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Wong et al.

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(54) **LOAD BALANCING IN LINK AGGREGATION AND TRUNKING**

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Related U.S. Application Data

(63) Continuation of application No. 10/041,665, filed on Jan. 10, 2002, now Pat. No. 6,614,758, which is a continuation of application No. 09/249,837, filed on Feb. 12, 1999, now Pat. No. 6,363,077.

(60) Provisional application No. 60/074,740, filed on Feb. 13, 1998.

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H04L 12/26 (2006.01)
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **370/232**; 370/235; 370/392; 370/401

(58) **Field of Classification Search** .... None
See application file for complete search history.

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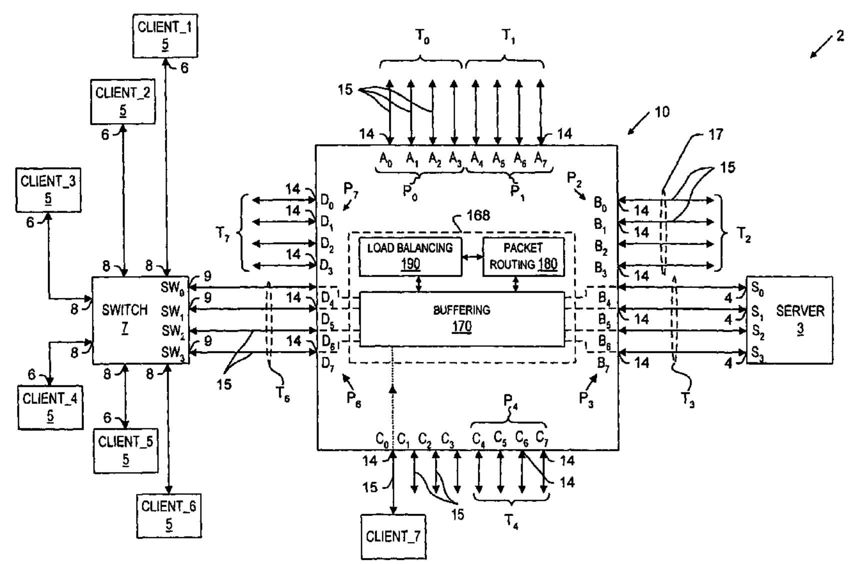
(57) **ABSTRACT**

A communications network switch includes a plurality of network ports for transmitting and receiving packets to and from network nodes via network links, each of the packets having a destination address and a source address, the switch being operative to communicate with at least one trunking network device via at least one trunk formed by a plurality of aggregated network links. The communications network switch provides a method and apparatus for balancing the loading of aggregated network links of the trunk, thereby increasing the data transmission rate through the trunk. The switch includes: a packet buffer for temporarily storing a packet received at a source port of the network ports, the packet having a source address value, and a destination address value indicating a destination node that is communicatively coupled with the switch via a data path including a trunk; a packet routing unit for determining a destination trunked port associated with the packet, the destination trunked port including a subset of the plurality of network ports, the destination trunked port being coupled to the destination node via the data path; and load balancing unit for selecting a destination port associated with the packet from the subset of network ports; whereby transmission loading of the aggregated network links of the trunk is balanced. In varying embodiments, the load balancing unit is operative to select destination ports from the subsets of network ports as a function of source port ID values, source addresses, and destination addresses.

22 Claims, 9 Drawing Sheets



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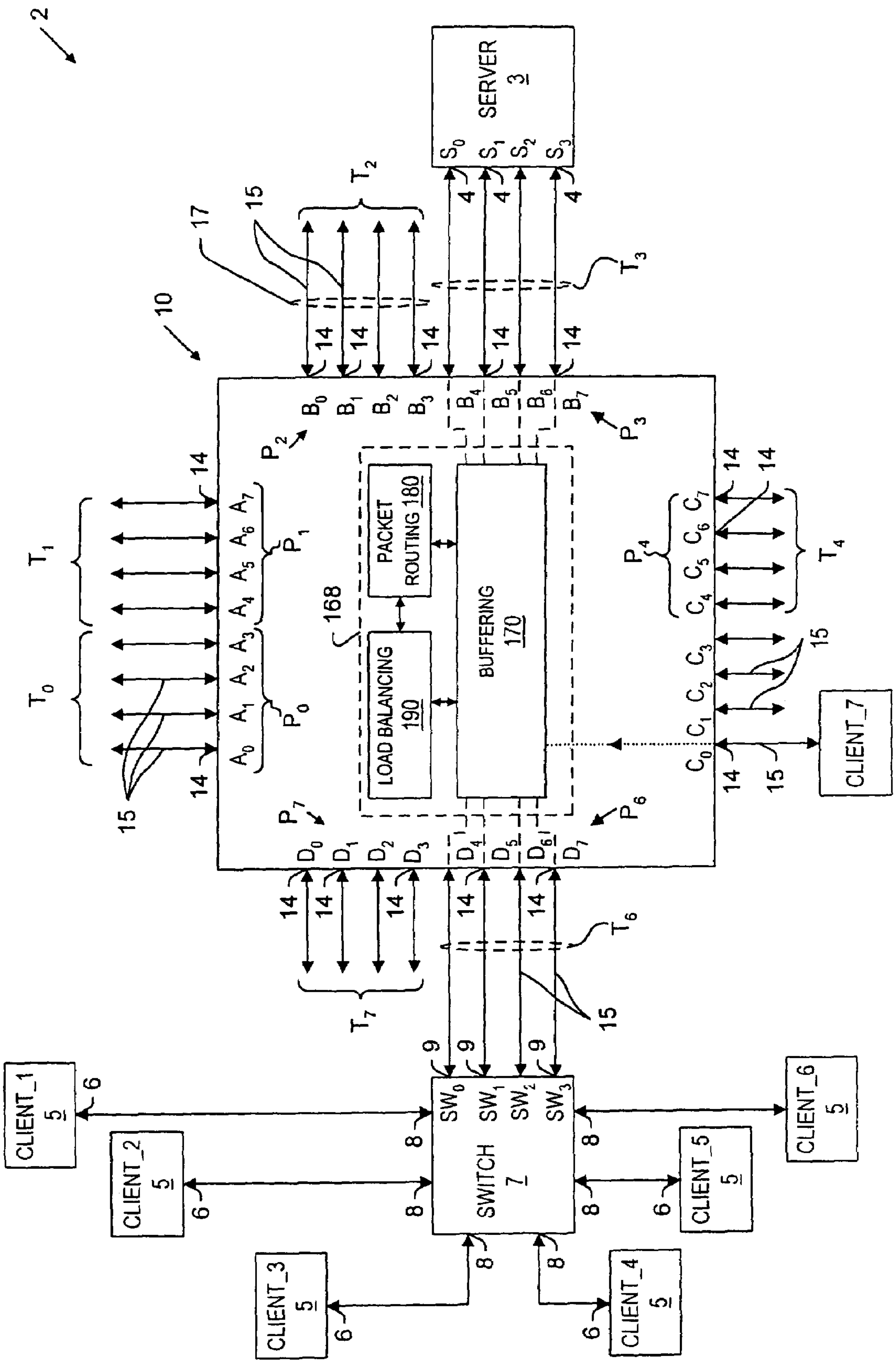

SERVER
3
PACKET ROUTING 180
LOAD BALANCING
190
BUFFERING
170
SWITCH
7
CLIENT_1
CLIENT_2
CLIENT_3
CLIENT_4
CLIENT_5
CLIENT_6
CLIENT_7
5

FIG. 1

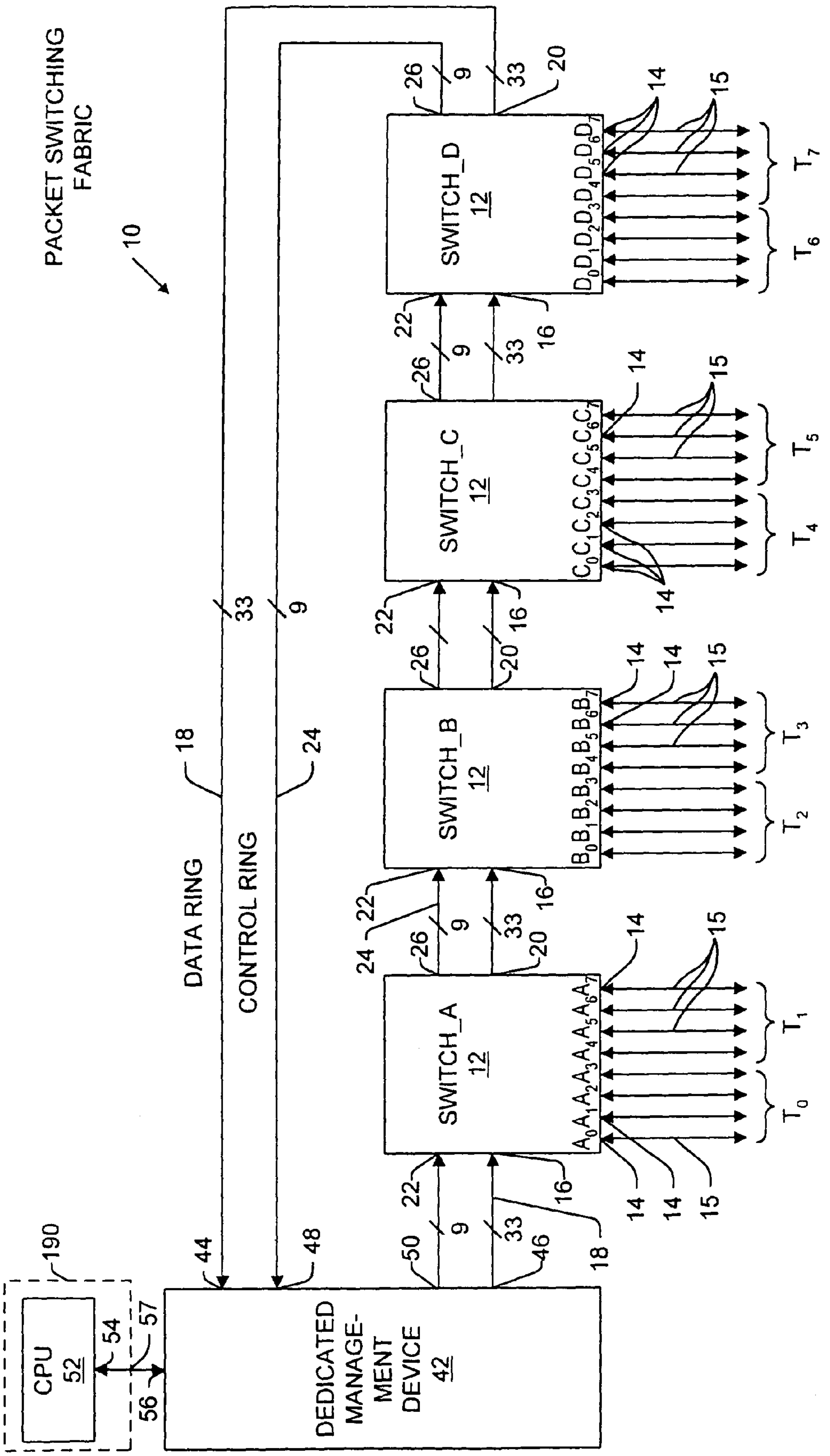

PACKET SWITCHING FABRIC
10
DATA RING
CONTROL RING
SWITCH_A
12
SWITCH_B
12
SWITCH_C
12
SWITCH_D
12
DEDICATED MANAGE- MENT DEVICE
42
CPU
52
190

