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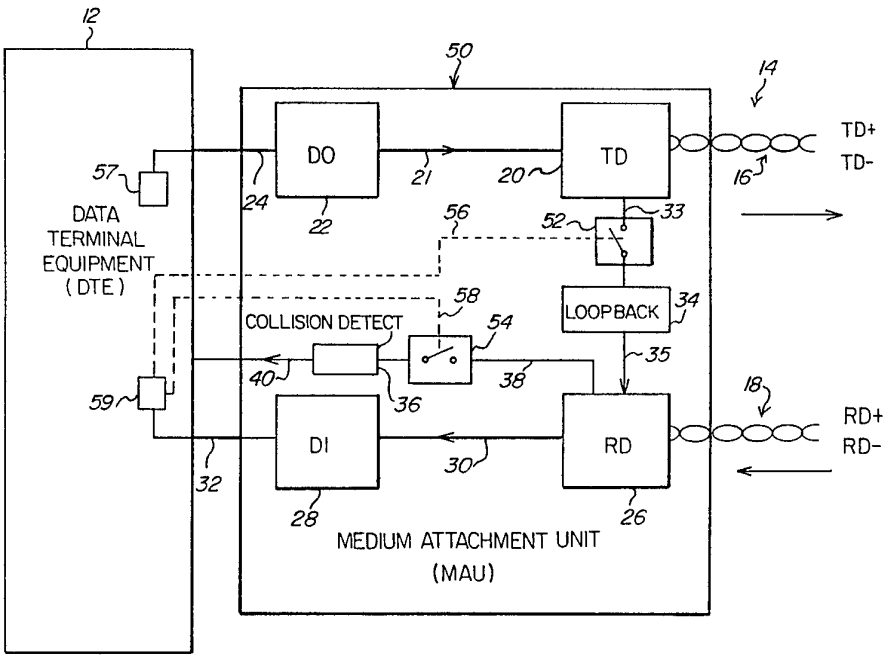
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(54) Title: FULL DUPLEX ETHERNET



(57) Abstract

A method and apparatus for providing full duplex operation of a link-based, point-to-point network that transmits signals in accordance with a carrier sense multiple access with collision detection protocol. The network may be a wide or local area network. The system includes a first data terminal equipment unit coupled to a first medium attachment unit, the first medium attachment unit including a collision detection disabling circuit (54) and a loopback disabling circuit (52) so that the first medium attachment unit provides full duplex transmission and reception of signals. The system additionally includes a second data terminal equipment unit coupled to a second medium attachment unit, the second medium attachment unit including a collision detection disabling circuit (54) and a loopback disabling circuit (52) so that the second medium attachment unit provides full duplex transmission and reception of signals.

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FULL DUPLEX ETHERNET

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of copending and commonly-owned U.S. Serial No. 07/961,184 filed October 15, 1992 by C.Oliver entitled "FULL DUPLEX ETHERNET."

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to data transmission networks. More particularly, the present invention relates to methods and apparatus for providing full duplex communication between data terminal equipment units connected to a network in a point-to-point system.

2. Discussion of the Related Art

Local area networks for connecting data terminal equipment units to each other and to Ethernet bridges or routers or combination bridge/routers to allow communication between different local area networks are becoming increasingly important. Within this disclosure, the term "data terminal equipment unit" is meant to refer to any device that can be connected to and exchange data with and over a local area network. Examples of data terminal equipment units include computer workstations, file servers, printers, modems, routers, bridges, and combination bridge/routers. With the increasing use being made of local area networks, there is an ongoing demand for increased data transmission rates (which requires a commensurate increase in bandwidth) to meet the increased performance expectations of network users.

One of the most popular local area networks is the so-called "Ethernet" local area network. Ethernet networks transmit signals on the network in accordance with a protocol

defined by ANSI/IEEE Standard 802.3, known as Carrier Sense Multiple Access with Collision Detection. Within this disclosure, the term "Ethernet" is meant to refer to any local area network that transmits signals in accordance with ANSI/IEEE Standard 802.3. Furthermore, within this disclosure, the term "signals" is meant to refer generally to information being transmitted over the network and includes, but is not limited to data packets and control signals. Although Ethernet provides a flexible, easily configurable local area network, it is only capable of transmitting signals at a data rate of 10 megabits per second in accordance with the standard. Furthermore, Ethernet is based on contention as the means by which a data terminal equipment unit acquires use of the data transmission medium. In a contention system, each data terminal equipment unit "listens" to the data transmission medium, and if no other data terminal equipment unit is transmitting data, a device can access and use the transmission medium. If two devices transmit data simultaneously, the data will collide, and both devices stop transmitting and wait a random period of time before attempting to re-transmit the data. As more data terminal equipment units attempt to use the data transmission medium, collisions tend to become more frequent and consequently the actual data transmission rate can be, in some cases, considerably less than the specified 10 megabits per second.

Currently, one way to provide more networking bandwidth for data terminal equipment units connected to a local area network is to convert the local area network to a Token Ring type network (in accordance with ANSI/IEEE Standard 802.5) that transmits signals at a data rate of 16 megabits per second or to a Fiber Distributed Data Interface (FDDI) network that transmits signals at a data rate of 100 megabits per second. Conversion to a Token Ring local area network is generally not economical because the increase in bandwidth does not justify the investment necessary to completely

change the physical installation. Furthermore, FDDI, although providing a high data transmission rate due to its large bandwidth, requires replacement of a substantial amount if not all of the hardware in the local area network and is therefore extremely expensive.

Another way to provide more effective bandwidth is to divide the network into smaller portions or segments, each segment having only a limited number of data terminal equipment units connected to a given network segment. This process is referred to as segmentation. Different network segments may be coupled together using bridges (for different networks) or routers (for the same type of networks).

Segmentation has also been used in Ethernet networks organized according to a star topology that uses a multi-port bridge/router as the center or hub of the star.

Individual data terminal equipment units are connected to the bridge/router ports via a dedicated transmission medium. The Ethernet backbone, rather than being connected to each data terminal equipment unit, is instead internal to the bridge/router, connecting the ports together. When one data terminal equipment unit transmits a signal intended for another data terminal equipment unit connected to the bridge/router, the signal is not broadcast to all of the data terminal equipment units connected to the bridge/router, but rather is transmitted only to the data terminal equipment unit that is intended to receive the particular signal. The bridge/router functions as a signal directing and distribution center. The bridge/router examines each data packet received at each port, determines its destination address, and transmits the data packet to the destination data terminal equipment unit via the port to which the destination individual data terminal equipment unit is connected. This type of network may be termed a point-to-point Ethernet network because signals are only transmitted between a data terminal equipment unit and a specified port on the bridge/router. Within this disclosure,

the term "point-to-point" network is meant to refer to a network such as an Ethernet network in which there are only two data terminal equipment units connected to a data link. Within this disclosure, the term "link-based" system is meant to refer to a network having separate transmission and reception paths, such as in a local area network. Within this disclosure, the term "bridge/router" is meant to refer to any type of data terminal equipment unit that performs this signal directing and distribution function. Examples of bridge/routers are bridges, routers, combination bridge/routers, and packet switches. Although this approach does provide more effective bandwidth over an Ethernet network that uses a repeater as the hub of the star, the connection between any one port on the bridge/router and a particular data terminal equipment unit connected to that port is still limited to the Ethernet signal transmission rate of 10 megabits per second.

Therefore, an object of the present invention is to provide a method and apparatus that allows an Ethernet network to operate with an effective signal transmission rate greater than the standard Ethernet signal transmission rate of 10 megabits per second.

