, 48
UpFlow2A	Cable	cmu_cbl2	UpCable2A	24, 28, 32
UpFlow2B	Cable	cmu_cbl2	UpCable2B	7, 9, 11

Fig 7

Figure 4-16 Cable Return Fiber Node and Dataflow Group Assignments

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15666

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04J 3/16
US CL :370/276, 312, 404, 412, 463, 478
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. : 370/276, 312, 400, 401, 402, 403, 404, 405, 406, 407, 412, 463, 478

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: broadband, routing table

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US 5,586,121 A (MOURA et al) 17 December 1996, col. 5-10	1-29
Y,E	US 5,675,732 A (MAJETI et al) 07 October 1997, col. 1-5	1-29
A	US 5,051,982 A (BROWN et al) 24 September 1991	1-29

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

* Special categories of cited documents:
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"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
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"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	Date of mailing of the international search report
30 OCTOBER 1997	06 FEB 1998

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