FIG. 2

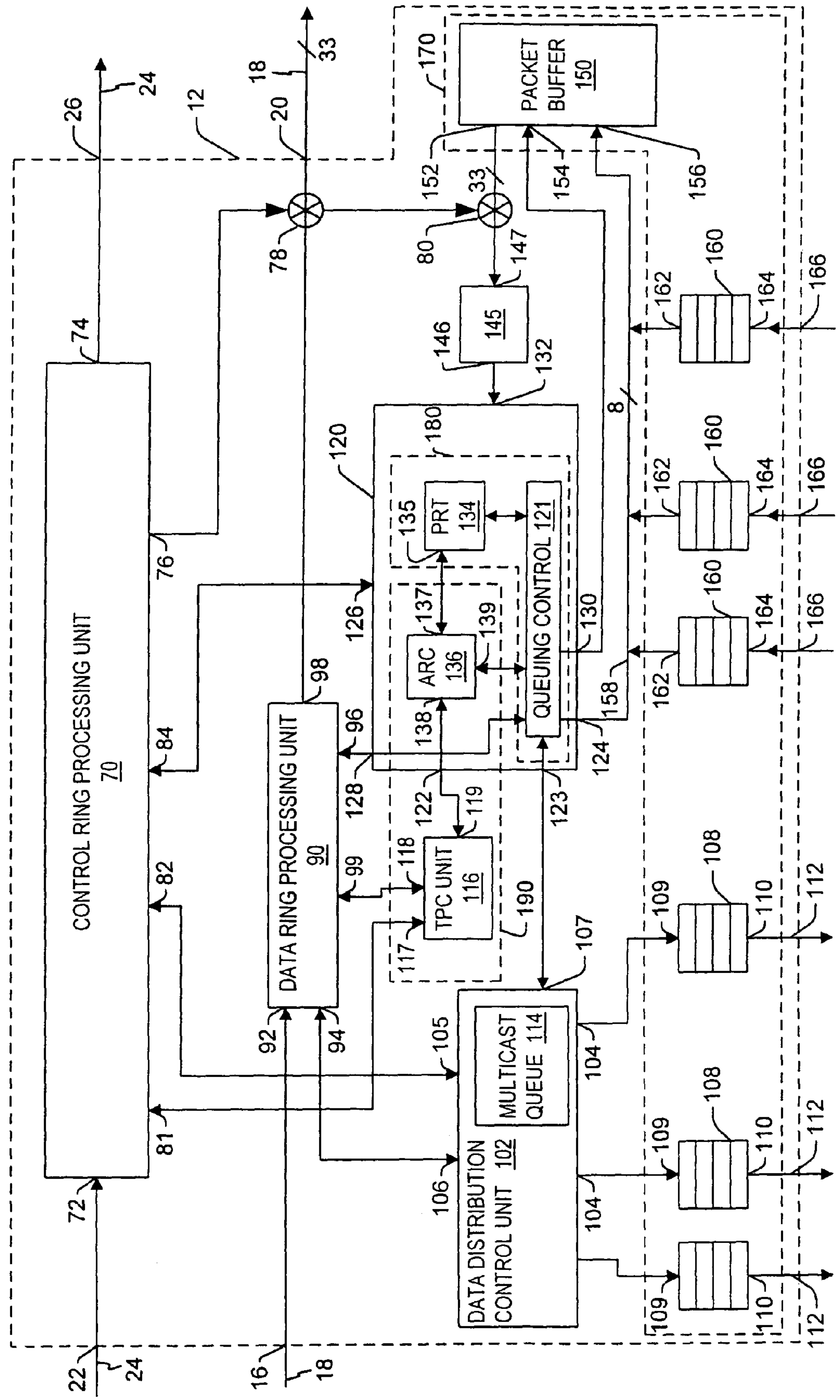
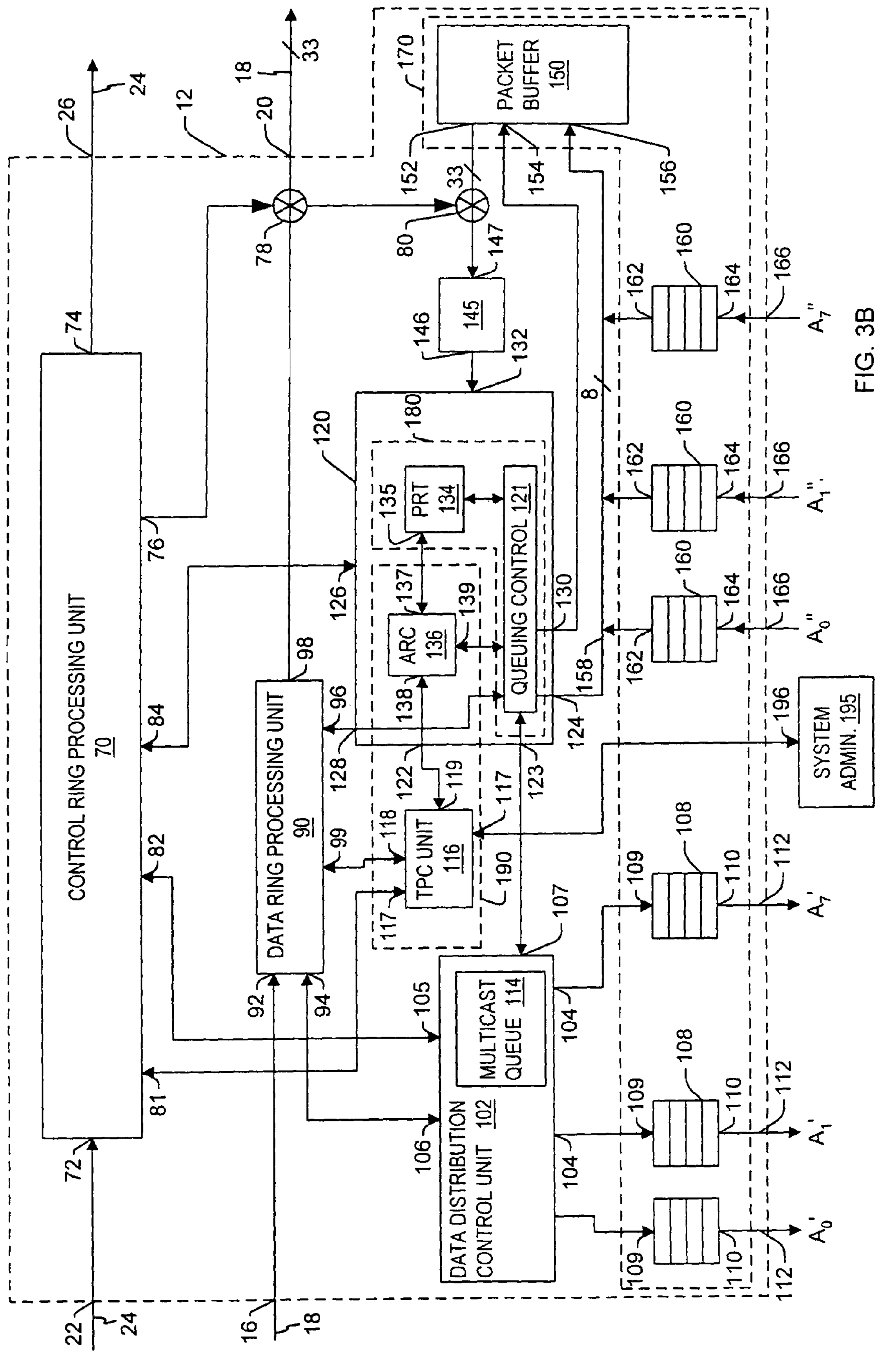

PACKET BUFFER 150
CONTROL RING PROCESSING UNIT 70
DATA RING PROCESSING UNIT 90
PRT 134
ARC 136
QUEUING CONTROL 121
TPC UNIT 116
MULTICAST QUEUE 114
DATA DISTRIBUTION CONTROL UNIT 102
145

FIG. 3A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TPC UNIT 116
ARC 136
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QUEUING CONTROL 121
PACKET BUFFER 150
145
SYSTEM ADMIN. 195

