US 20080130671A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2008/0130671 A1

(43) Pub. Date: Jun. 5, 2008

OKAMOTO

(54) **PACKET DISTRIBUTING APPARATUS AND PACKET DISTRIBUTING METHOD**

(75) Inventor: **Tsugio OKAMOTO**, Tokyo (JP)

Correspondence Address:
Young & Thompson
Second Floor, 745 S. 23rd Street.
Arlington, VA 22202

(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

(21) Appl. No.: **12/018,278**

(22) Filed: **Jan. 23, 2008**

Related U.S. Application Data

(63) Continuation of application No. 10/195,371, filed on Jul. 16, 2002.

(30) **Foreign Application Priority Data**

Jul. 18, 2001 (JP) 2001-218640

Publication Classification

(51) **Int. Cl.**
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **370/412**

(57) **ABSTRACT**

In a packet distributing apparatus and a packet distributing method which, in a situation in which a link can be allocated to a specific user or a specific traffic with priority, can effectively utilize any unoccupied link, a packet inputted via first through Nth the input interface circuits **203**$_1$ through **203**$_N$ is provided by a transfer destination searching unit **205** with a transfer destination port and a transfer-admissible port. Usage detecting units **211**$_1$ through **211**$_N$ check the usage of a transfer-admissible port matching the pertinent one of first through Nth output buffer units **209**$_1$ through **209**$_N$, and distribute the packet to a transfer-admissible port bearing a less load than a prescribed level (less loaded transfer-admissible port). If there is no less-loaded transfer-admissible port, the packet is distributed to the transfer destination port for which it is destined in its own right.