Another object of the present invention is to provide a method and apparatus which allows a link based, point-to-point Ethernet network to operate at an effective signal transmission rate greater than the standard signal transmission rate of 10 megabits per second, while also remaining compatible with conventional, already-installed, Ethernet hardware and data terminal equipment units.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages of the prior art by providing a medium attachment unit providing full duplex transmission and reception of signals in a point-to-point network including means for transmitting and receiving signals in accordance with a carrier sense multiple

access with collision detection protocol and control circuitry, coupled to and controlling the means for transmitting and receiving signals, to allow simultaneous transmission and reception of signals. The control circuitry includes means for disabling a collision detection function of the medium attachment unit and means for disabling a loopback function of the medium attachment unit. The means for disabling the collision detection function and the means for disabling the loopback function may include hardware or software controlled switches.

In another embodiment of the invention, the medium attachment unit automatically determines whether a medium attachment unit connected to the network is capable of operating in the full duplex mode. The medium attachment unit comprises means for sending a signal having a first state indicative of full duplex capability and a second state indicative of half-duplex capability onto the network. The medium attachment unit further comprises a fourth circuit for receiving the signal from a medium attachment unit connected to the network, a fifth circuit, responsive to the first state of the signal, activating the first and second circuits, and a sixth circuit, responsive to the second state of the signal, deactivating the first and second circuits.

In another embodiment of the invention, a network that transmits signals in accordance with a carrier sense multiple access with collision detection protocol comprises a first data terminal equipment unit coupled to a first medium attachment unit, the first medium attachment unit including means for disabling a collision detection function of the first medium attachment unit and means for disabling a loopback function of the first medium attachment unit so that the first medium attachment unit provides full duplex transmission and reception of signals, and a second data terminal equipment unit coupled to a second medium attachment unit, the second medium attachment unit including means for disabling a collision detection function of the second medium

attachment unit and means for disabling a loopback function of a second medium attachment unit so that the second medium attachment unit provides full duplex transmission and reception of signals. The network includes a first transmission path for transmitting the signals from the first medium attachment unit to the second medium attachment unit and a second transmission path for transmitting the signals from the second medium attachment unit to the first medium attachment unit. The network may be, for example, a link-based, point-to-point local area network.

The features and advantages of the present invention will be more readily understood and apparent from the following detailed description of the invention, which should be read in conjunction with the accompanying drawings, and from the claims which appended at the end of the detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are incorporated herein by reference and in which like elements have been given like reference characters,

FIG. 1 is a functional block diagram of a medium attachment unit of the prior art;

FIG. 2 is a functional block diagram of a medium attachment unit of the present invention;

FIG. 3 is a schematic block diagram of a basic link-based, point-to-point Ethernet local area network using the medium attachment unit of FIG. 2;

FIG. 4 is a schematic block diagram of an embodiment of the invention using an Ethernet bridge/router coupled to multiple workstations using the medium attachment unit illustrated in FIG. 2; and

FIG. 5 is a flow chart illustrating the processing steps that may be carried out by the point-to-point local area network illustrated in FIG. 4 to provide automatic configuration of the network for operation in the full duplex mode.

DETAILED DESCRIPTION

For purposes of illustration only and not to limit generality, the present invention will now be explained with reference to its use for connecting a data terminal equipment unit (or multiple data terminal equipment units), such as a workstation (or workstations), to a bridge/router. One skilled in the art will recognize that the present invention is applicable to other configurations as well and may be used, for example, to provide a higher effective data transmission rate between data terminal equipment units which connect multiple networks together.

Reference is now made to FIG. 1, which figure illustrates a generalized functional block diagram of a medium attachment unit 10 as specified in ANSI/IEEE Standard 802.3. The medium attachment unit provides the interface between a data terminal equipment unit 12 and the local area network transmission medium indicated generally at 14. Each data terminal equipment unit on the local area network is provided with a medium attachment unit. The medium attachment unit may be a separate unit or alternatively, it may be incorporated into the data terminal equipment unit.

The medium attachment unit includes a transmitter circuit 20 which receives data from a DATAOUT control circuit 22 via connection 21 and transmits this data onto transmission path 16. DATAOUT circuit 22 receives data from data terminal equipment unit 12 over connection 24 and controls the timing of the transmission of the data. Medium attachment unit 10 also includes a receiver circuit 26 that receives data from transmission reception path 18 and transmits the data to DATAIN circuit 28 via connection 30. DATAIN circuit 28 controls the reception of data and transmits received data to data terminal equipment unit 12 for processing via connection 32.

Medium attachment unit 10 also includes a loopback circuit 34 coupled to transmitter circuit 20 via connection 33 and receiver circuit 26 via connection 35. The function

of loopback circuit 34 is to send a signal such as a data packet which has been transmitted by transmitter 20 back to data terminal equipment unit 12 via receiver 26 to ensure that the data packet was properly and successfully transmitted onto the network.

Medium attachment unit 10 also includes a collision detection circuit 36 coupled to receiver 26 via connection 38 and to data terminal equipment unit 12 via connection 40. Collision detection circuit 36 detects the occurrence of a collision between data packets transmitted by different medium attachment units on the network. If a collision occurs and is detected by collision detection circuit 36, a collision detected signal is sent to data terminal equipment unit 12 via connection 40. One skilled in the art will appreciate that collision detection circuit 36 is merely illustrative; it may be alternatively located in data terminal equipment unit 12, receiver 26, its functions may be split between data terminal equipment unit 12 and receiver 26, or embodied in a software function of unit 12. In the latter case, receiver 26 merely sends a collision detect signal to unit 12 for processing. Data terminal equipment unit 12 executes the normal wait and re-transmit Ethernet protocol specified in ANSI/IEEE Standard 802.3. Further explanation of the particular circuits and operation of the medium attachment unit is not given because they are well-known to those skilled in the art. A typical example of medium attachment unit 10 may be seen in transceiver units of the TPT or FOTF series, manufactured by Cabletron Systems, Inc., Rochester, New Hampshire.

One disadvantage of medium attachment unit 10 lies in that it, and the Ethernet local area network as a result, operates in the half-duplex mode. That is, the medium attachment unit transmits and receives data sequentially in accordance with Ethernet signalling protocol. This means that a data terminal equipment unit is either transmitting or receiving signals. According to the Ethernet protocol,

signal transmission and signal reception are mutually exclusive operations. Consequently, even though separate transmission and reception signal paths 16 and 18 are available in link-based, point-to-point networks, they are only used sequentially.

Reference is now made to FIG. 2, which figure illustrates a medium attachment unit 50 in accordance with the present invention. The local area network transmission medium 14 to which the present invention is applicable may be any link-based, transmission medium such as shielded or unshielded twisted pair wiring or optical fibers, radio frequency links or satellite links. The transmission medium generally includes a separate transmission path 16 which is used to transmit signals from medium attachment unit 50 to another medium attachment unit connected to the link-based, point-to-point local area network and a separate receive transmission path 18 which is used by medium attachment unit 50 to receive signals from the other medium attachment unit connected to the link-based, point-to-point local area network.

In medium attachment unit 50, a loopback disabling circuit 52 and a collision detection disabling circuit 54 have been added. When loopback disabling circuit 52 is activated, loopback circuit 34 is disabled and is prevented from sending a loopback signal from transmitter 20 to receiver 26. When collision detection disabling circuit 54 is activated, collision detection circuit 36 is disabled and prevented from sending a collision detection signal from receiver 26 to data terminal equipment unit 12.

Loopback disabling circuit 52 and collision detection disabling circuit 54 may be embodied in a number of ways. For example, these disabling circuits may ground, open circuit, or otherwise disable the inputs to the loopback and collision detection circuits, respectively. They may also ground or open or otherwise disable the outputs of loopback circuit 34 and collision detection circuit 36, respectively.