FIG. 3B

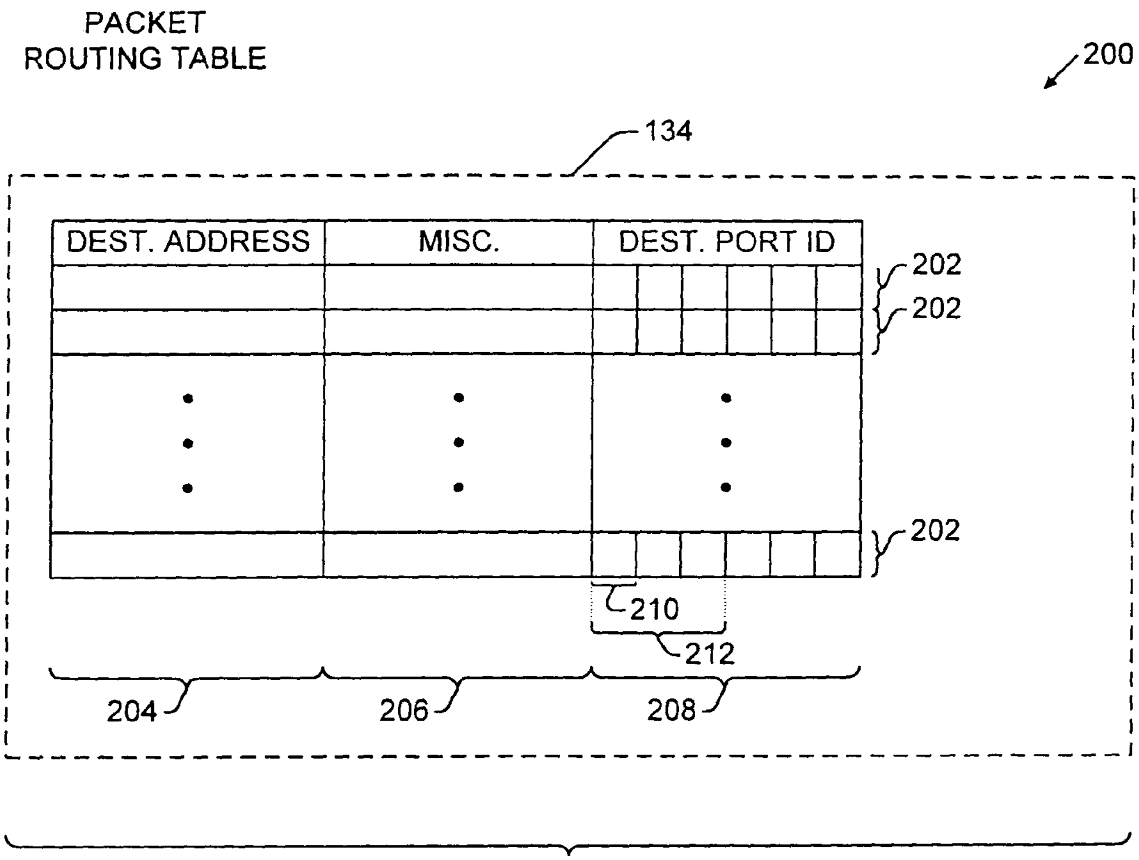


FIG. 4A

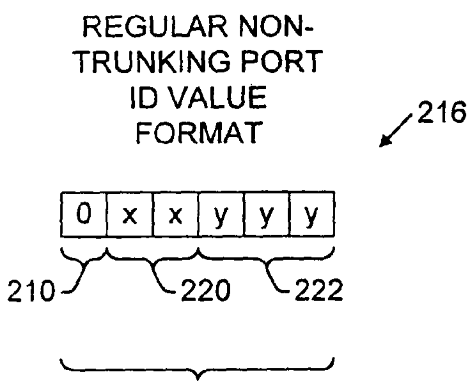


FIG. 4B

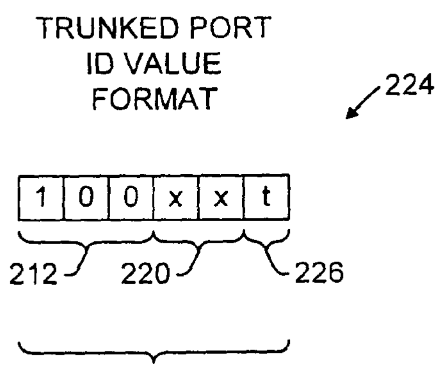


FIG. 4C

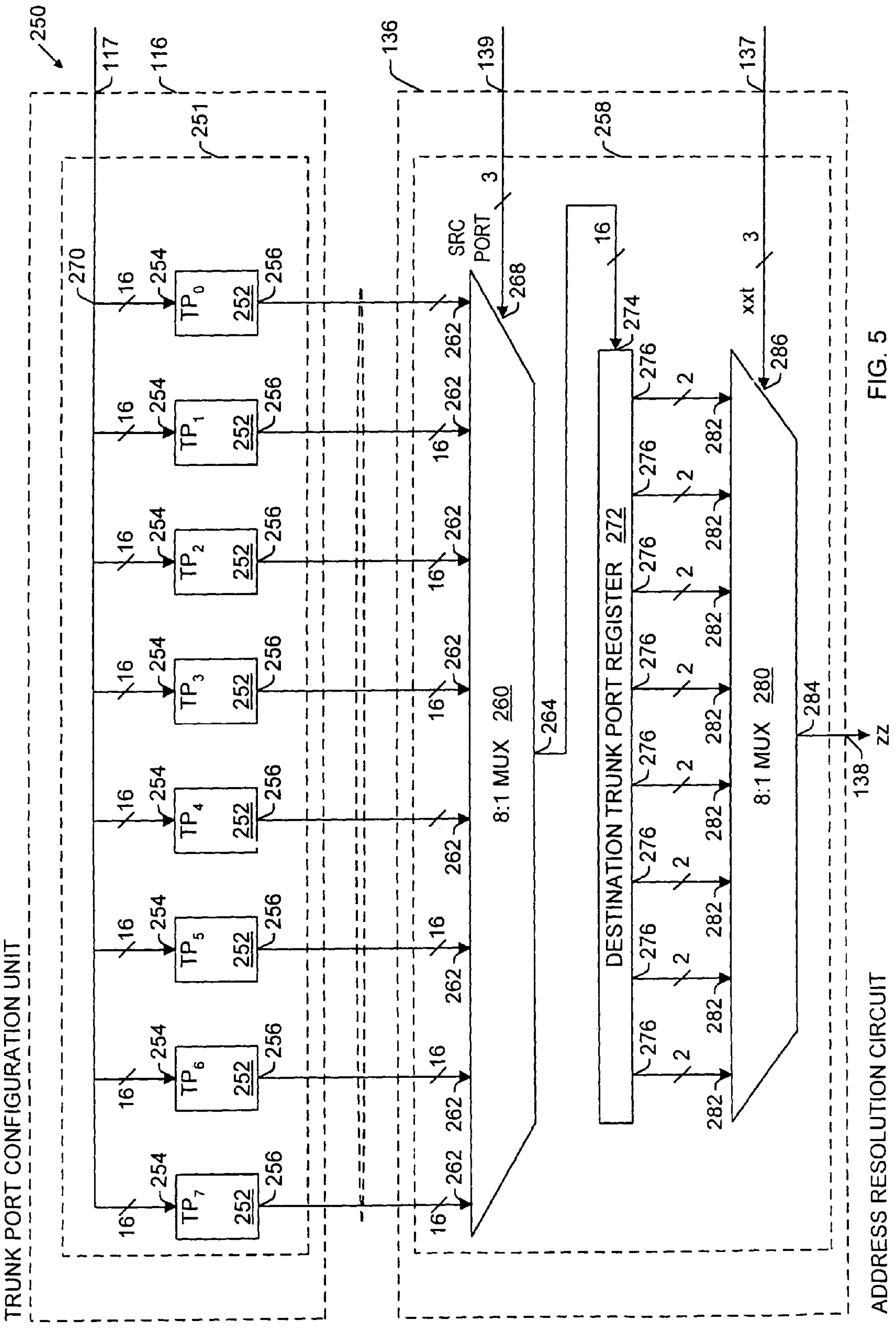

TRUNK PORT CONFIGURATION UNIT
250
117
116
251
270
TP0 252
TP1 252
TP2 252
TP3 252
TP4 252
TP5 252
TP6 252
TP7 252
254
256
16
ADDRESS RESOLUTION CIRCUIT
136
139
258
SRC PORT
3
268
262
8:1 MUX 260
264
16
274
DESTINATION TRUNK PORT REGISTER 272
276
2
282
137
xxt
3
286
8:1 MUX 280
284
zz
138

FIG. 5

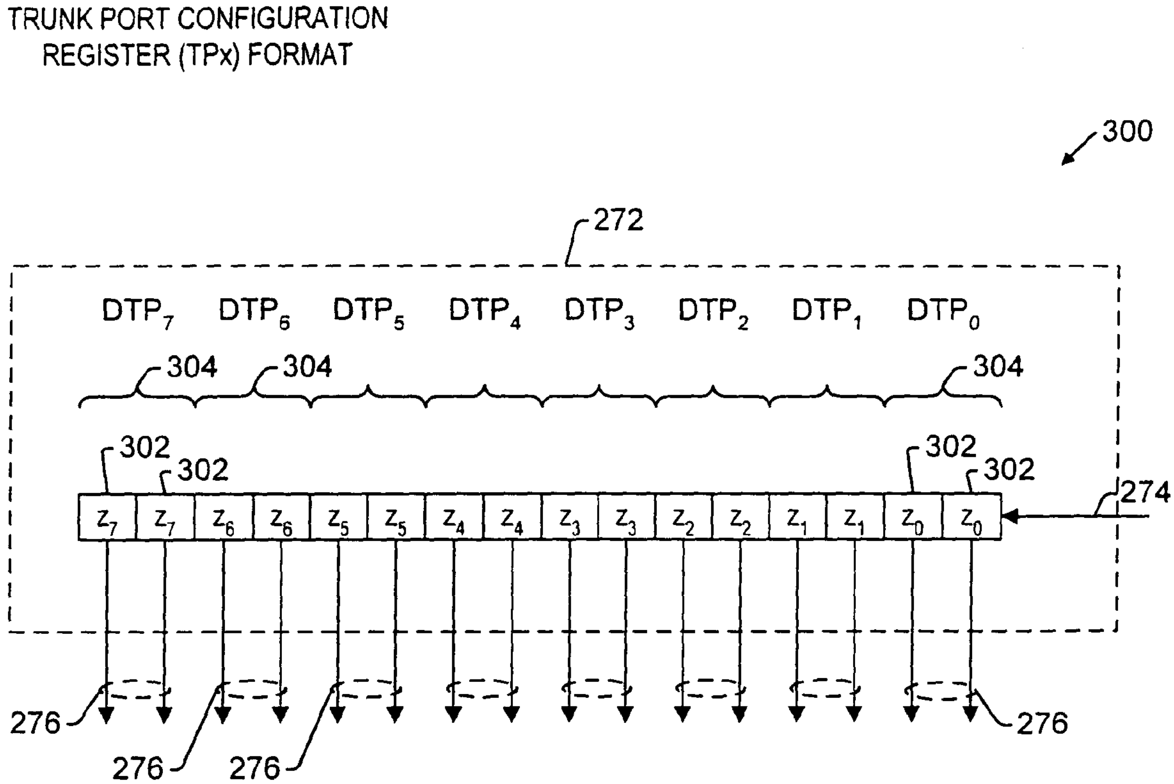
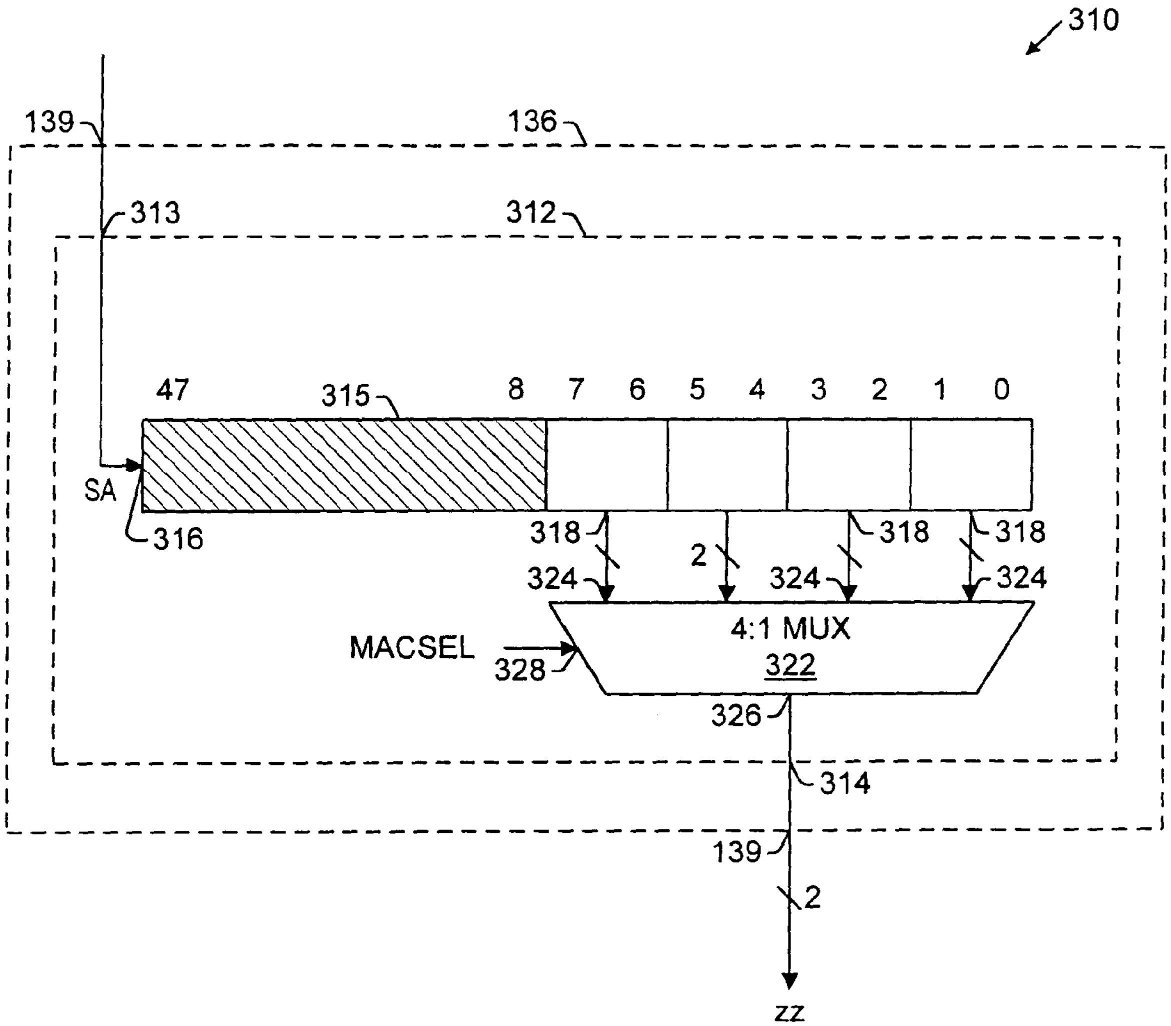