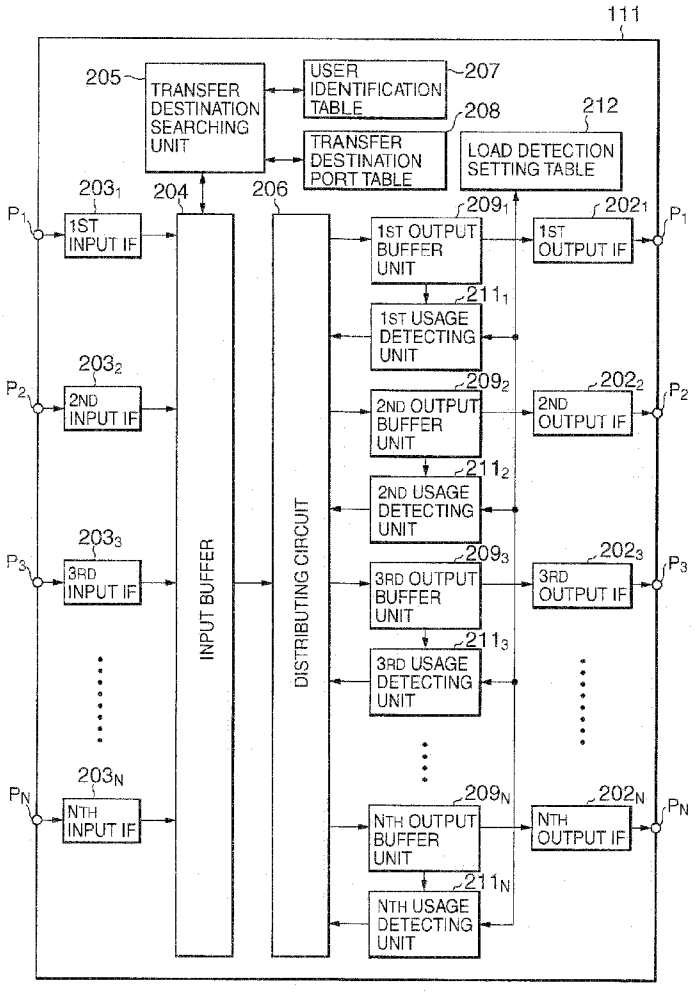


Fig.1

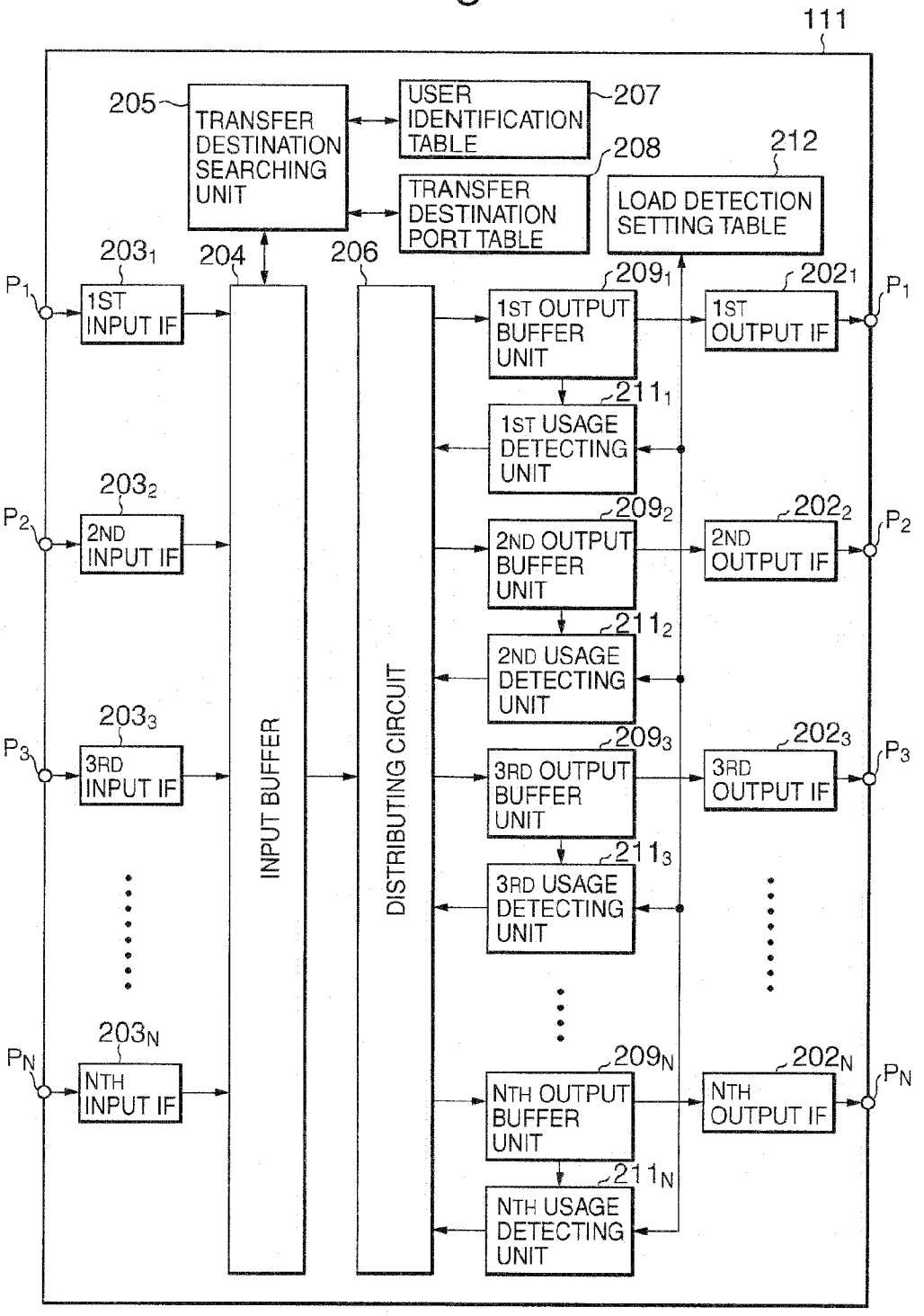

111
205
TRANSFER DESTINATION SEARCHING UNIT
USER IDENTIFICATION TABLE
207
208
TRANSFER DESTINATION PORT TABLE
212
LOAD DETECTION SETTING TABLE
204
206
INPUT BUFFER
DISTRIBUTING CIRCUIT
P1
1ST INPUT IF
2031
1ST OUTPUT BUFFER UNIT
2091
1ST OUTPUT IF
2021
1ST USAGE DETECTING UNIT
2111
P2
2ND INPUT IF
2032
2ND OUTPUT BUFFER UNIT
2092
2ND OUTPUT IF
2022
2ND USAGE DETECTING UNIT
2112
P3
3RD INPUT IF
2033
3RD OUTPUT BUFFER UNIT
2093
3RD OUTPUT IF
2023
3RD USAGE DETECTING UNIT
2113
PN
NTH INPUT IF
203N
NTH OUTPUT BUFFER UNIT
209N
NTH OUTPUT IF
202N
NTH USAGE DETECTING UNIT
211N