Disabling circuits 52 and 54 may be hardware switches located in a case of medium attachment unit 50 allowing the user to manually disable the loopback and collision detection circuits. Alternatively, disabling circuits 52 and 54 may be software controlled switches responsive to a control signal over respective connections 56 and 58 wherein the control signals originate as software commands from data terminal equipment unit 12.

Once loopback circuit 34 and collision detection circuit 36 have been disabled, the medium attachment unit is no longer restricted to operation in the half-duplex mode. The medium attachment unit is now able to transmit and receive signals simultaneously, i.e., in a full duplex mode. Within this disclosure, the term "full duplex" is meant to describe an operation mode in which signals may be transmitted to transmission path 16 or received from transmission path 18 without any temporal restrictions. That is signal transmission or reception may occur simultaneously, sequentially, or at any random time. As long as data terminal equipment unit 12 can receive and transmit signals without temporal restrictions i.e., in the full duplex mode, the medium attachment unit no longer restricts the data transmission rate. Since Ethernet local area networks operate with a signal transmission rate of 10 megabits per second, the medium attachment unit of the present invention effectively doubles this data transmission rate to 20 megabits per second by allowing a 10 megabit per second signal transmission rate along transmission path 16 and a 10 megabit per second signal transmission rate along transmission path 18. As will be explained and illustrated in detail hereinafter, when medium attachment unit 50 is used in conjunction with a multi-port bridge/router in a link-based, point-to-point configuration on a local area network having separate transmit and receive paths, such as a 10BASE-T type network, optical fiber, or radio frequency type networks, the effective signal transmission rate of a data

link between a data terminal equipment unit and a port on the multi-port bridge/router is increased to 20 megabits per second.

As will be explained in greater detail hereinafter, particularly in connection with FIG. 5, a circuit 57 may be provided in data terminal equipment unit 12 or medium attachment 50 that sends a signal (such as a binary digital signal) onto the network indicating that the data terminal equipment unit/medium attachment unit is capable of full duplex operation. A circuit 59 may also be provided in the data terminal equipment unit or medium attachment unit that responds to an acknowledgment signal received from the network to activate or deactivate collision detection disabling circuit 54 and loopback disabling circuit 52 via control connections 58 and 56.

Medium attachment unit 50 may be constructed by modifying transceiver units of the TPT or FOTF series, manufactured by Cabletron Systems, Inc., Rochester, New Hampshire in accordance with the teachings of the present invention.

Reference is now made to FIG. 3, which figure illustrates a basic link-based, point-to-point Ethernet local area network in accordance with the present invention. The present invention may be used in any Ethernet local area network where separate transmission and reception paths are provided between two data terminal equipment units. Examples of this type of Ethernet local area network include the 10BASE-T and 10BASE-FL local area networks and local area networks which use optical fibers or radio frequency signals as the transmission medium. Two data terminal equipment units 12A and 12B are respectively coupled to two medium attachment units 50A and 50B. Medium attachment units 50A and 50B are identical to medium attachment unit 50 illustrated in FIG. 2. A data link 17 that corresponds to the local area network transmission medium connects medium attachment unit 50A and 50B together. Data link 17 includes a first transmission path 16 connecting a transmitter 20A of

medium attachment unit 50A to a receiver 26B of medium attachment unit 50B. Data link 17 also includes a second data transmission path 18 connecting a receiver 26A of medium attachment unit 50A to a transmitter 20B of medium attachment unit 50B.

With all other circuits in the local area network unaltered and conforming to Ethernet local area network standards, disabling of the loopback and collision detection circuits in medium attachment units 50A and 50B allows an effective signal transmission rate of 20 megabits per second between data terminal equipment units 12A and 12B since a full duplex connection is now provided between medium attachment units 50A and 50B.

Reference is now made to FIG. 4, which figure illustrates another embodiment of a point-to-point Ethernet local area network in accordance with the present invention. The local area network includes a data terminal equipment unit 12D that is an Ethernet bridge/router. The bridge/router has a number of ports 60, 62, and 64. Although only three ports are illustrated on bridge/router 12D, one skilled in the art will appreciate that this is not a limitation of the invention, and the bridge/router can have as many ports as is desired. Medium attachment units 50F, 50G, and 50H are respectively coupled to ports 60, 62, and 64. The medium attachment units may be separate units, or they may be incorporated into bridge/router 12D. As is known to those skilled in the art, bridge/router 12D functions to direct data packets received at each port of the bridge/router to the port connected to the data terminal equipment unit having the proper destination address.

Three data terminal equipment units 12A, 12B, and 12C, which may be, for example, workstations, are respectively coupled to medium attachment units 50C, 50D, 50E. The medium attachment units may be separate units or may be incorporated into the workstations. Each of the medium attachment units is respectively coupled to a medium attachment unit of a

respective port on bridge/router 12D via data links 17A, 17B, 17C. Medium attachment unit 50C is coupled via separate transmit and receive paths 16A, 18A to medium attachment unit 50F. Medium attachment unit 50D is coupled via separate transmit and receive paths 16B and 18B to medium attachment unit 50G. Medium attachment unit 50E is coupled via separate transmit and receive paths 16C and 18C to medium attachment unit 50H.

When the collision detection and loopback circuitry of medium attachment units 50C-50H is disabled in accordance with the present invention, data links 17A, 17B, and 17C effectively operate at double the normal Ethernet signal transmission rate of 10 megabits per second, resulting in an effective signal transmission rate between bridge/router 12D and data terminal equipment units 12A, 12B, 12C of 20 megabits per second. Since only a single data terminal equipment unit is coupled to a single port on bridge/router 12D, in a link-based, point-to-point local area network there is no need for the collision detection function normally specified in an Ethernet local area network. Collisions between multiple data terminal equipment units do not occur because there are only two data terminal equipment units coupled to each data link via separate transmit and receive paths. In addition, since separate receive and transmit paths are provided in each of links 17A, 17B, and 17C, signals can be transmitted between bridge/ router 12D and a data terminal equipment unit coupled to a port simultaneously. To take advantage of the capability of full duplex transmission of signals between bridge/router 12D and a workstation, the loopback function normally specified in an Ethernet local area network must be disabled to avoid interference between signals transmitted on path 16 and signals transmitted on path 18. As long as a workstation and the bridge/router can transmit and receive data with no temporal restrictions, the system operates in the full duplex mode.

Bridge/router 12D may be constructed by modifying an Ethernet bridge/router such as model EMME manufactured by Cabletron Systems, Inc., Rochester, New Hampshire in accordance with the teachings of the present invention.

Reference is now made to FIG. 5, which figure illustrates a flow chart of the processing steps which may be carried out by bridge/router 12D and a data terminal equipment unit coupled to a port thereon in accordance with another embodiment of the invention to have fully automatic, backwards compatible control of the operation mode of a point-to-point Ethernet local area network.

In step 100, bridge/router 12D is initialized (as on power-up, for example). From step 100, the bridge/router proceeds to step 102 in which the data communications mode is automatically set to half-duplex mode as a default. From step 102, the bridge/router proceeds to step 104 in which the bridge/router checks the network (i.e., a port on the bridge/router) to determine if there is any network activity. If the answer is no in step 104, the bridge/router proceeds to step 102 and processing continues as already previously described. On the other hand, if the answer in step 104 is yes, indicating that there is at least one data terminal equipment unit on the network (i.e., connected to a port on the bridge/router), the bridge/router proceeds to step 106.

These same processing steps are also carried out by a data terminal equipment unit connected to one of the ports of bridge/router 12D. These steps are illustrated in the flow chart as steps 200, 202, and 204.