TRUNK PORT CONFIGURATION
REGISTER (TPx) FORMAT
300
272
DTP7 DTP6 DTP5 DTP4 DTP3 DTP2 DTP1 DTP0
304
304
304
302
302
302
302
274
Z7 Z7 Z6 Z6 Z5 Z5 Z4 Z4 Z3 Z3 Z2 Z2 Z1 Z1 Z0 Z0
276
276
276
276

FIG. 6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MACSEL
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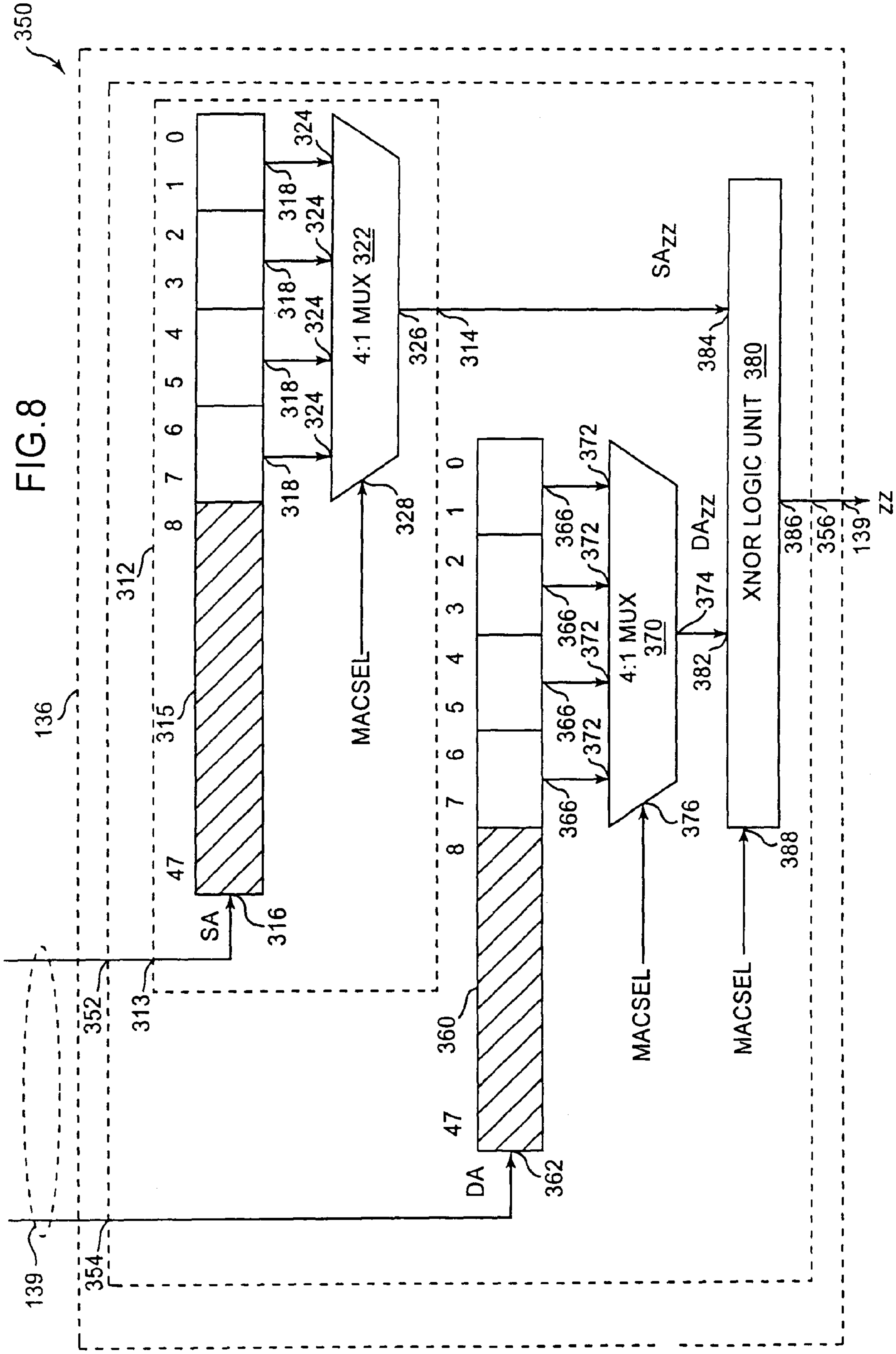
FIG. 7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MACSEL
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XNOR LOGIC UNIT 380
386
356
139
zz
360
362
DA
366
372
4:1 MUX 370
374
DAzz
382
376
388
352
354
139

FIG.8

LOAD BALANCING IN LINK AGGREGATION AND TRUNKING

CROSS REFERENCE TO RELATED APPLICATIONS

This is Continuation of application Ser. No. 10/041,665 filed Jan. 10, 2002 now U.S. Pat. No. 6,614,758, which in turn is a Continuation Application of Parent application Ser. No. 09/249,837, filed Feb. 12, 1999 now U.S. Pat. 6,363, 077. The disclosure of the prior application(s) is hereby incorporated by reference herein in its entirety.

This application claims priority to U.S. Pat. application Ser. No. 60/074,740, filed Feb. 13, 1998, entitled "Methods For Load Balancing In Link Aggregation And Trunking", which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to computer network systems. More specifically, the present invention relates to a method and apparatus for balancing the loading of network links of a trunked link.

2. Description of the Prior Art

Personal computers and engineering workstations are commonly inter-coupled into local area networks (LANs) that allow messages to be sent and programs to be downloaded, e.g., from file servers on the LAN. The ETHERNET, originally a joint effort of Intel, Xerox and Digital Equipment Corporations, is an example of a shared-access LAN now in widespread use. The ETHERNET was originally conceived as a ten megabit per second (Mbps) network that allowed every node on the LAN to transmit and receive.

Faster engineering workstations and distributed file systems have seriously increased the traffic placed on ordinary LANs. Many variations in ETHERNET have been developed. Different kinds of ETHERNET are referred to as "10BASE-T", "10BASE-2", "10BASE-5", "100BASE-VG", and "100BASE-X". Different speeds include ten Mbps, twenty Mbps, one hundred Mbps, and beyond. The ETHERNET 100 BaseFX specification defines transmission over fiber optic cable. 1 Gbit per second EHERNET

Servers are typically at the focus of network activity and are often subjected to parallel access requests from clients which have the same data transfer speed limitations as the server itself.

High performance computers are becoming affordable for use in applications including computing resources, high-performance file servers, and visualization workstations. However, the LANs that are now in use do not provide the capacity that is needed to support these higher performance computers. While bandwidths in the 10-100 Mbps range are sufficient for many applications, the more demanding computing and visualization applications require gigabit-per-second (Gbps) data transfer rates. Such applications include high-quality video applications, live video links, and meeting-support systems. Some of these applications, such as real-time video, will place a more continuous load on the network and require one-to-many ("multicasting") transmission in addition to point-point ("unicast") links. Therefore, a reasonable assumption is that LANs may soon require aggregate bandwidths in the 10-40 Gbps range for supporting a more or less ordinary community of users simultaneously. Different user communities typically have different needs, and the requirements of any given user community generally expand over time, so there is a need for a high performance LAN that scales gracefully and economically to satisfy the requirements of its user community.

ETHERNET switching provides for the connection of multiple ETHERNET LANs to a central switch. Within the ETHERNET switch, circuit switching allows the simultaneous transport of multiple packets across the switch.

What is needed is a local network switch including a plurality of network ports for transmitting and receiving packets to and from network nodes via network links, each of the packets having a destination address and a source address, the switch being operative to communicate with at least one trunking network device via at least one trunk formed by a plurality of aggregated network links.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method an apparatus for load balancing in trunked links.

Briefly, a presently preferred embodiment of the present invention includes a local area network switch including a plurality of network ports for transmitting and receiving packets to and from network nodes via network links, each of the packets having a destination address and a source address, the switch being operative to communicate with at least one trunking network device via at least one trunk formed by a plurality of aggregated network links. The present invention provides a method and apparatus for balancing the loading of the aggregated network links of the trunk, thereby increasing the data transmission rate through the trunk.

The switch includes: a packet buffer for temporarily storing a packet received at a source port of the network ports, the packet having a source address value, and a destination address value indicating a destination node that is communicatively coupled with the switch via a data path including a trunk; a packet routing unit for determining a destination trunked port associated with the packet, the destination trunked port including a subset of the plurality of network ports, the destination trunked port being coupled to the destination node via the data path; and a load balancing unit for selecting a destination port associated with the packet from the subset of network ports; whereby transmission loading of the aggregated network links of the trunk is balanced.

In a port-based load balancing embodiment of the present invention, the load balancing unit is responsive to a source port ID value indicating the source port, and is operative to select the destination port as a function of the source port ID value.

In accordance with a first MAC address based load balancing embodiment of the present invention, the load balancing unit is responsive to the source address value of the packet, and is operative to select the destination port as a function of the source address value. In accordance with a second MAC address based load balancing embodiment, the load balancing unit is responsive to the corresponding source and destination address values of the packet, and is operative to select the destination port as a function of the source and destination address values.

An important advantage of a switch according to the present invention is that it provides a method and apparatus for balancing the loading of aggregated network links of a trunk connected to the switch, thereby increasing the data transmission rate through the trunk.