Fig.2

(USER IDENTIFICATION TABLE) 207

	SENDER ADDRESS	SENDER PORT NO.	DESTINATION ADDRESS	DESTINATION PORT NO.	USER IDENTIFIER
1	10.11.x.x	any	any	any	UID-2
2	10.2.x.x	any	any	any	UID-1
3					
⋮	⋮	⋮	⋮	⋮	⋮
n					

Fig.3

(TRANSFER DESTINATION PORT TABLE FOR ALL USERS) 208

USER IDENTIFIER	DESTINATION ADDRESS	TRANSFER DESTINATION PORT	1ST TRANSFER-ADMISSIBLE PORT	2ND TRANSFER-ADMISSIBLE PORT	3RD TRANSFER-ADMISSIBLE PORT	.....	t-TH TRANSFER-ADMISSIBLE PORT
UID-1	10.1.x.x	P_2	P_1	0	0	.....	0
	10.2.x.x	P_4	0	0	0	.....	0
						.....	
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
						.....	
UID-2	10.10.x.x	P_1				.....	
	10.11.x.x	P_3				.....	
						.....	
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
						.....	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
UID-m						.....	
						.....	
						.....	
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
						.....	

Fig.4

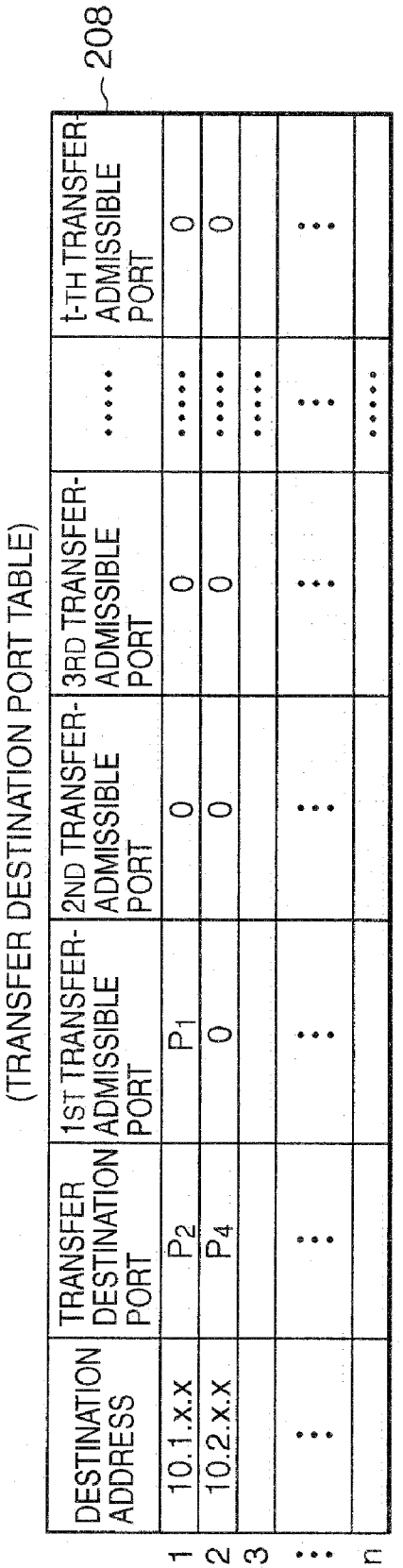

(TRANSFER DESTINATION PORT TABLE)
208
DESTINATION ADDRESS
TRANSFER DESTINATION PORT
1ST TRANSFER-ADMISSIBLE PORT
2ND TRANSFER-ADMISSIBLE PORT
3RD TRANSFER-ADMISSIBLE PORT
t-TH TRANSFER-ADMISSIBLE PORT
1
10.1.x.x
P2
P1
0
0
0
2
10.2.x.x
P4
0
0
0
0
3
n

Fig.5

(LOAD DETECTION SETTING TABLE)