In step 106, the bridge/router interrogates the network (i.e., a port) to determine how many workstations are connected to the port. In step 206, the data terminal equipment unit provides this information to the bridge/router. From step 106, the bridge/router proceeds to step 108. In step 108, the bridge/router checks to see if it received responses from more than one workstation by

determining how many workstation addresses were received in step 106. If the answer in step 108 is no, indicating that only a single data terminal equipment unit is coupled to the port on the bridge/router, the bridge/router proceeds to step 110 in which a duplex enable signal is issued to the data terminal equipment unit. In step 208, the data terminal equipment unit responds to the duplex enable signal by activating collision detection disabling circuit 54 and loopback disabling circuit 52 in its medium attachment unit.

On the other hand, if the answer in step 108 is yes, indicating that more than one workstation is connected to the port, the bridge/router proceeds to step 116. The processing in step 116 will be described hereinafter.

From step 110, the bridge/router proceeds to step 112. From step 208, the data terminal equipment unit proceeds to step 210. In step 210, the data terminal equipment unit sends a duplex acknowledgment signal to the bridge/router. In step 112, the bridge/router checks to determine whether or not a duplex acknowledgment signal has been received. The duplex acknowledgment signal indicates that the data terminal equipment unit coupled to the port is capable of full duplex communications operations and that the loopback circuitry and collision detection circuitry of the medium attachment unit of the data terminal unit have been disabled. If the answer is yes in step 112, meaning that a duplex acknowledgment signal has been received from the data terminal equipment unit, the bridge/router proceeds to step 114 in which the medium attachment unit connected to the particular port of the bridge/router is set to full duplex mode by activating loopback circuitry disabling circuit 52 and collision detection disabling circuit 54. From step 114, the bridge/router proceeds to step 116. On the other hand, if no duplex acknowledgment signal is received in step 112, the bridge/router proceeds to step 116.

In step 116, the bridge/router sends a request for data in the half-duplex mode or the duplex mode, depending upon

the results of the previous processing steps to the data terminal equipment unit. In step 212, the data terminal equipment unit sends a request acknowledgment signal for operation in the half-duplex mode or duplex mode to the bridge/router depending on the results of the previous processing steps. From step 116, the bridge/router proceeds to step 118.

In step 118, the bridge/router checks whether or not an acknowledgment signal sent was by the data terminal equipment unit. If the answer in step 118 is yes, the bridge/router proceeds to step 118 and the data terminal equipment unit proceeds to step 214 and data communications are begun. If, on the other hand, the answer in step 118 is no, the bridge/router proceeds to step 102 and processing continues as already previously described.

The processing steps illustrated in the flow chart of FIG. 5 allows the system to automatically determine whether the data link connected to the port on the bridge/router is a point-to-point connection and whether the equipment connected to the link is capable of supporting full duplex operations. If the data link and the data terminal equipment unit connected to the link is capable of full duplex operations, the system will automatically begin data communications in the full duplex mode. On the other hand, if the data terminal equipment unit is not capable of full duplex operations, the system will default to operation in the half-duplex mode. Consequently, the present invention provides full backwards capability with already-installed networks and equipment, while at the same time allowing automatic upgrade to full duplex operations if the equipment attached to the network is capable of full duplex communications.

Furthermore, if a hardware switch is provided on the case of a medium attachment unit (or a data terminal equipment unit if the medium attachment is incorporated therein), backwards compatibility is maintained because the user can

manually choose between full duplex and half-duplex operating modes.

Having thus described one particular embodiment of the invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. For example, if a point-to-point Ethernet system is to be built that is to always operate in the full duplex mode, loopback circuit 34 and collision detection circuit 36 can be eliminated from medium attachment unit 50. Such alterations, modifications, and improvements as are made obvious by this disclosure are intended to be part of this disclosure though not expressly stated herein, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only and is not intended as limiting.

Another embodiment of the present invention for automatically implementing a full-duplex mode is illustrated in the flow chart of Fig. 6. Fig. 6 illustrates the processing steps undergone by any data equipment terminal unit, i.e., a work station, bridge, router, etc., and thus the flow diagram is simplified in comparison to the embodiment of Fig. 5.

In step 300, the data terminal equipment unit is initialized (as on power-up, for example). From step 300, the unit proceeds to step 302 in which the data communication mode is automatically set to full-duplex mode as a default, by activating both the collision detection disabling circuit 54 and loopback disabling circuit 52. From step 302, the unit proceeds to step 304 in which it sends a request for data in the full-duplex mode onto the network. Proceding to step 306, if the unit receives a response in half-duplex mode (simplex), then the answer at step 306 is "yes" and the unit proceeds to change to a half-duplex mode at step 312 by deactivating both the collision detection disabling circuit 54 and the loopback disabling circuit 52. From step 312, the unit proceeds to step 314 and sends a half-duplex signal onto

the network and proceeds to step 310 wherein it begins data comunications with the other data terminal equipment unit on the network in a half-duplex mode.

In contrast, where the unit does not receive a half-duplex signal at step 306, the answer is "no" and the unit proceeds to determine whether it has received a full-duplex signal at step 308. If the answer is "yes," it begins data communication in the full-duplex mode with the network. If "no," it returns to step 306 to check for the half-duplex mode.

Having thus described a number of particular embodiments, the invention is limited only as defined in the following claims and the equivalents thereto.

What is claimed is:

CLAIMS

1. A network that transmits signals in accordance with a carrier sense multiple access with collision detection protocol, comprising:

a first data terminal equipment unit coupled to a first medium attachment unit, the first medium attachment unit including means for disabling a collision detection function of the first medium attachment unit and means for disabling a loopback function of the first medium attachment unit so that the first medium attachment unit provides full duplex transmission and reception of signals; and

a second data terminal equipment unit coupled to a second medium attachment unit, the second medium attachment unit including means for disabling a collision detection function of the second medium attachment unit and means for disabling a loopback function of the second medium attachment unit so that the second medium attachment unit provides full duplex transmission and reception of signals.

2. The network of claim 1, further comprising a first transmission path for transmitting the signals from the first medium attachment unit to the second medium attachment unit and a second transmission path for transmitting the signals from the second medium attachment unit to the first medium attachment unit.

3. The network of claim 2, wherein the first and second transmission paths comprise optical paths.

4. The network of claim 2, wherein the first and second transmission paths comprise twisted-pair wire paths.

5. The network of claim 4, wherein the network is a 10BASE-T local area network.

6. The network of claim 1, wherein the network is an Ethernet local area network.

7. The network of claim 6, wherein the network operates in accordance with IEEE 802.3 Standards.

8. The network of claim 7, wherein the network is a link-based, point-to-point system coupling the first data terminal equipment unit and first medium attachment unit directly to the second medium attachment unit and second data terminal equipment unit.

9. The network of claim 1, wherein at least one of the first and second data terminal equipment units is an Ethernet router.

10. The network of claim 1, wherein at least one of the first and second data terminal equipment units is an Ethernet bridge.

11. The network of claim 1, wherein at least one of the first and second data terminal equipment units is an Ethernet bridge/router.

12. The network of claim 1, wherein at least one of the first and second data terminal equipment units is a packet switch.

13. The network of claim 1, wherein the means for disabling a collision detection function and the means for disabling a loopback function of the first and second medium attachment units comprise respective hardware switches.

14. The network of claim 1, wherein the means for disabling a collision detection function and the means for disabling a loopback function of the first and second medium

attachment units comprise respective software controlled switches.

15. The network of claim 1, wherein at least one of the first and second medium attachment units further comprise means for sending a signal having a first state indicative of full duplex capability and a second state indicative of half-duplex capability onto the network.

16. The network of claim 15, wherein at least one of the first and second medium attachment units further comprise:

means for receiving the signal from a medium attachment unit connected to the network;

means, responsive to the first state of the signal, for activating the means for disabling the collision detection function and the means for disabling the loopback function; and

means, responsive to the second state of the signal, for deactivating the means for disabling the collision detection function and the means for disabling the loopback function.