The foregoing and other objects, features, and advantages of the present invention will be apparent from the following detailed description of the preferred embodiment which makes reference to the several figures of the drawing.

IN THE DRAWING

FIG. **1** is a schematic block diagram of an exemplary network system having a packet switch providing load balancing for a trunked link coupled between the switch and other network devices in accordance with the present invention;

FIG. **2** is a schematic block diagram of one embodiment of the packet switch of FIG. **1**, the switch including a system administration unit, and a plurality of switching devices each providing load balancing functions in accordance with the present invention;

FIG. **3**A is a detailed schematic circuit block diagram of a switching device of the packet switch of FIG. **2**, the switching device including an address resolution circuit, a packet routing table, and a trunk port configuration unit in accordance with the present invention;

FIG. **3**B is a detailed schematic circuit block diagram of an alternative embodiment of the switching device of FIG. **3**A wherein the device is responsive to a local system administrator;

FIG. **4**A is a generalized block diagram illustrating the structure and contents of the packet routing table of FIGS. **3**A and **3**B, the table being addressable via destination addresses of received packets and providing destination port ID values associated with the received packets;

FIG. **4**B is a block diagram illustrating the format of a regular non-trunking destination port ID value,

FIG. **4**C is a block diagram illustrating the format of trunked destination port ID value,

FIG. **5** is a detailed block diagram illustrating details of the trunk port configuration unit and address resolution circuit of one of the switching devices in accordance with a port based trunked link load balancing scheme of the present invention;

FIG. **6** is a detailed block diagram of a destination trunk port register of the trunk port configuration unit of FIG. **5**;

FIG. **7** is a block diagram of one embodiment of the address resolution circuit of FIGS. **3**A and **3**B in accordance with a first MAC address based trunked link load balancing scheme in accordance with the present invention; and

FIG. **8** is a block diagram of an embodiment of the address resolution circuit of FIGS. **3**A and **3**B in accordance with a second MAC address based trunked link load balancing scheme in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention overcomes the problems associated with the prior art by providing a method and apparatus for load balancing in trunking and link aggregation. In the following description, numerous specific details are set forth (e.g., a specific format for a trunked port ID value in a packet switch having a predefined number of ports) in order to provide a thorough understanding of the invention. Those skilled in the art will recognize, however, that the invention may be practiced apart from these specific details. In other instances, well known details of circuits (e.g., ETHERNET protocol) have been omitted, so as not to unnecessarily obscure the present invention.

FIG. **1** shows a schematic block diagram at **2** of an exemplary local area network system employing methods and apparatus for load balancing in trunking and link aggregation in accordance with the present invention. The network system **2** includes: a high speed server **3** having a plurality of network ports **4** for transmitting and receiving data packets via corresponding network links; a plurality of clients **5** each having at least one network port **6** for transmitting and receiving data packets to and from device including the server **3** via corresponding network data streams; a packet switch **7** having a plurality of client network ports **8** for transmitting and receiving data packets to and from corresponding ones of the clients **5** via corresponding network links, and a plurality of network ports **9**; and a packet switch **10** providing load balancing for trunked, or aggregated, links in accordance with the present invention as further explained below.

In the depicted embodiment, the local area network system **2** includes six of the clients **5** designated CLIENT_**1**, CLIENT_**2**, CLIENT_**3**, CLIENT_**4**, CLIENT_**6**, and CLIENT_**6**. Each of the clients **5** may be a computer work station, any type of peripheral device connected with the switch **7** via an ETHERNET link (e.g., a printer), or any other type of network node.

The packet switch **10** includes four sets of eight network ports **14** designated ($A_0, A_1, \ldots, A_7$), ($B_0, B_1, \ldots, B_7$), ($C_0, C_1, \ldots, C_7$) and ($D_0, D_1, \ldots, D_7$) respectively for transmitting and receiving data packets via corresponding network links **15**. In one embodiment of the present invention, the local area network **2** operates in accordance with ETHERNET, and each of the network links **15** is an ETHERNET link which transmits and receives packets of information in accordance with ETHERNET protocol.

The packet switch **10** includes means for link aggregation and trunking wherein a plurality of trunked links **17** are formed by aggregating sets of four of the network links **15** as further explained below. In one embodiment, the packet switch **10** may include a maximum of eight trunked ports designated P_0, P_1, P_2, P_3, P_4, P_5, P_6, and P_7 formed by aggregating ports A_0-A_3, ports A_4-A_7, ports B_0-B_3, ports B_4-B_7, ports C_0-C_3, and ports C_4-C_7, ports D_0-D_3, and ports D_4-D_7 respectively. In the depicted embodiment, the packet switch **10** includes seven trunked ports designated P_0, P_1, P_2, P_3, P_4, P_5, and P_7 wherein ports C_0-C_3 are not trunked. Port C_0 is shown to be coupled to a CLIENT_**7** via one of the regular non-trunking network links **15**. The eight trunked ports P_0, P_1, P_2, P_3, P_4, P_5, and P_7 are respectively coupled to eight trunked links designated T_0, T_1, T_2, T_3, T_4, T_5, and T_7. In varying embodiments of the present invention, switch **10** may include any integer number of ports **14**, and trunked ports and trunked links may be formed by aggregating any integer number of ports **14** and links **15**.

In one embodiment, each of the network links **15** has a bandwidth of 100 Megabits per second (100 Mbps), and each of the trunked links **17** provides a bandwidth 400 Mbps. Switch **7** may be implemented by any type of switch having trunking capability. The high speed server **3** includes a network interface card (not shown) providing for trunked link communication via the trunked link T_3.

Each of the server **3**, and clients **5** has media access control information (MAC information) associated therewith including a destination MAC address and a source MAC address of the ETHERNET network. Each of the information packets communicated in the communications network include a destination address and a source address.

Each of the plurality of clients **5** communicates with the server **3** via the network links and the switches **7** and **10**. Because traffic is heavy between the server **3** and the plurality of clients **5**, it is desirable to provide a communication link having a maximized bandwidth between the clients **5** and server **3**. In the depicted embodiment, the ports B_4-B_7 of switch **10** are respectively connected to the ports **4** designated S_0-S_3 of the server **3** via the trunked link T_3, and the ports D_4-D_7 of switch **10** are respectively connected to the ports **9** designated SW_0-SW_3 of the switch **7** via the trunked link T_6. Data streams are provided between the server **3** and the plurality of clients **5** via the trunked link T_3, switch **10**, trunked link T_6, and switch **7**.

Upon receiving a packet from a source device (e.g., the server **3** or one of the clients) at a source port, the switch **10** must provide for: determining a destination port associated with the received packet; and if the destination port is one of the trunked ports P of the switch, the switch **10** must also provide for selecting a particular destination port **14** from the plurality of ports **14** of the destination trunked port P.

In accordance with the present invention, the switch **10** includes a load balanced trunked link port mapping system **168** which is depicted generally in FIG. **1** and which is further explained below. The system **168** generally includes: a packet buffer **170** coupled to receive packets from network nodes via the ports **14** and the trunking ports P; a packet routing unit **180** coupled with the buffer **170** for receiving packet header information including a source MAC address and a destination MAC address of each packet received by the switch, and for determining a destination port ID value associated with each received packet wherein the destination port ID value indicates a corresponding one of either the regular non-trunking ports **14** or one of the trunking ports P; and a load balancing unit **190** coupled with the packet buffer **170** and routing unit **180** and providing for selecting a one of the ports **14** of a destination trunking port P if the destination port ID value indicates one of the trunking ports for a received packet.

For example, consider that a first packet is received from CLIENT_**7** at port C_0, and the destination address of the first packet indicates the high speed server **3**. The packet routing unit **180** generates a destination port ID value indicating trunked port P_3 as the destination port associated with the first packet. The load balancing unit **190** then selects a destination port from ports B_4-B_7 of the trunked destination port P_3. As another example, consider that a second packet is received from CLIENT_**5** at port D_0, and the destination address of the second packet indicates the high speed server **3**. The packet routing unit **180** generates a destination port ID value indicating trunked port P_3 as the destination port associated with the second packet. The load balancing unit **190** then selects a destination port from ports B_4-B_7 of the trunked destination port P_3. As a further example, consider that a third packet is received from the high speed server at port B_4, and the destination address of the third packet indicates CLIENT_**1**. In this case, the packet routing unit **180** generates a destination port ID value indicating trunked port P_6 as the destination trunked port associated with the third packet, and the load balancing unit **190** selects a destination port from ports D_4-D_7 of the trunked destination port P_6.

In accordance with the present invention, the load balancing unit **190** implements a trunked link load balancing scheme. The loading of each of the network links **15** of each of the trunked links **17** is proportional to the number of packets transmitted to the particular link, and is determined in accordance with the type of load balancing scheme implemented by the load balancing unit **190**. In ETHERNET, it is required that the ordering of packets communicated between a particular source and its associated destination be maintained. For a given source-destination data stream providing communication between a source and its associated destination, the ordering of transmitted packets is maintained if the source-destination data stream is implemented over a non-varying physical data path. Therefore, it is not practical to implement a mapping scheme in the switch **10** between ports of a receiving trunked port and ports of a transmitting trunked port wherein packets received via the receiving trunked port are provided to and transmitted from the first available port of the receiving trunked port.

In accordance with a port-based load balancing scheme, further described below, a destination port selected for a particular packet received at a particular source port is determined in accordance with a port-based static programmed mapping scheme. As an example, packets received at source ports B_4-B_7 may be programmed to be provided to and transmitted from corresponding destination ports D_4-D_7 respectively. As another example, packets received at source ports B_5, B_6, B_7, and B_4 may be programmed to be provided to and transmitted from corresponding destination ports D_6, D_4, D_5, and D_7 respectively. In the port based load balancing scheme, the destination port for a particular packet (selected from the plurality of ports of a corresponding destination trunked link) is determined based on the source port at which the packet has been received.

In accordance with a first MAC address table based load balancing scheme, further described below, the load balancing unit **190** implements a dynamic trunked port mapping scheme wherein the destination port for a particular packet (selected from the plurality of ports of its corresponding destination trunked link) is determined based on the source address of the packet.

In accordance with a second MAC address table based load balancing scheme, further described below, the load balancing unit **190** implements a dynamic trunked port mapping scheme wherein the destination port for a particular packet (selected from the plurality of ports of the destination trunked link associated with the particular packet) is determined based on the MAC source address and the MAC destination address of the packet.

FIG. **2** shows a schematic block diagram at **10** of one embodiment of the packet switch **10** (FIG. **1**) implemented as a packet switching fabric including means for load balancing for link aggregation and trunking (not shown) according to the present invention as further explained below. Although the load balanced trunked link port mapping system **168** (FIG. **1**) is shown as implemented in a packet switching fabric having a ring topology, it will be apparent to those skilled in the art that the load balanced trunked link port mapping methods of the present invention may be implemented in a packet switch having any type of topology including a bus, a token ring, and a cross bar switch. Therefore, the trunked link load balancing methods and apparatus of the present invention should not be construed as limited to use in a packet switching fabric having a ring topology.