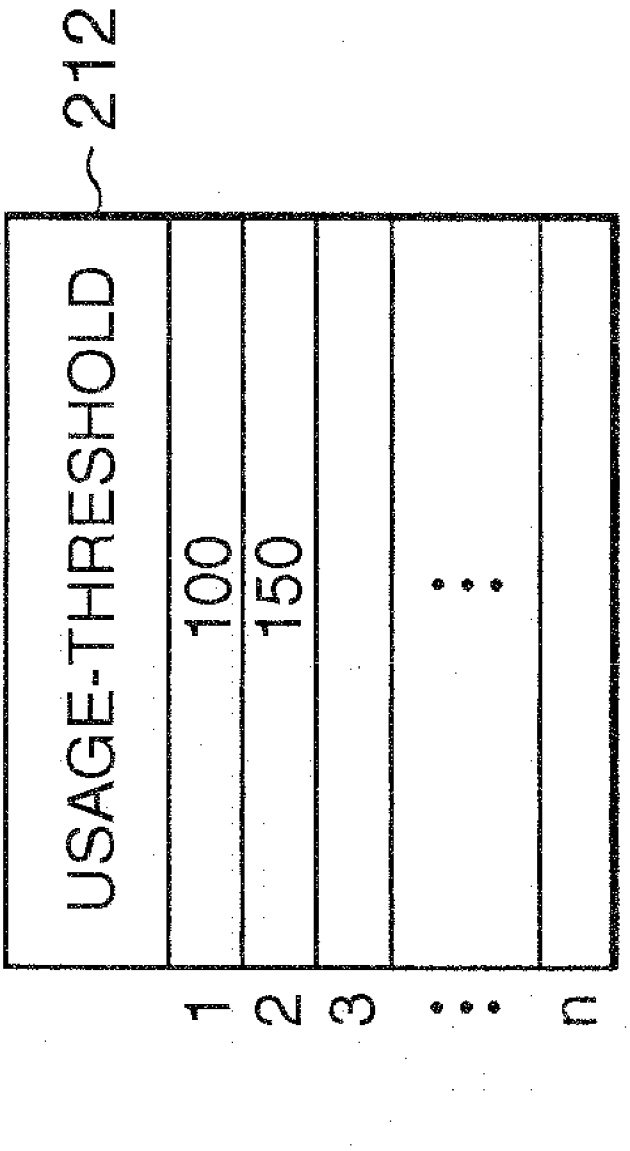


Fig.6

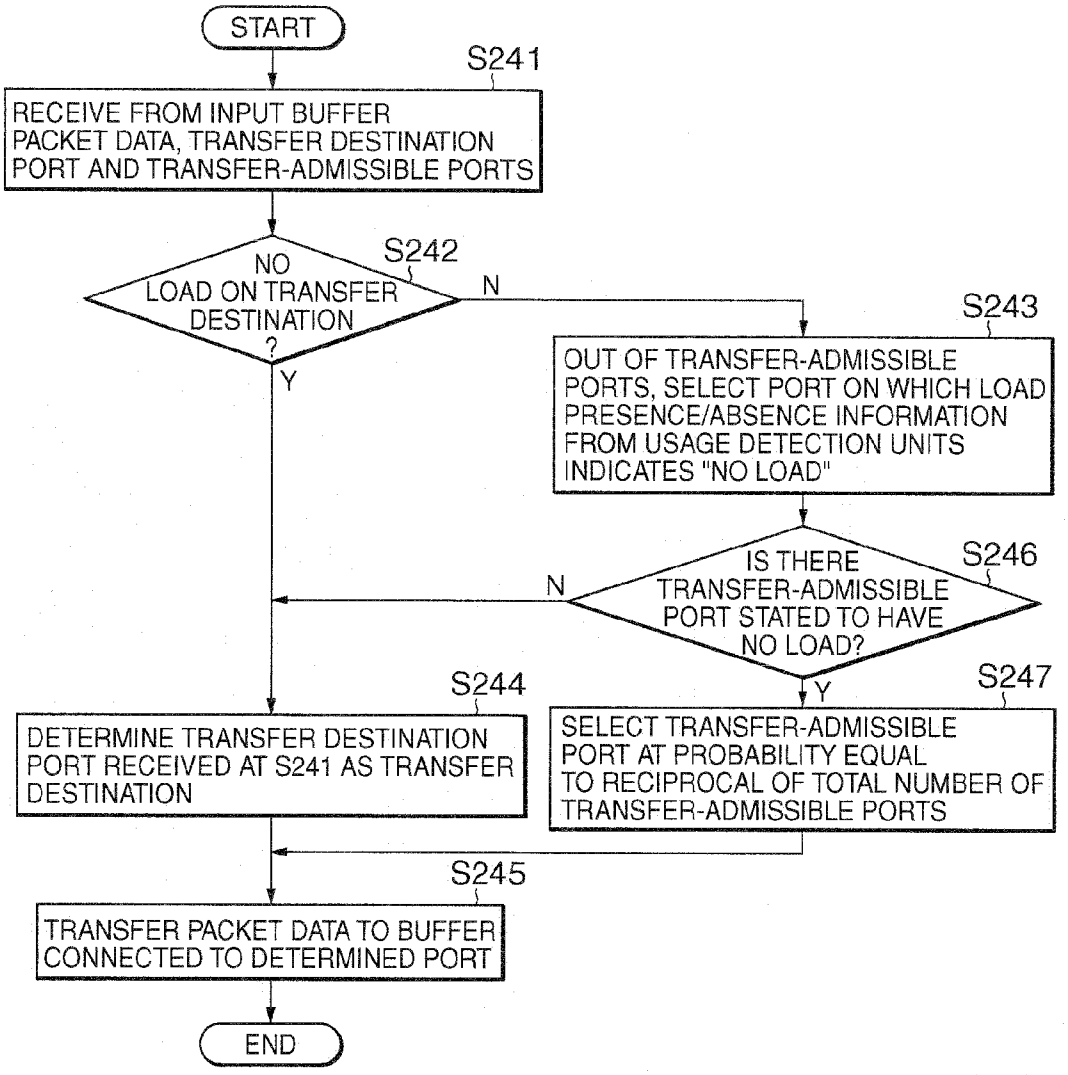

START
S241
RECEIVE FROM INPUT BUFFER PACKET DATA, TRANSFER DESTINATION PORT AND TRANSFER-ADMISSIBLE PORTS
S242
NO LOAD ON TRANSFER DESTINATION ?
N
Y
S243
OUT OF TRANSFER-ADMISSIBLE PORTS, SELECT PORT ON WHICH LOAD PRESENCE/ABSENCE INFORMATION FROM USAGE DETECTION UNITS INDICATES "NO LOAD"
S246
IS THERE TRANSFER-ADMISSIBLE PORT STATED TO HAVE NO LOAD?
N
Y
S244
DETERMINE TRANSFER DESTINATION PORT RECEIVED AT S241 AS TRANSFER DESTINATION
S247
SELECT TRANSFER-ADMISSIBLE PORT AT PROBABILITY EQUAL TO RECIPROCAL OF TOTAL NUMBER OF TRANSFER-ADMISSIBLE PORTS
S245
TRANSFER PACKET DATA TO BUFFER CONNECTED TO DETERMINED PORT
END