17. A medium attachment unit providing full duplex transmission and reception of signals for a network, comprising:

means for transmitting and receiving signals in accordance with a carrier sense multiple access with collision detection protocol;

means for disabling a collision detection function of the medium attachment unit; and

means for disabling a loopback function of the medium attachment unit.

18. The medium attachment unit of claim 17, wherein the means for disabling a collision detection function and the means for disabling a loopback function comprise respective hardware switches.

19. The medium attachment unit of claim 17, wherein the means for disabling a collision detection function and the means for disabling a loopback function comprise respective software controlled switches.

20. A medium attachment unit providing full duplex transmission and reception of signals for a network, comprising:

means for transmitting and receiving signals in accordance with a carrier sense multiple access with collision detection protocol; and

control circuitry, coupled to and controlling the means for transmitting and receiving signals, to allow simultaneous transmission and reception of signals.

21. The medium attachment unit of claim 20, wherein the control circuitry comprises at least one hardware switch.

22. The medium attachment unit of claim 20, wherein the control circuitry comprises at least one software controlled switch.

23. The medium attachment unit of claim 20, wherein the control circuitry further comprises a first circuit disabling a collision detection function and a second circuit disabling a loopback function.

24. In a network including a first data terminal equipment unit coupled to a first medium attachment unit and a second data terminal equipment unit coupled to a second medium attachment unit wherein the local area network transmits signals in accordance with a carrier sense multiple access with collision detection protocol, the improvement for providing full duplex transmission and reception of signals over the local area network, comprising:

means for disabling a collision detection function of the first medium attachment unit;

means for disabling a loopback function of the first medium attachment unit;

means for disabling a collision detection function of the second medium attachment unit; and

means for disabling a loopback function of the second medium attachment unit.

25. A method of operating a point-to-point network including a first data terminal equipment unit coupled to a first medium attachment unit coupled to a network data transmission medium and a second data terminal equipment unit coupled to a second medium attachment unit coupled to the network data transmission medium, wherein the local area network transmits signals in accordance with a carrier sense multiple access with collision detection protocol, the method providing full duplex transmission and reception of signals and comprising the steps of:

disabling a collision detection function of the first medium attachment unit;

disabling a loopback function of the first medium attachment unit;

disabling a collision detection function of the second medium attachment unit; and

disabling a loopback function of the second medium attachment unit.

26. The method of claim 25, further comprising the step of sending a signal having a first state indicative of full duplex capability and a second state indicative of half-duplex capability onto the network.

27. The method of claim 26, further comprising the steps of

receiving the signal from a medium attachment unit connected to the network;

executing the disabling steps in response to the first state of the signal; and

not executing the disabling steps in response to the second state of the signal.

28. A network that transmits signals in accordance with a carrier sense multiple access with collision detection protocol, comprising:

a first data terminal equipment unit coupled to a first medium attachment unit, the first medium attachment unit including a collision detection disabling circuit and a loopback disabling circuit so that the first medium attachment unit provides full duplex transmission and reception of signals; and

a second data terminal equipment unit coupled to a second medium attachment unit, the second medium attachment unit including a collision detection disabling circuit and a loopback disabling circuit so that the second medium attachment unit provides full duplex transmission and reception of signals.

29. A data terminal equipment unit, comprising:

means for transmitting and receiving signals in accordance with a carrier sense multiple access with collision detection protocol; and

control circuitry coupled to and controlling the means for transmitting and receiving signals, to allow simultaneous transmission and reception of signals.

30. The data terminal equipment unit of claim 29, wherein the control circuitry comprises at least one hardware switch.

31. The data terminal equipment unit of claim 29, wherein the control circuitry comprises at least one software controlled switch.

32. The data terminal equipment unit of claim 29, wherein the control circuitry further comprises a first circuit disabling a collision detection function and a second circuit disabling a loopback function.

33. The data terminal equipment unit of claim 32, wherein the control circuitry further comprises a third circuit sending a signal having a first state indicative of full duplex capability and a second state indicative of half-duplex capability onto the network.

34. The data terminal equipment unit of claim 33, wherein the control circuitry further comprises a fourth circuit receiving the signal from the network and responsive to the first state of the signal, for activating the first and second circuits, the fourth circuit being further responsive to the second state of the signal, for deactivating the first and second circuits.

35. A medium attachment unit for a network, comprising:

means for transmitting and receiving signals in accordance with a carrier sense multiple access with collision detection protocol; and

means for providing full duplex transmission and reception of signals.

36. A network that transmits signals in accordance with a carrier sense multiple access with collision detection protocol, comprising:

a multi-port bridge/router including a medium attachment unit coupled to each port on the bridge/router, each medium attachment unit including a collision detection disabling

circuit and a loopback disabling circuit so that each medium attachment unit is capable of providing full duplex transmission and reception of signals; and

a plurality of data terminal equipment units coupled to respective medium attachment units coupled to respective ports on the bridge/router, each medium attachment unit including a collision detection disabling circuit and a loopback disabling circuit so that each medium attachment unit is capable of providing full duplex transmission and reception of signals.