The switching fabric **10** includes four switching devices **12**, designated SWITCH_A, SWITCH_B, SWITCH_C, and SWITCH_D, having the network ports **14** designated (A_0, A_1, . . . , A_7), (B_0, B_1, . . . , B_7), (C_0, C_1, . . . , C_7) and (D_0, D_1, . . . , D_7) respectively for transmitting and receiving data packets via the corresponding ETHERNET links **15**; a data ring input port **16** connected to receive data and data ring messages from an upstream device via a corresponding one of a plurality of 33-bit data ring segments **18**; a data ring output port **20** connected to transmit data and data ring messages to a corresponding downstream device via a corresponding one of the data ring segments **18**; a control ring input port **22** connected to receive control ring messages which include resource reservation protocol messages from the corresponding upstream device via a corresponding one of a plurality of control ring segments **24**; and a control ring output port **26** connected to transmit control ring messages to the corresponding downstream device via a corresponding one of the control ring segments **24**.

The switching fabric includes means for link aggregation and trunking wherein each of the switching devices **12** includes two selectable trunked ports each formed by aggregating four of the network ports **14** as further explained below. SWITCH_A includes two selectable trunked ports designated P_0 and P_1 which are formed by aggregating ports A_0-A_3, and ports A_4-A_7 respectively. SWITCH_B includes two selectable trunked ports designated P_2 and P_3 which are formed by aggregating ports B_0-B_3, and ports B_4-B_7 respectively. SWITCH_C includes two selectable trunked ports designated P_4 and P_5 which are formed by aggregating ports C_0-C_3, and ports C_4-C_7 respectively. SWITCH_D includes two selectable trunked ports designated P_6 and P_7 which are formed by aggregating ports D_0-D_3, and ports D_4-D_7 respectively. Trunked ports P_0-P_7 are coupled to trunked links T_0-T_7 respectively.

The packet switching fabric **10** also includes: a dedicated ring management device **42** having a data ring input port **44** connected to receive data and data ring messages from the corresponding upstream device, SWITCH_D, via a corresponding one of the data ring segments **18**, a data ring output port **46** connected to transmit data and data ring messages to the corresponding downstream device, SWITCH_A, via a corresponding one of the data ring segments, a control ring input port **48** connected to receive control ring messages from the upstream device via a corresponding one of the control ring segments **24**, and a control ring output port **46** for transmitting control ring messages to the downstream device via a corresponding one of the control ring segments; and a central processing unit (CPU) **52** having a port **54** connected to a port **56** of the management device **42** via a CPU link **57**.

The CPU **52**, which is included within the load balancing unit **190** (FIG. **1**), executes system administration software, and provides for port mapping in accordance with the port based load balancing embodiment. As further explained below, each of the switching devices **12** includes apparatus for configuring the trunk ports T_0-T_7 of the packet switch **10**. The system administrator provides trunk port configuration signals to each of the switching devices **12** via the control ring **24** for the purpose of configuring the trunk ports T_0-T_7 of the packet switch **10**.

FIG. **3**A shows a detailed schematic circuit block diagram of components of one of the switching devices **12** of the packet switching fabric of **10** (FIG. **2**). Each of the switching devices includes a data ring processing sub-system, a network interface sub-system, and a control ring sub-system. The control ring sub-system of the switching device **12** includes a control ring processing unit **70** having: an input port **72** connected to receive control ring messages including resource reservation protocol messages via control ring input port **22**; an output port **74** connected to provide the control ring messages to the control ring via the control ring output port **26**; a bandwidth control port **76** connected to provide channel bandwidth resource control signals to a data ring channel bandwidth resource means **78**, and a packet buffer channel bandwidth resource means **80** further explained below; and ports **81**, **82**, and **84** further explained below.

The data ring processing sub-system of the switching device **12** includes a data ring processing unit **90** having: an input **92** connected to receive packet data bursts from a corresponding upstream switching device **12** (FIG. **2**) via a corresponding data segment **18** and the data ring input port **16**; a data port **94** further explained below; a port **96** further explained below; an output **98** connected to the data ring output port **20** via the data ring channel bandwidth resource means **78**, and a port **99** further explained below.

The depicted switching device **12** further includes: a data distribution control unit **102** having eight outputs **104**, a port **105** coupled for communication with port **82** of the control ring processing unit **70**, a port **106** connected to receive packet data bursts from output **94** of the data ring processing unit **90**, and a port **107** further explained below; and eight transmit buffer queues **108** each having an input **109** connected to receive data from a corresponding one of the eight outputs **104** of unit **102**, and an output **110** connected to a corresponding one of eight network output ports **112** designated (A_0', A_1', . . . , A_7'). The data distribution control unit **102** also includes a multicast queue **114** having an input **115** connected to port **107** of the control unit **102** as further explained below.

The data distribution control unit **102** further includes a network output port arbitration sub-system (not shown) for communicating with local and non-local requesting agents competing for access to the eight network output ports for the purpose of transmitting data packets to the network. Details of the arbitration sub-system are described in Applicants' pending U.S. Patent Application (Serial Number not yet assigned) which claims priority to Applicants' U.S. Provisional Patent Application Ser. No. 60/073,861 filed Feb. 3, 1998, entitled "Bit Slice Arbiter" which is incorporated herein by reference in its entirety.

The control ring processing sub-system of the depicted switching device **12** further includes: a trunk port configuration unit (TPC unit) **116** having a port **117** coupled for communication with port **81** of the control ring processing unit **70**, a port **118** coupled for communication with port **99** of the data ring processing unit **90**, and a port **119**; and an input queuing control unit **120** having a queuing control logic unit **121**.

The input queuing control unit **120** includes: a port **122** coupled to port **119** of the trunk port configuration unit **116**; a port **123** coupled to port **107** of the data distribution control unit **102**; a bus port **124**; a control port **126** connected to receive queuing enable signals from port **84** of the control ring processing unit **70**; a port **128** connected to port **96** of the data ring processing unit **90**; a packet buffer memory control port **130**; and a data port **132**.

The input queuing control unit **120** further includes: a packet routing table (PRT) **134** providing packet routing information as further described below, and having a port **135**; and an address resolution circuit **136** having a port **137** coupled for communication with port **135** of the packet routing table (PRT) **134**, and a port **138** coupled for communication with port **118** of the trunk port configuration unit **116**. In one embodiment, the trunk port configuration unit **116**, and address resolution circuit **136** implement the load balancing unit **190** (FIG. **1**) and provide trunked link load balancing functions in accordance with the present invention as further explained below. Also, in one embodiment, the queuing control logic unit **121** and packet routing table **134** implement the packet routing unit **180** (FIG. **1**).

A network interface sub-system of the depicted switching device **12** includes an internal first in-first out buffer (FIFO) **145** having an output **146** connected to provide data to input **134** of the control unit **120**, and an input **147**; an external packet buffer **150** having a data output **152** connected to input **147** of FIFO **145** via the packet buffer channel bandwidth resource means **80** which is responsive to the channel bandwidth resource control signals provided by the control ring processing unit **70** to control the bandwidth resources of the 32 bit wide communication path between output **152** of packet buffer **150** and input **147** of the FIFO **145**, a control port **154** connected to receive queuing control signals from the packet buffer memory control port **132** of the control unit **120** and also providing data address pointer information to control port **130** of the input queuing control unit, and an input **156** connected to a bus **158** which is connected to bus port **124** of the control unit **120**; and eight receive buffer queues **160** each having an output **162** connected to provide data to the bus **158**, and an input **164** connected to receive data from a corresponding one of eight network input ports **166** designated (A_0", A_1", . . . , A_7"). The eight network input ports **166**, and corresponding eight network output ports **112** designated (A_0', A_1', . . . , A_7') are implemented by the eight network bi-directional ports **14** designated (A_0, A_1, . . . , A_7) (FIG. **2**). In one embodiment, each of the buffer queues **108** and **160**, and the packet buffer **160** implement the packet buffering unit **170** (FIG. **1**).

An ETHERNET frame, or packet of data, includes header information specifying a source address of a source end node, and a destination address of a destination end node. When a data packet is received via one of the network input ports **166**, the data packet is initially buffered by the corresponding receive buffer queue **160**. The control unit **120**, which is connected to bus **158** via port **124**, receives header information of the packet including its media access control information (MAC information) including a destination MAC address and a source MAC address of the ETHERNET. Concurrently, the packet is transmitted to and stored in buffer **150**. Upon storing the data packet, buffer **150** provides pointer addresses to port **132** of the control unit **120** which includes queuing structure storage registers for storing pointer addresses corresponding to each received data packet.

After the arbitration sub-system (not shown) grants access to the packet routing table **134** for a data packet, the address resolution circuit **136** reads the destination address included in the header information of the data packet received via the network ports to determine a destination port of the packet via the packet routing table **134** which provides ID codes of the destination device and output port which is communicatively coupled to the destination end node specified by the destination address. The packet routing table **134** indicates to which network output port **112** of which device **12** a particular packet must be forwarded to reach the end node indicated by the destination address specified by the packets header. The address resolution circuit **136** reads the header information of the data packet including the source address and destination address, and performs a packet destination look up operation using the destination address.

When a match is found in the packet routing table **134** for a destination address specified by packet header information, it is then determined whether the destination address is connected to a network port of the receiving device, or to a network port of another device of the switching fabric **10** (FIG. **2**). If the destination port is a local network port **14** (FIG. **2**) of the current receiving device, only a local transaction must be processed. If the destination port is a network port **14** (FIG. **2**) of a device of the fabric other than the current receiving device, the data packet must be transferred from the current receiving device, or "source device", to the destination device via the data ring by processing an interconnect transaction which requires resource reservation performed using a resource reservation protocol.

The resource reservation protocol is used to set up source-destination channels for each interconnect transaction prior to beginning the transfer of data from a source device to a destination device via a source-destination channel on the data ring. The resource reservation protocol uses protocol control messages including a source request message (SRC_REQ message), a get resource message (GET_RES message), and a destination grant message (DST_GRANT message).

To initiate an interconnect transaction, the control ring processing unit **70** of a source device develops a SRC_REQ message including a field carrying the destination port ID code associated with the destination port, determined by and received from the control unit **120**. The control ring processing unit **70** transmits the SRC_REQ message to the destination device via the control ring. When a destination device receives a SRC_REQ message from a source device via the control ring, the SRC_REQ message is temporarily buffered. The control ring processing unit **70** reads the SRC_REQ messages and provides corresponding request signals to the network output port arbitration sub-system **116**. Based on the source port and destination port indicated by the SRC_REQ message, the processing unit **70** provides a signal to the arbitration sub-system **116** requesting access to the destination port on behalf of the source port as the requesting agent.

The control unit **120** is operative to access data packets a data burst at a time from the external packet buffer **150** in response to the queuing enable signal received at port **126** from the control ring processing unit **70**. Data packets are read out a burst at a time from the external packet buffer **150** via multiple channels under control of the control unit **120**. When the control ring processing unit **70** allocates sufficient external packet buffer channel bandwidth, the packet buffer begins transmitting packet data bursts from output **178** of the buffer **150** to input **147** of the internal FIFO **145** under control of the input queuing control unit **120**.