Fig.7

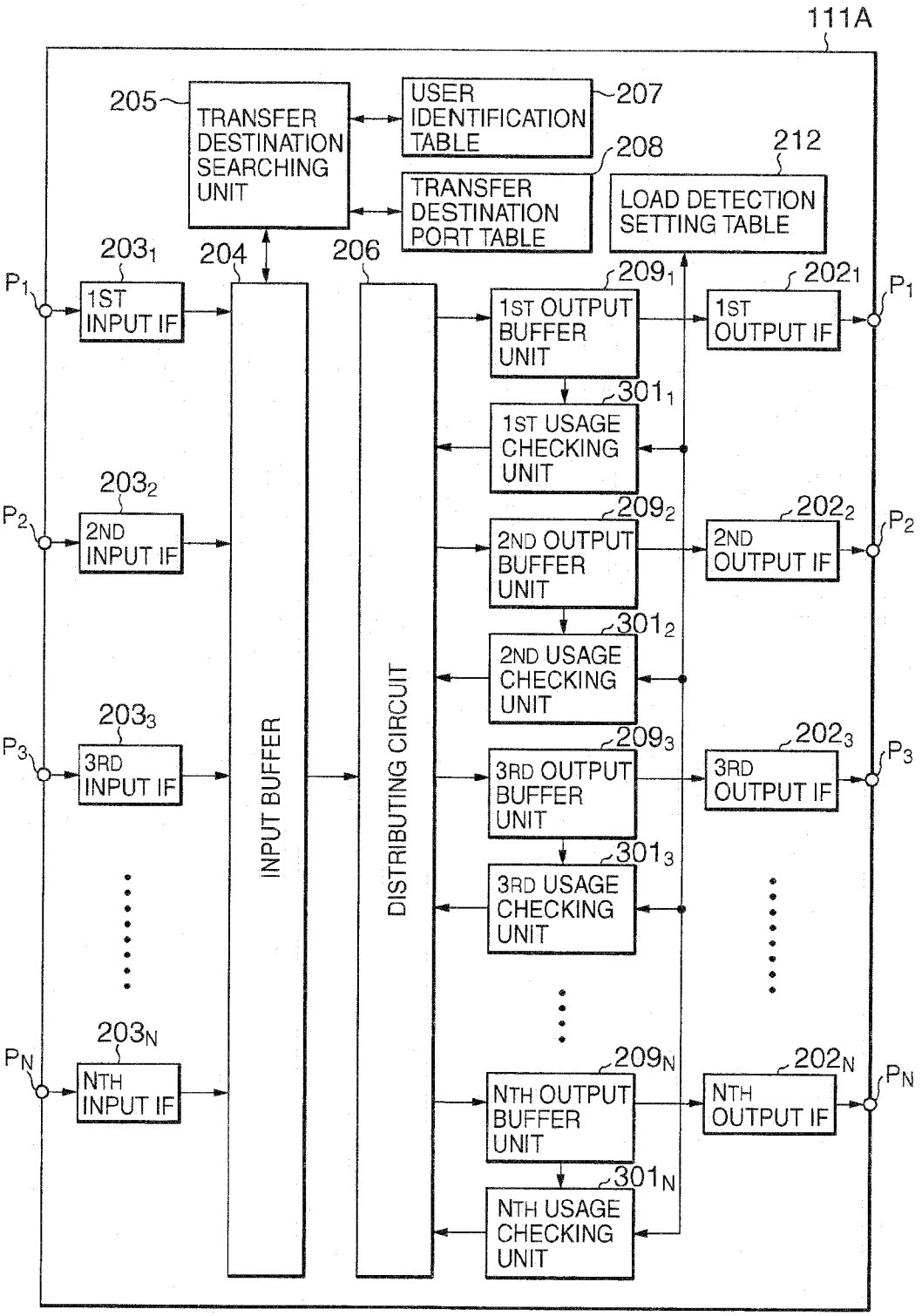

111A
205
TRANSFER DESTINATION SEARCHING UNIT
USER IDENTIFICATION TABLE
207
208
TRANSFER DESTINATION PORT TABLE
212
LOAD DETECTION SETTING TABLE
203_1
204
206
P_1
1ST INPUT IF
209_1
1ST OUTPUT BUFFER UNIT
202_1
1ST OUTPUT IF
P_1
301_1
1ST USAGE CHECKING UNIT
203_2
P_2
2ND INPUT IF
209_2
2ND OUTPUT BUFFER UNIT
202_2
2ND OUTPUT IF
P_2
301_2
2ND USAGE CHECKING UNIT
203_3
P_3
3RD INPUT IF
209_3
3RD OUTPUT BUFFER UNIT
202_3
3RD OUTPUT IF
P_3
301_3
3RD USAGE CHECKING UNIT
INPUT BUFFER
DISTRIBUTING CIRCUIT
203_N
P_N
NTH INPUT IF
209_N
NTH OUTPUT BUFFER UNIT
202_N
NTH OUTPUT IF
P_N
301_N
NTH USAGE CHECKING UNIT