37. The network of claim 2, wherein the first and second transmission paths comprise shielded twisted-pair wire paths.

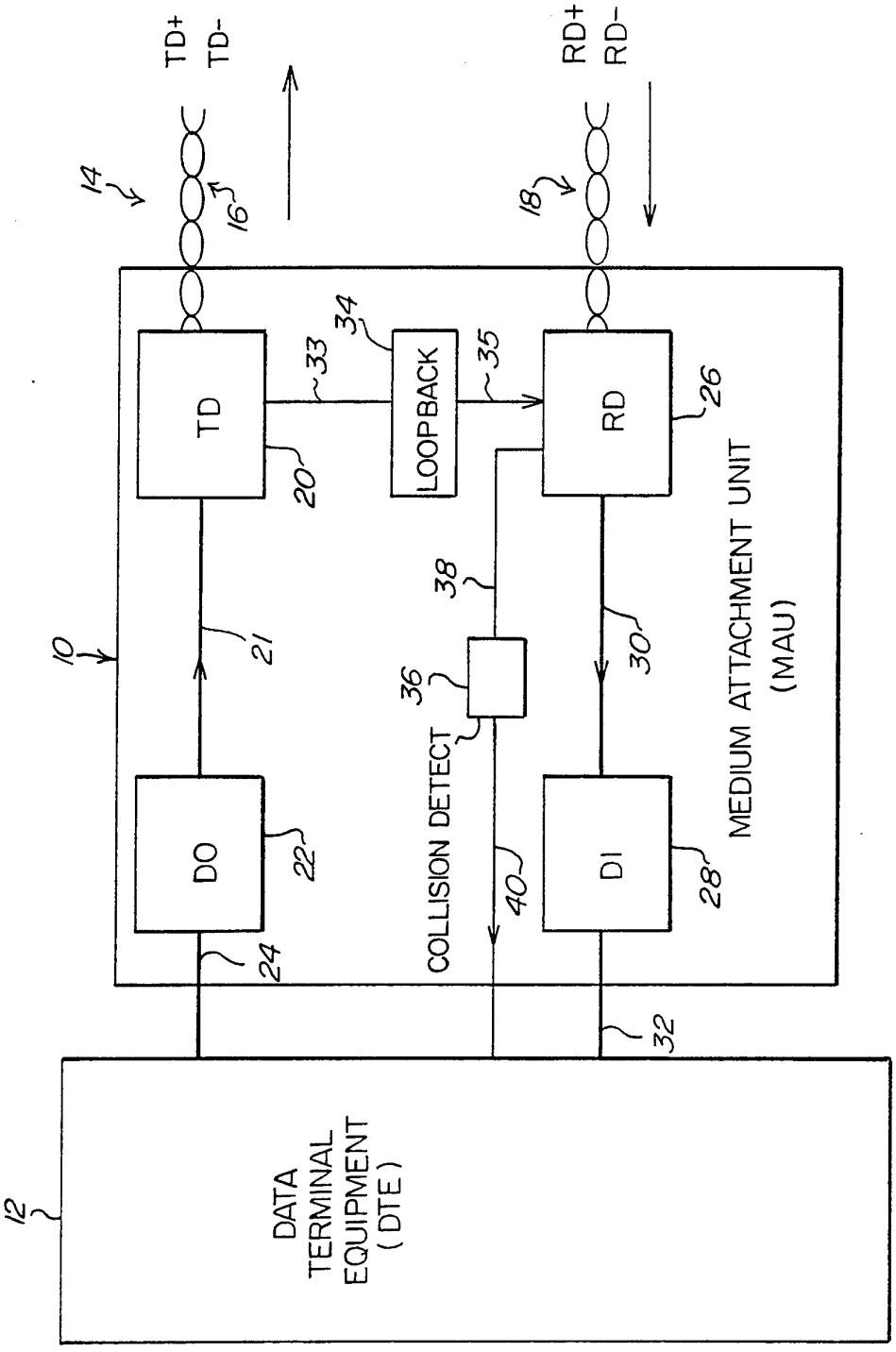


Fig. 1
PRIOR ART

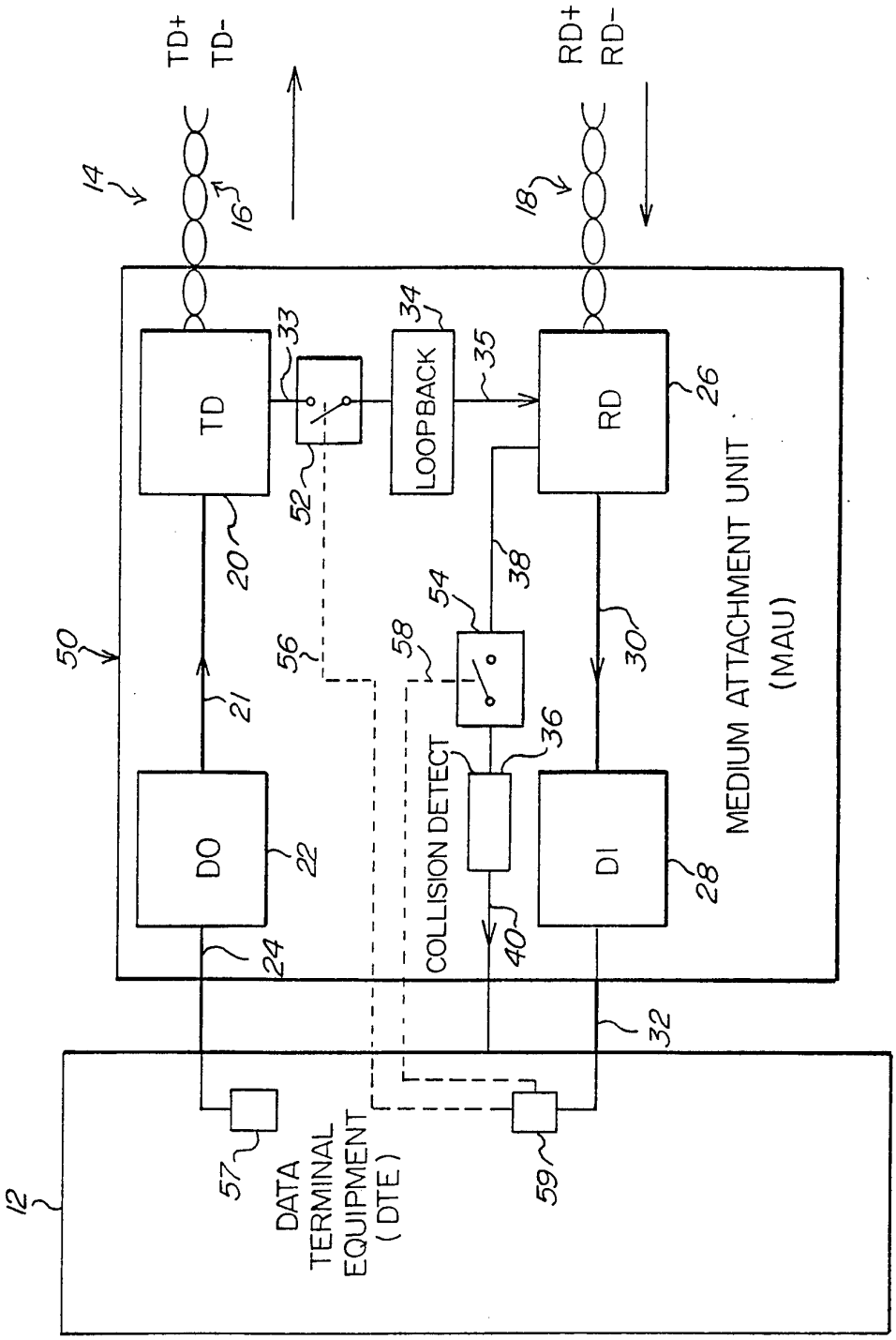

TD+
TD-
RD+
RD-
14
16
18
TD
33
34
LOOPBACK
35
RD
26
52
20
38
54
56
58
50
30
21
36
DO
22
COLLISION DETECT
DI
28
MEDIUM ATTACHMENT UNIT
(MAU)
24
40
32
57
59
12
DATA
TERMINAL
EQUIPMENT
(DTE)

Fig.2

Fig.3

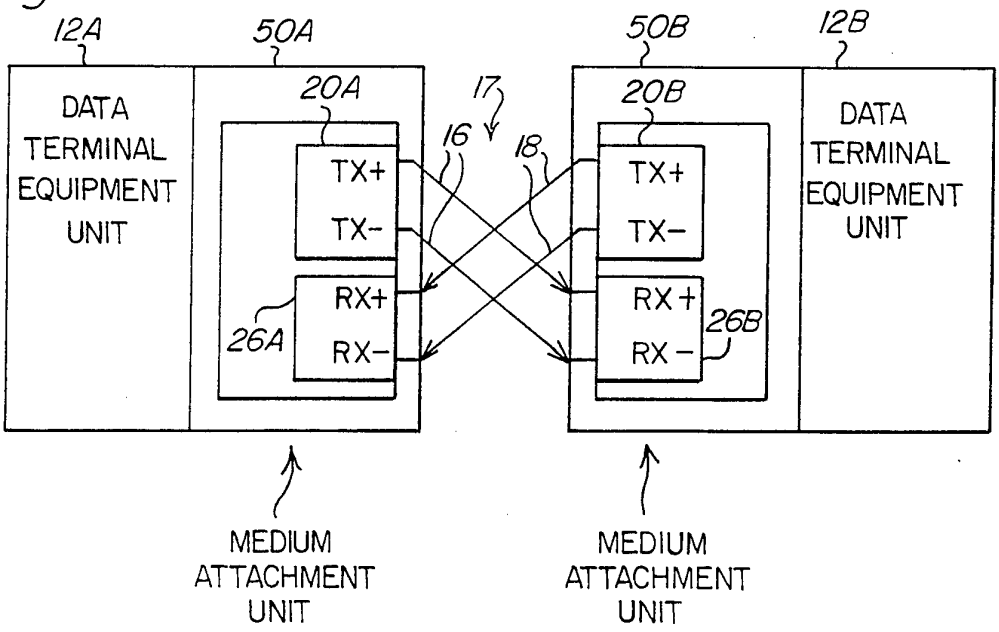

12A
50A
50B
12B
DATA TERMINAL EQUIPMENT UNIT
20A
17
20B
16
18
TX+
TX-
RX+
RX-
26A
26B
DATA TERMINAL EQUIPMENT UNIT
MEDIUM ATTACHMENT UNIT
MEDIUM ATTACHMENT UNIT