For local transactions for which the destination port is a local interconnect output port: if the source selected by the arbitration process is the local multicast queue **110** of the data distribution control unit **102**, the packet at the head of the multicast queue is transferred to the appropriate one of the transmit buffer queues **106** for transmission via the corresponding network output port **108**; and if the source selected by the arbitration process is one of the local receive buffer queues **160**, the control ring processing unit **70** sets up a channel to communicatively couple the external packet buffer **150** to the appropriate one of the transmit buffer queues **108** when the requested packet buffer channel bandwidth is available. In a local interconnect transaction for which the destination port is the local multicast queue **112**, if the source selected is a local receive queue **160**, the control ring processing unit **70** sets up a channel to communicatively couple the external packet buffer **150** to the multicast queue **10** when the requested packet buffer channel bandwidth is available.

Additional details of the packet switching fabric **110** are described in Applicants' pending U.S. patent application Ser. No. 09/092,350, filed Jun. 5, 1998, entitled "Packet Switching Fabric Using A Segmented Ring With Resource Reservation Protocol", which is incorporated herein by reference in its entirety. U.S. patent application Ser. No. 09/092,350 claims the benefit of Applicants' earlier filed U.S. Provisional Application Ser. No. 60/073,535, filed Feb.

3, 1998, entitled "Packet Switching Fabric Using the Segmented Ring With Resource Reservation Control."

FIG. **3**B shows a detailed schematic circuit block diagram of an alternative embodiment of one of the switching devices **12** of the packet switching fabric of **10** (FIG. **2**). In this embodiment, the packet switching fabric (FIG. **2**) does not include the dedicated system management device **42** and CPU **52** (FIG. **2**), and the system administration functions, mentioned above and further described below, are implemented by a local system administration unit **180** which is connected to communicate with the trunk port configuration unit **116** via its port **117**. In varying embodiments, the local system administration unit **180** may be implemented by an EEPROM or by a processing unit.

FIG. **4**A shows a generalized block diagram illustrating at **200** the structure and contents of the packet routing table **134** (FIGS. **3**A and **3**B) of a particular one of the switching devices **12** of the packet switching fabric **10** (FIG. **2**). In the depicted embodiment, the packet routing table **134** includes a plurality of entries **202**, each entry including: a MAC destination address field **204** for storing the MAC destination address of a corresponding one of the packets received by the particular switching device; miscellaneous fields **206** for storing additional packet routing information; and a destination port ID field **208** for storing a destination port ID value indicating a destination port of the switching fabric **10** (FIG. **2**) for the corresponding received packet. The destination port ID value may indicate one of the trunked ports P_0-P_7 (FIG. **1**) of the switch **10** (FIG. **1**), or a regular non-trunking network port **14** (FIG. **1**) as determined by a destination port ID value coding scheme as further explained below.

The packet routing table **134** is accessed by logic (not shown) of the address resolution circuit **136** (FIG. **3**A) of the input queuing control unit **120** (FIG. **3**A). Upon receiving a particular packet from one of the eight receive buffer queues **160** (FIGS. **3**A and **3**B) of the particular switching device **12**, the address resolution circuit **136** provides the destination MAC address value of the particular packet to the packet routing table **134** to determine a target entry **202** storing a destination address value matching the destination MAC address value of the particular packet. The address resolution circuit then reads the destination port ID value from the destination port field **208** associated with the target entry **202** to determine a destination port corresponding with the particular packet. As mentioned above, the destination port is communicatively coupled with a destination node specified by the MAC destination address indicated by the particular packet.

In the depicted embodiment, the destination port ID field **208** of each entry **202** stores a 6 bit destination port ID value indicating the destination port for a corresponding packet. In one embodiment of a destination port ID value coding scheme in accordance with the present invention, if a first bit field **210** of the destination port ID field **208** stores a value of zero, then it is assumed that the indicated destination port is a regular non-trunking network port **14** (FIG. **1**) of the switch **10**. Alternatively, if a trunk port subfield **212** including the first three bits of the destination port ID field **208** stores the value '100', then it is assumed that the indicated destination port is one of the trunked ports P_0-P_7 (FIG. **1**) of the switch.

FIG. **4**B shows a block diagram illustrating a format at **216** of a regular non-trunking destination port ID value including: the first bit **210** having the value '0' stored therein to indicate that the destination port is a regular non-trunking network port **14** (FIG. **1**); a device ID field **220** for storing an N-bit destination device ID value uniquely identifying a corresponding destination one of the plurality of switching devices **12** (FIG. **2**) wherein N is the minimum number of bits required to uniquely identify each of 2^N switching devices; and a port ID field **222** for storing an M-bit destination port ID value for uniquely identifying a corresponding destination one of a plurality of M network ports **14** (FIG. **2**) of the destination device, wherein M is the minimum number of bits required to uniquely identify each of 2^M network ports of the destination switching device. In the example of the switching fabric **10** (FIG. **2**) which includes four switching devices **12** each having network ports **14** (N=2, and M=3), a regular non-trunking destination port may be uniquely identified by a two-bit destination device ID value (x, x) stored in device ID field **220**, and a three-bit destination port ID value (y, y, y) stored in port ID field **222**.

FIG. **4**C shows a block diagram illustrating a format at **224** of a destination trunked port ID value including: the trunk port field **212** having the value '100' stored therein to indicate that the destination port is one of the trunked destination ports P_0-P_7 (FIG. **1**); the device ID field **220** for storing the two-bit destination device ID value (x, x) uniquely identifying a corresponding destination one of the plurality of switching devices **12** (FIG. **2**); and a trunk identification field **226** for storing a one-bit destination trunk ID value specifying one of the two trunked ports of the indicated destination device, the trunked ports being coupled to corresponding trunked links **17** (FIG. **1**).

FIG. **5** shows a block diagram at **250** illustrating details of the trunk port configuration unit **116** (FIG. **3**A) and the address resolution circuit **136** (FIG. **3**A) of one the switching devices **12** in accordance with a first embodiment of the present invention wherein the switch **10** (FIG. **1**) provides port based load balancing for each of the trunked links **17** (FIG. **1**). In the depicted embodiment, the trunk port configuration unit **116** includes a register bank **251** having a plurality of 8 trunk port configuration registers **252**, each being associated with a corresponding one of the network input ports **166** (FIGS. **3**A and **3**B) of the switching device **12** (FIGS. **3**A and **3**B). Each of the registers **252** include an input **254** coupled to receive a port mapping signal carrying a sixteen-bit port mapping value from the CPU **52** (FIG. **1**) via port **117** of the TPC unit **116**, and an output **256**. In the alternative embodiment of the switching device **12** (FIG. **3**B) of the packet switching fabric of **10** (FIG. **2**), the inputs **254** of the trunk port configuration registers **252** are coupled to receive the port mapping signals carrying the sixteen bit port mapping values from the local system administration unit **180** (FIG. **3**B) via port **117** of the TPC unit **116**.

The address resolution circuit **136** comprises a port based load balancing circuit **258** including: a source port selection multiplexer **260** having a plurality of (2^M=8) inputs **262** each coupled to receive a corresponding one of the port mapping values from output **256** of a corresponding one of the configuration registers **252** of unit **116**, an output **264**, and a control port **268** coupled to receive a three-bit source port ID value carried by a source port signal received from the input queuing control logic unit **121** (FIG. **3**A) of the particular switching device; a destination trunk port register **272** having an input **274** coupled to receive selected ones of the port mapping values from output **264** of multiplexer **260**, and a plurality of (2^M=8) outputs **276**; and a trunk port selection multiplexer **280** having a plurality of (2^M=8) inputs **282** each coupled to receive a two-bit value from a corresponding one of the outputs **276** of register **272**, an output **284**, and a control port **286** coupled to receive a trunked port

ID signal carrying a three bit trunked port ID value (x, x, t) from the packet routing table **134** (FIGS. **3**A and **3**B) as further explained below.

In the depicted embodiment, the register bank **251** of unit **116** includes eight of the trunk port configuration registers **252**, designated TP_0-TP_7, each being associated with a corresponding one of the eight network ports **14** of the particular switching device **12** (FIG. **3**A). The source port selection multiplexer **260** selects from the outputs **256** of registers **252** in response to the source port value received at its control port **268** from the input queuing control logic **121** (FIG. **3**A). The source port value indicates the source port at which a particular packet has been received. Therefore, the multiplexer **260** selects one of the registers **252** which corresponds with the source port associated with the received packet. As further described below, the 16-bit port mapping value stored in the selected one of the registers **252** includes eight separate 2-bit port values select each indicating a destination port associated with the particular packet received at the corresponding source port.

The destination trunk port register **272**, further described below, stores the 16-bit port mapping value received from the selected one of the registers **252**, and in response to the 3-bit trunk port ID value (x, x, t) received from the packet routing table, multiplexer **280** selects one of the 2-bit values of the 16-bit port mapping value.

FIG. **6** shows a detailed block diagram at **300** of the destination trunk port configuration register **272** of the port based load balancing circuit **258** (FIG. **5**). The register **272** includes sixteen cells **302** each providing storage for one binary value. As mentioned above, input **274** of the register is couple to receive a selected one of the sixteen-bit port mapping values from output **264** of multiplexer **260**, wherein the selected port mapping value for a received packet is determined based on the source port associated with the received packet. As further explained below, each of the sixteen-bit port mapping values includes eight two-bit port select values (z, z) for indicating one of the four network ports **14** of an associated one of the trunked ports P_0-P_7 of the switch **10** (FIG. **1**).

The register **272** provides for storing eight two-bit port select fields **304** designated DTP_0-DTP_7, each field **304** corresponding with one of the trunked ports P_0-P_7 of the switch **10** (FIG. **1**). Each field **304** provides for storing a two-bit port select value (z, z) for indicating one of the four network ports **14** of the corresponding one of the trunked ports P_0-P_7 associated with the particular port select field **304**. For example, the port select field **304** designated DTP_0 stores a two-bit port select value (z_0, z_0) indicating a destination one of the four network ports A_0-A_4 of the trunked port P_0 of the switch **10** (FIG. **1**). Therefore, the sixteen-bit port mapping values, which are provided by the system administrator, determine the particular destination port of the corresponding destination trunked port for each packet based on the source port associated with the packet. These port mapping values are programmed by a user. Therefore, the port based load balancing scheme is static in the sense that the port mapping may only be changed by reprogramming the port mapping values stored in the system administrator.

FIG. **7** shows a block diagram at **310** of one embodiment of the address resolution circuit **136** (FIGS. **3**A and **3**B) in accordance with a source MAC address based load balancing scheme for trunked links in accordance with the present invention. In the depicted embodiment, the address resolution circuit **136** includes a source MAC address code selection circuit **312** having a port **313** coupled to receive 48-bit source MAC address values from the input queuing control logic **121** (FIGS. **3**A and **3**B) via port **139** of the address resolution circuit **136**, and an output **314** coupled to provide two-bit port select values (z, z) for indicating selected ones of the four network ports **14** of corresponding ones of the trunked ports P_0-P_7 of the switch **10** (FIG. **1**). Each of the 48-bit source MAC address values is associated with a received packet, and the two-bit port select value (z, z) indicates a destination port (for the received packet) of the four network ports **14** of a destination one of the trunked ports P_0-P_7 of the switch **10** (FIG. **1**).