Fig.8

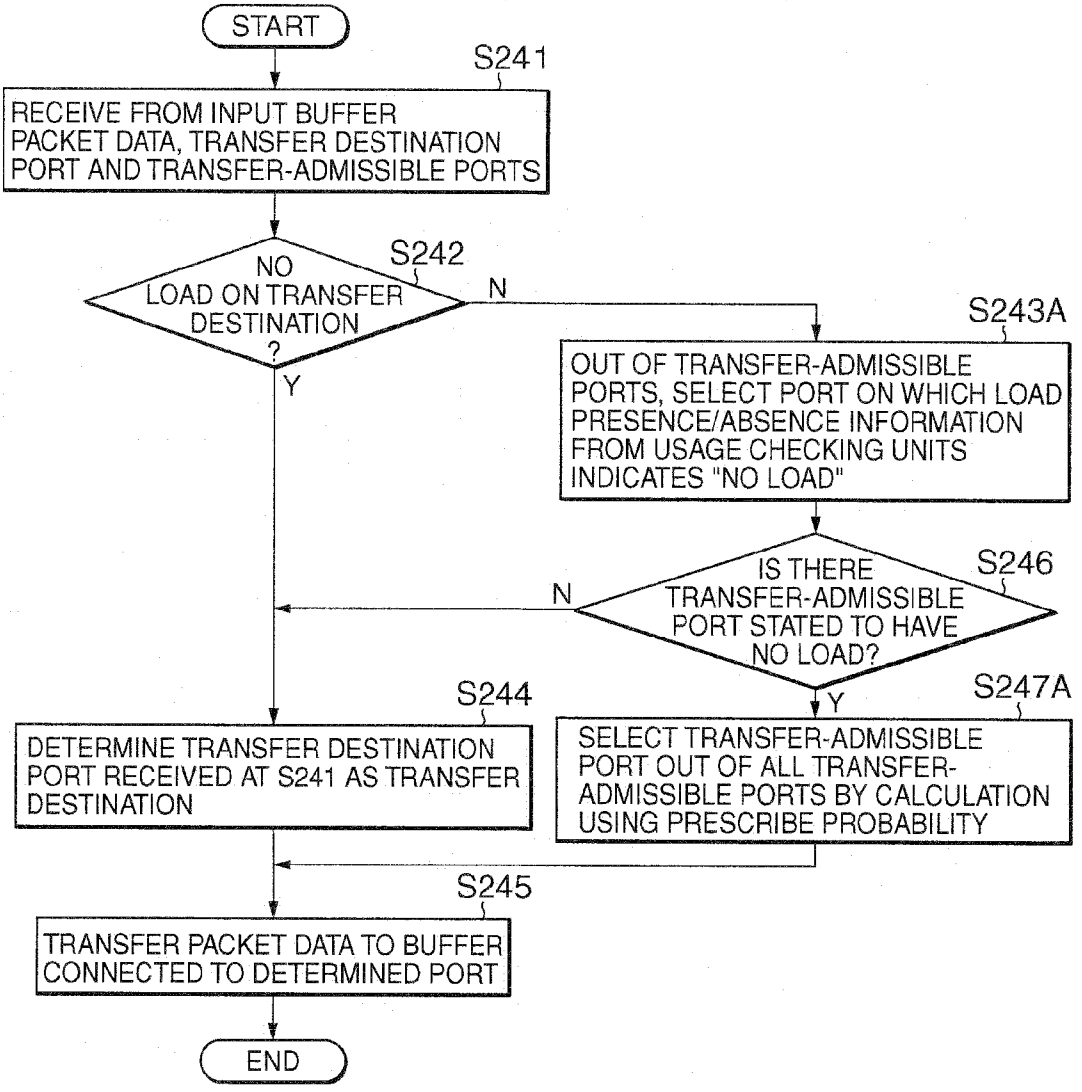

START
S241
RECEIVE FROM INPUT BUFFER PACKET DATA, TRANSFER DESTINATION PORT AND TRANSFER-ADMISSIBLE PORTS
S242
NO LOAD ON TRANSFER DESTINATION ?
N
Y
S243A
OUT OF TRANSFER-ADMISSIBLE PORTS, SELECT PORT ON WHICH LOAD PRESENCE/ABSENCE INFORMATION FROM USAGE CHECKING UNITS INDICATES "NO LOAD"
S246
IS THERE TRANSFER-ADMISSIBLE PORT STATED TO HAVE NO LOAD?
N
Y
S244
DETERMINE TRANSFER DESTINATION PORT RECEIVED AT S241 AS TRANSFER DESTINATION
S247A
SELECT TRANSFER-ADMISSIBLE PORT OUT OF ALL TRANSFER-ADMISSIBLE PORTS BY CALCULATION USING PRESCRIBE PROBABILITY
S245
TRANSFER PACKET DATA TO BUFFER CONNECTED TO DETERMINED PORT
END