Fig.4

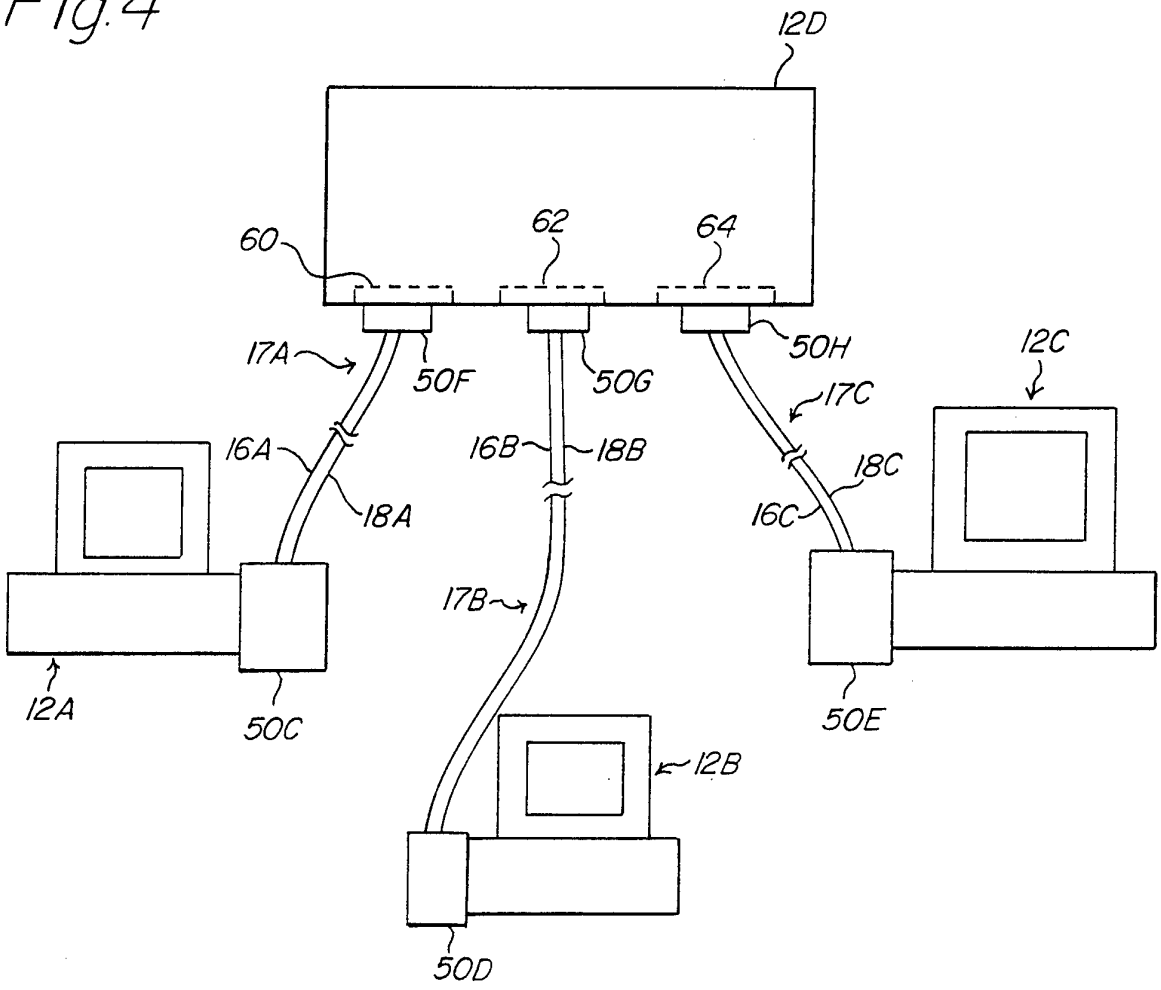

12D
60
62
64
17A
50F
50G
50H
12C
17C
16A
18A
16B
18B
18C
16C
17B
12A
50C
50E
12B
50D

Fig.5

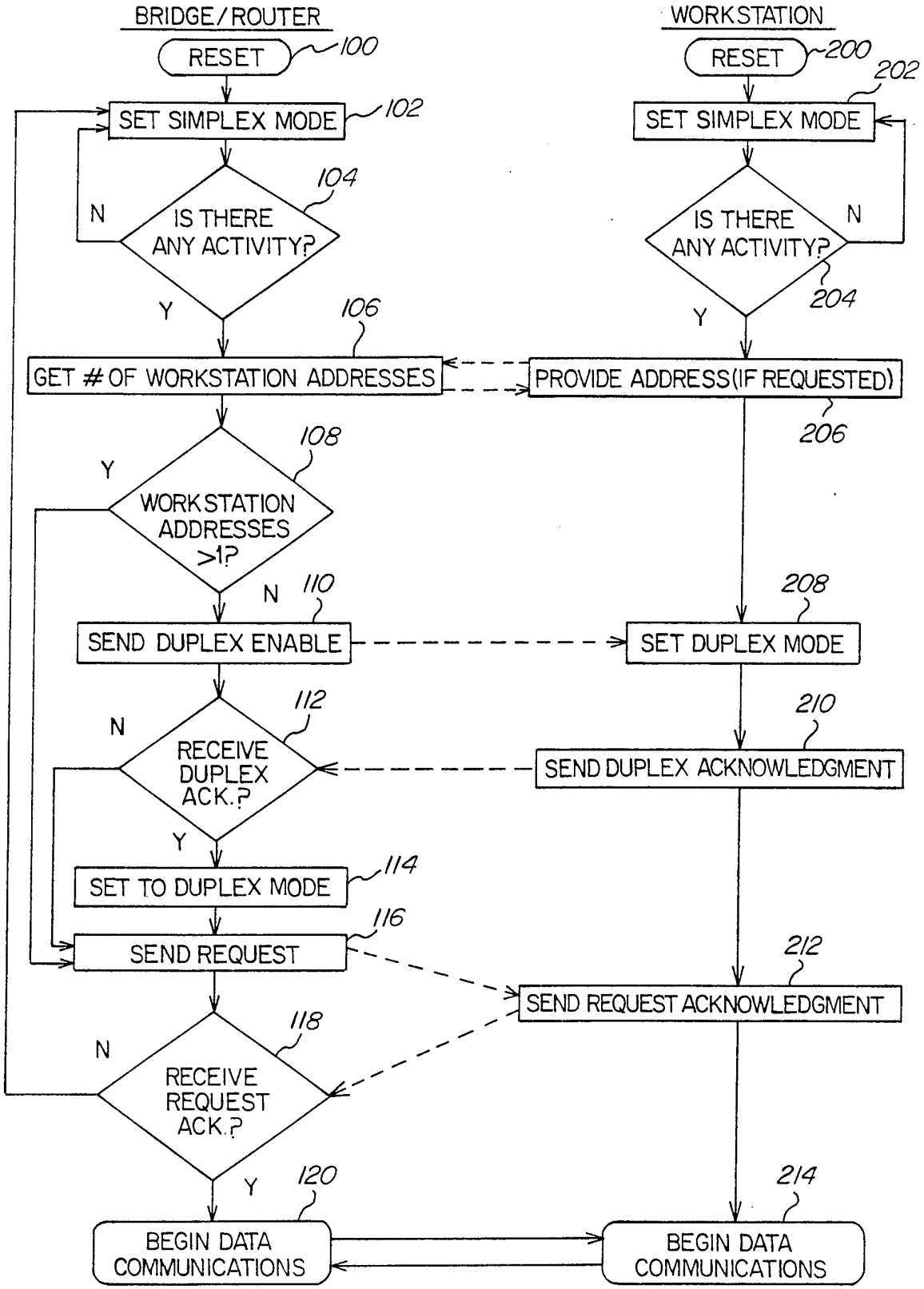
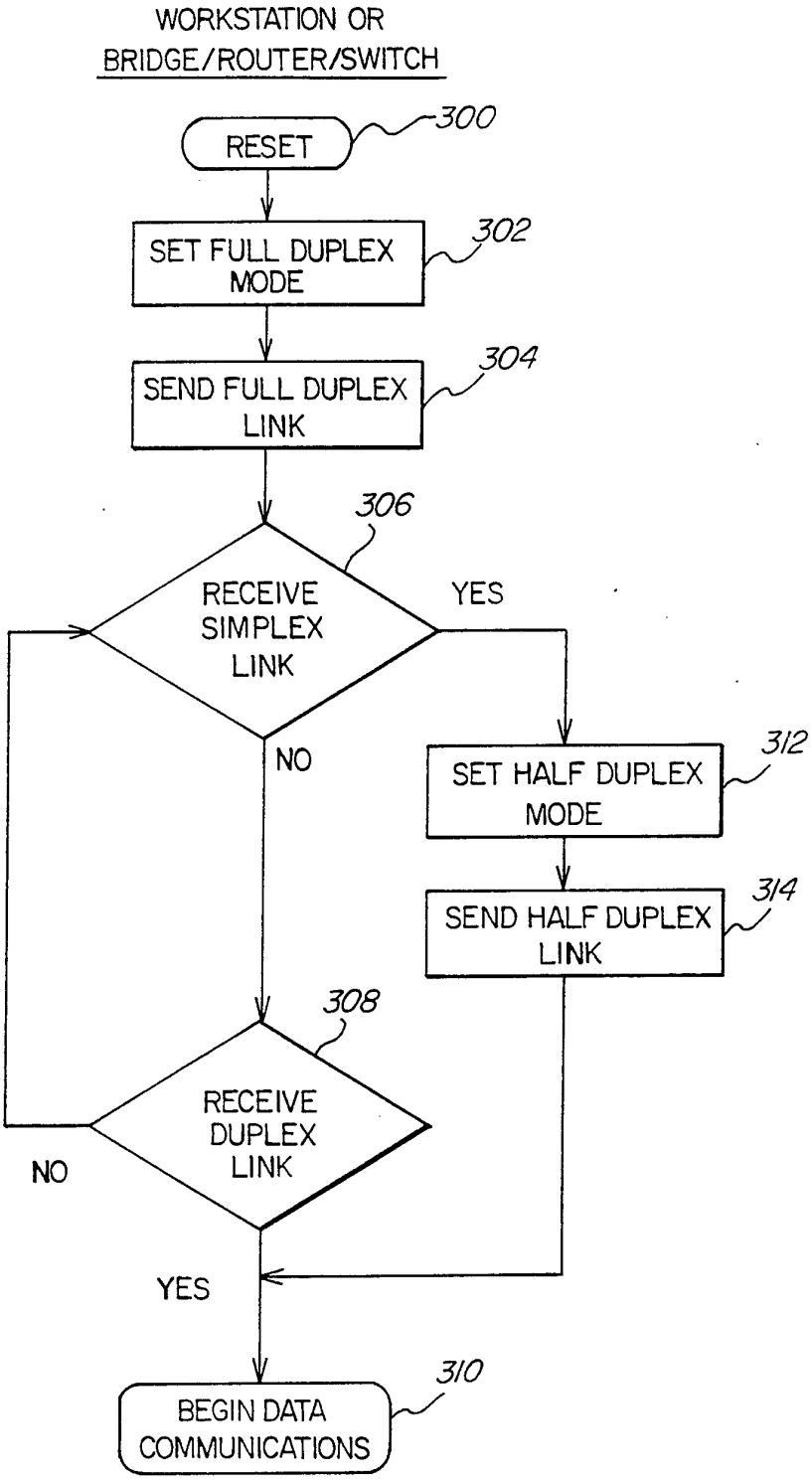

BRIDGE/ROUTER
WORKSTATION
RESET
100
RESET
200
202
SET SIMPLEX MODE
102
SET SIMPLEX MODE
104
N
IS THERE ANY ACTIVITY?
IS THERE ANY ACTIVITY?
N
204
Y
Y
106
GET # OF WORKSTATION ADDRESSES
PROVIDE ADDRESS(IF REQUESTED)
206
108
Y
WORKSTATION ADDRESSES >1?
N
110
208
SEND DUPLEX ENABLE
SET DUPLEX MODE
112
210
N
RECEIVE DUPLEX ACK.?
SEND DUPLEX ACKNOWLEDGMENT
Y
114
SET TO DUPLEX MODE
116
212
SEND REQUEST
SEND REQUEST ACKNOWLEDGMENT
118
N
RECEIVE REQUEST ACK.?
Y
120
214
BEGIN DATA COMMUNICATIONS
BEGIN DATA COMMUNICATIONS

Fig.6


WORKSTATION OR
BRIDGE/ROUTER/SWITCH
RESET
300
SET FULL DUPLEX MODE
302
SEND FULL DUPLEX LINK
304
306
RECEIVE SIMPLEX LINK
YES
NO
SET HALF DUPLEX MODE
312
SEND HALF DUPLEX LINK
314
308
RECEIVE DUPLEX LINK
NO
YES
BEGIN DATA COMMUNICATIONS
310

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 93/09864

A. CLASSIFICATION OF SUBJECT MATTER

H 04 L 12/28,H 04 L 12/46

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)

H 04 L,H 04 J

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, A2, 0 174 182 (KABUSHIKI KAISHA TOSHIBA) 12 March 1986 (12.03.86), abstract; page 1, line 3 - page 2, line 34; page 4, line 4 - page 6, line 27; fig. 1-3.	1,7,8, 16,17, 20,24, 25,28, 29,35, 36
A	US, A, 5 124 982 (KAKU) 23 June 1992 (23.06.92), abstract; column 1, line 14 - column 2, line 68; column 2, line 24 - column 5, line 14; fig. 1-3.	1,6-8, 16,17, 20,24, 25,28, 29,35, 36
A	WO, A1, 92/04 790 (MICROCOM SYSTEMS, INC.) 19 March 1992 (19.03.92),	1,5-11,16, 17,20,

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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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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"&" document member of the same patent family

Date of the actual completion of the international search
03 February 1994

Date of mailing of the international search report
25.02.94

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HAJOS e.h.

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	abstract; page 1, line 1 - page 3, line 20; page 4, lines 12-30; fig. 1. --	24,25, 28,29, 35,36
A	EP, A2, 0 303 407 (HEWLETT-PACKARD COMPANY) 15 February 1989 (15.02.89), abstract; page 2, line 5 - page 3, line 17; page 3, lines 32-58; fig. 1. ----	1,4,7, 8,16, 17,20, 24,25, 28,29, 35,36

ANHANG — ANNEX — ANNEXE

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

to the International Search Report to the International Patent Application No.

au rapport de recherche international relatif á la demande de brevet international n°

PCT/US 93/09864 SAE 81269

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben. Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.

La présente annexe indique les membres de la famille de brevets relatifs aux documents de brevets cités dans le rapport de recherche international visée ci-dessus. Les reseignements fournis sont donnés á titre indicatif et n'engagent pas la responsibilité de l'Office.

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