The source MAC address code selection circuit **312** includes: a 48-bit register **315** having an input **316** coupled to receive the 48-bit source MAC address values from the input queuing control logic **121** (FIGS. **3**A and **3**B) via port **313**, and a plurality of outputs **318** each providing a corresponding two-bit source address derived value (derived from the stored source address value) from a corresponding pair of cells of the register; and a multiplexer **322** having a plurality of inputs **324** coupled to receive corresponding ones of the two-bit source address derived values from corresponding ones of the outputs **318** of register **315**, an output **326**, and a control port **328** coupled to receive a two-bit (N=2) source address bit select signal from dedicated registers (not shown) of the trunk port configuration unit **116** (FIGS. **3**A and **3**B).

FIG. **8** shows a block diagram at **350** of an embodiment of the address resolution circuit of FIGS. **3**A and **3**B in accordance with a second MAC address based load balancing scheme for aggregated links in accordance with the present invention, wherein destination ports associated with a particular packet are selected from the trunked network ports coupled to a corresponding destination trunk port based on the source address and destination address of the particular packet.

In the depicted embodiment, the address resolution circuit **136** includes the source MAC address code selection circuit **312** (FIG. **7**) having its port **313** coupled to receive the 48-bit source MAC address values from the input queuing control logic **121** (FIGS. **3**A and **3**B) via port **139** of the address resolution circuit **136**, and its output **314** coupled to provide a two-bit port select value (z, z) for indicating one of the four network ports **14** of a corresponding one of the trunked ports P_0-P_7 of the switch **10** (FIG. **1**).

In the depicted embodiment, the address resolution circuit **136** additionally includes a 48-bit destination address register **360** having an input **362** coupled to receive the 48-bit destination MAC address values from the input queuing control logic **121** (FIGS. **3**A and **3**B) via port **139** of the address resolution circuit **136**, and a plurality of outputs **366** each providing a corresponding two-bit value from a corresponding pair of cells of the register **360**; a multiplexer **370** having a plurality of inputs **372** coupled to receive corresponding ones of the two-bit values from corresponding ones of the outputs **366** of register **360**, an output **374**, and a control port **376** coupled to receive a two-bit destination address bit select signal from dedicated registers (not shown) of the trunk port configuration unit **116** (FIGS. **3**A and **3**B); and an exclusive-OR logic unit **380** having a first input **382** coupled to receive a two-bit destination address value DA_{zz} from output **374** of multiplexer **370**, and a second input **384** coupled to receive a two-bit source address value SA_{zz} from output **314** of the source MAC address code selection circuit **312**.

Table 1, below, provides a truth table illustrating the function of the exclusive-NOR logic unit **380**.

TABLE 1

MAC-Address-Table Based Load Balancing Truth Table

DAzz	SAzz	zz
00	00	11
00	01	10
00	10	01
00	11	00
01	00	10
01	01	11
01	10	00
01	11	01
10	00	01
10	01	00
10	10	11
10	11	10
11	00	00
11	01	10
11	10	10
11	11	11

Although the present invention has been particularly shown and described above with reference to a specific embodiment, it is anticipated that alterations and modifications thereof will no doubt become apparent to those skilled in the art. It is therefore intended that the following claims be interpreted as covering all such alterations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A communications device, comprising:

a plurality of network ports, said plurality of network ports including a trunk group formed of a subset of the plurality of network ports, said trunk group communicating with aggregated network links;

a packet routing unit connected to said plurality of network ports, said packet routing unit receiving a packet, said packet including a source address value, and a destination address value, said packet routing unit determining said trunk group as a destination port; and

a load balancing unit in communication with the packet routing unit, said load balancing unit configured to select the destination port from the subset of network ports in the trunk group, said destination port being determined as a function of a source port ID value corresponding to a source port for the packet,

wherein said load balancing unit balances a distribution of packets among the subset of network ports of the trunk group.

2. A communications device as recited in claim **1**, wherein said load balancing unit generates the source port ID value based upon the source address value of the packet, and therefore selects the destination port as a function of the source address value.

3. A communications device as recited in claim **1**, wherein said packet routing unit identifies the trunk group as a single logical port.

4. A communications device as recited in claim **1**, wherein said packet routing unit includes a packet routing table which generates a trunked port ID value based upon the destination address value for the packet.

5. A communications device as recited in claim **4**, wherein said load balancing unit comprises:

a systems administration unit providing a plurality of port mapping values, each port mapping value being associated with a corresponding one of the plurality of network ports, each port mapping value including a plurality of port select values, each port select value being associated with a corresponding one of a plurality of trunked ports of the communications device, each of the plurality of trunked ports including a corresponding subset of the plurality of network ports, each of the port select values indicating a corresponding selected one of the corresponding subset of the network ports of the trunk group;

a trunk port configuration unit coupled to receive said port mapping values from said system administration unit, said trunk port configuration unit including a plurality of configuration registers for storing corresponding ones of the port mapping values; and

an address resolution circuit connected to said trunk port configuration unit.

6. A communications device as recited in claim **5**, wherein said address resolution circuit comprises:

a first multiplexer having a plurality of inputs for receiving corresponding ones of said port mapping values, a control port responsive to said source port ID value, and an output providing a selected one of said port mapping values in response to said source port ID value being applied to said control port of said first multiplexer,

a destination register coupled to said first multiplexer for storing said selected port mapping value, and having a plurality of outputs each providing a corresponding one of said port select values, and

a second multiplexer having a plurality of inputs coupled to said outputs of said destination register, a control port responsive to said trunked port ID value, and an output providing a selected one of said port select values in response to said trunked port ID value being applied to said control port of said second multiplexer, said selected port select value indicating said destination port.

7. A communications device as recited in claim **5**, wherein said system administration unit comprises a processing unit and a memory, and wherein said port mapping values are programmable.

8. A communications device as recited in claim **1**, wherein said load balancing unit comprises:

a register for storing the source address value of the packet, the register including at least one register output, said at least one register output providing a port select value derived from the source address value, the port select value for indicating a selected one of a plurality of network ports of a destination trunked port for the packet.

9. A communications device as recited in claim **8**, further comprising a multiplexer having a plurality of inputs for receiving a corresponding one of the port select values, a control port responsive to a predefined bit select value, and an output providing a selected one of said port select values.

10. A communications device as recited in claim **1**, wherein said load balancing unit comprises:

a first register for storing the source address value of the packet, said first register including at least one output providing a corresponding first value derived from said source address value; and

a second register for storing the destination address value of the packet, said second register including at least one output providing a second value derived from said destination address value.

11. A communications device as recited in claim **10**, wherein said load balancing means further comprises:

an exclusive NOR logic unit responsive to said first and second values, said exclusive NOR logic unit providing a port select value for indicating a selected one of the plurality of network ports of the trunk group.

12. A communications device as recited in claim **1**, wherein each trunk group provides a bandwidth of approximately X times Y, wherein X is a bandwidth of each network link, and Y is a number of network links associated with the trunk group.

13. A communications apparatus, comprising:

a plurality of network ports, said plurality of network ports including a trunk group formed of a subset of the plurality of network ports, said trunk group communicating with aggregated network links;

a packet routing means connected to said plurality of network ports, for receiving a packet, said packet including a source address value, and a destination address value, said packet routing unit determining said trunk group as a destination port; and

a load balancing means in communication with the packet routing means, for selecting the destination port from the subset of network ports in the trunk group, said destination port being determined as a function of a source port ID value corresponding to a source port for the packet,

wherein said load balancing means balances a distribution of packets among the subset of network ports of the trunk group.

14. The apparatus of claim **13**, further comprising:

a systems administration means for providing a plurality of port mapping values, each port mapping value being associated with a corresponding one of the plurality of network ports, each port mapping value including a plurality of port select values, each port select value being associated with a corresponding one of a plurality of trunked ports of the communications apparatus, each of the plurality of trunked ports including a corresponding subset of the plurality of network ports, each of the port select values indicating a corresponding selected one of the corresponding subset of the network ports of the trunk group;

a trunk port configuration means for receiving said port mapping values from said system administration unit, said trunk port configuration means including a plurality of configuration registers for storing corresponding ones of the port mapping values; and

an address resolution means for address resolution, connected to said trunk port configuration means.

15. The communications apparatus according to claim **14**, wherein said address resolution means comprises:

a first multiplexer means having a plurality of inputs, for receiving corresponding ones of said port mapping values, a control port responsive to said source port ID value, and an output providing a selected one of said port mapping values in response to said source port ID value being applied to said control port of said first multiplexer,

a destination register means coupled to said first multiplexer means for storing said selected port mapping value, and having a plurality of outputs each providing a corresponding one of said port select values, and

a second multiplexer means having a plurality of inputs coupled to said outputs of said destination register means, a control port responsive to said trunked port ID value, and an output, for providing a selected one of said port select values in response to said trunked port ID value being applied to said control port of said second multiplexer, said selected port select value indicating said destination port.

16. The communications apparatus according to claim **14**, wherein said system administration means comprises a processing means for processing and a memory means for storing, and wherein said port mapping values are programmable.

17. A method for load balancing, the method comprising:

providing a plurality of network ports, said plurality of network ports including a trunk group formed of a subset of the plurality of network ports, said trunk group communicating with aggregated network links;

receiving a packet by a packet router, said packet including a source address value, and a destination address value, said packet routing unit determining said trunk group as a destination port; and

selecting, by a load balancing unit in communication with the packet router, the destination port from the subset of network ports in the trunk group, said destination port being determined as a function of a source port ID value corresponding to a source port for the packet; and

balancing a distribution of packets among the subset of network ports of the trunk group.

18. The method according to claim **17**, further comprising:

generating the source port ID value based upon the source address value of the packet, and

selecting the destination port as a function of the source address value.

19. The method according to claim **17**, further comprising identifying the trunk group as a single logical port.

20. The method according to claim **17**, further comprising generating a trunked port ID value based upon the destination address value for the packet, by a packet routing table.

21. The method according to claim **20**, further comprising:

providing a plurality of port mapping values, each port mapping value being associated with a corresponding one of the plurality of network ports, each port mapping value including a plurality of port select values, each port select value being associated with a corresponding one of a plurality of trunked ports of the communications device, each of the plurality of trunked ports including a corresponding subset of the plurality of network ports, each of the port select values indicating a corresponding selected one of the corresponding subset of the network ports of the trunk group;

receiving said port mapping values; and

storing corresponding ones of the port mapping values.

22. The method according to claim **21**, further comprising:

receiving corresponding ones of said port mapping values;

providing a selected one of said port mapping values in response to said source port ID value being applied to said control port of said first multiplexer;

storing said selected port mapping value, and having a plurality of outputs each providing a corresponding one of said port select values, and

providing a selected one of said port select values in response to said trunked port ID value, said selected port select value indicating said destination port.

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