Fig.9

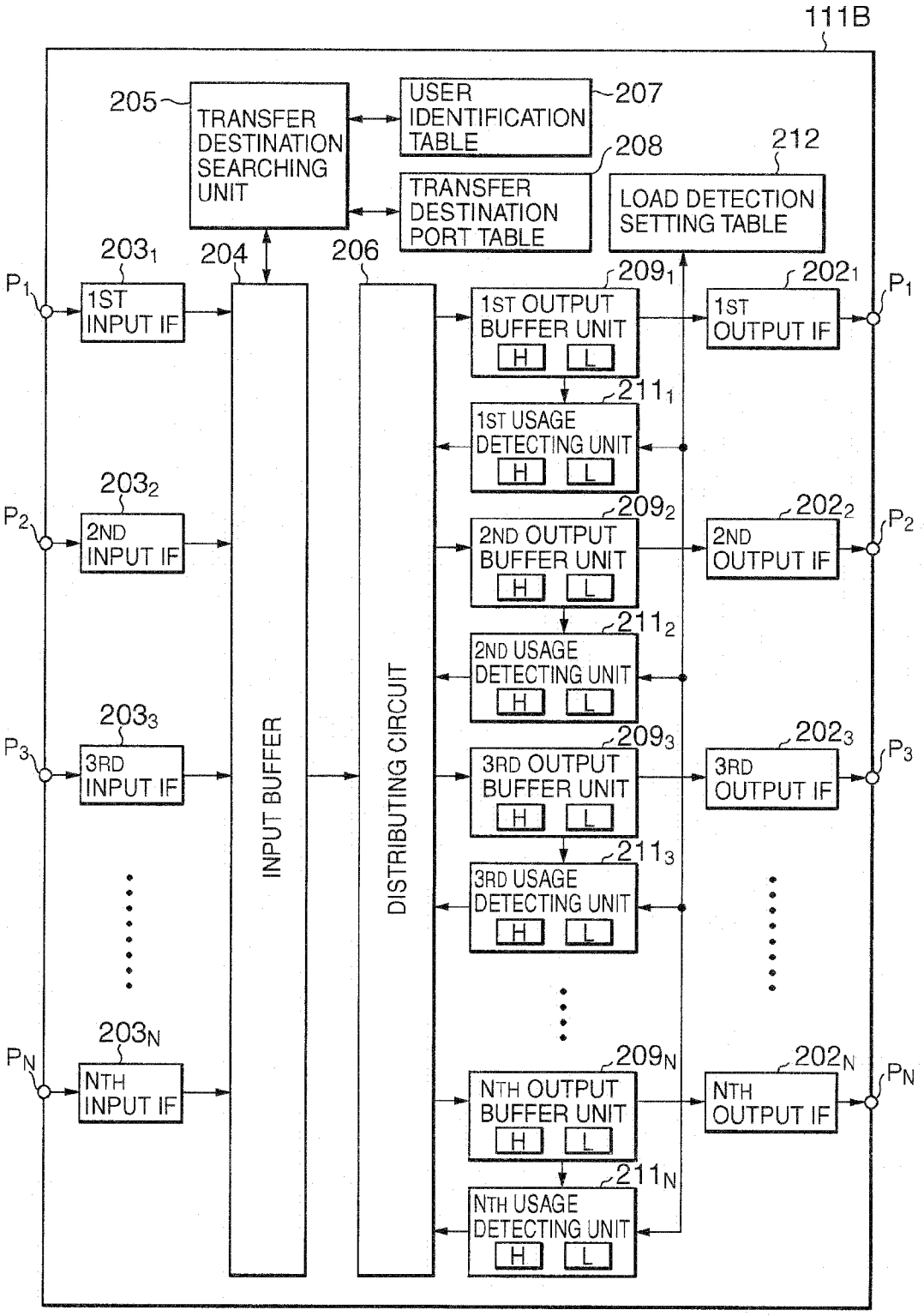

111B
205
TRANSFER DESTINATION SEARCHING UNIT
USER IDENTIFICATION TABLE
207
208
TRANSFER DESTINATION PORT TABLE
212
LOAD DETECTION SETTING TABLE
203_1
204
206
P_1
1ST INPUT IF
209_1
1ST OUTPUT BUFFER UNIT
H
L
202_1
1ST OUTPUT IF
P_1
211_1
1ST USAGE DETECTING UNIT
203_2
P_2
2ND INPUT IF
209_2
2ND OUTPUT BUFFER UNIT
202_2
2ND OUTPUT IF
P_2
211_2
2ND USAGE DETECTING UNIT
203_3
P_3
3RD INPUT IF
209_3
3RD OUTPUT BUFFER UNIT
202_3
3RD OUTPUT IF
P_3
211_3
3RD USAGE DETECTING UNIT
INPUT BUFFER
DISTRIBUTING CIRCUIT
203_N
P_N
NTH INPUT IF
209_N
NTH OUTPUT BUFFER UNIT
202_N
NTH OUTPUT IF
P_N
211_N
NTH USAGE DETECTING UNIT

Fig.10

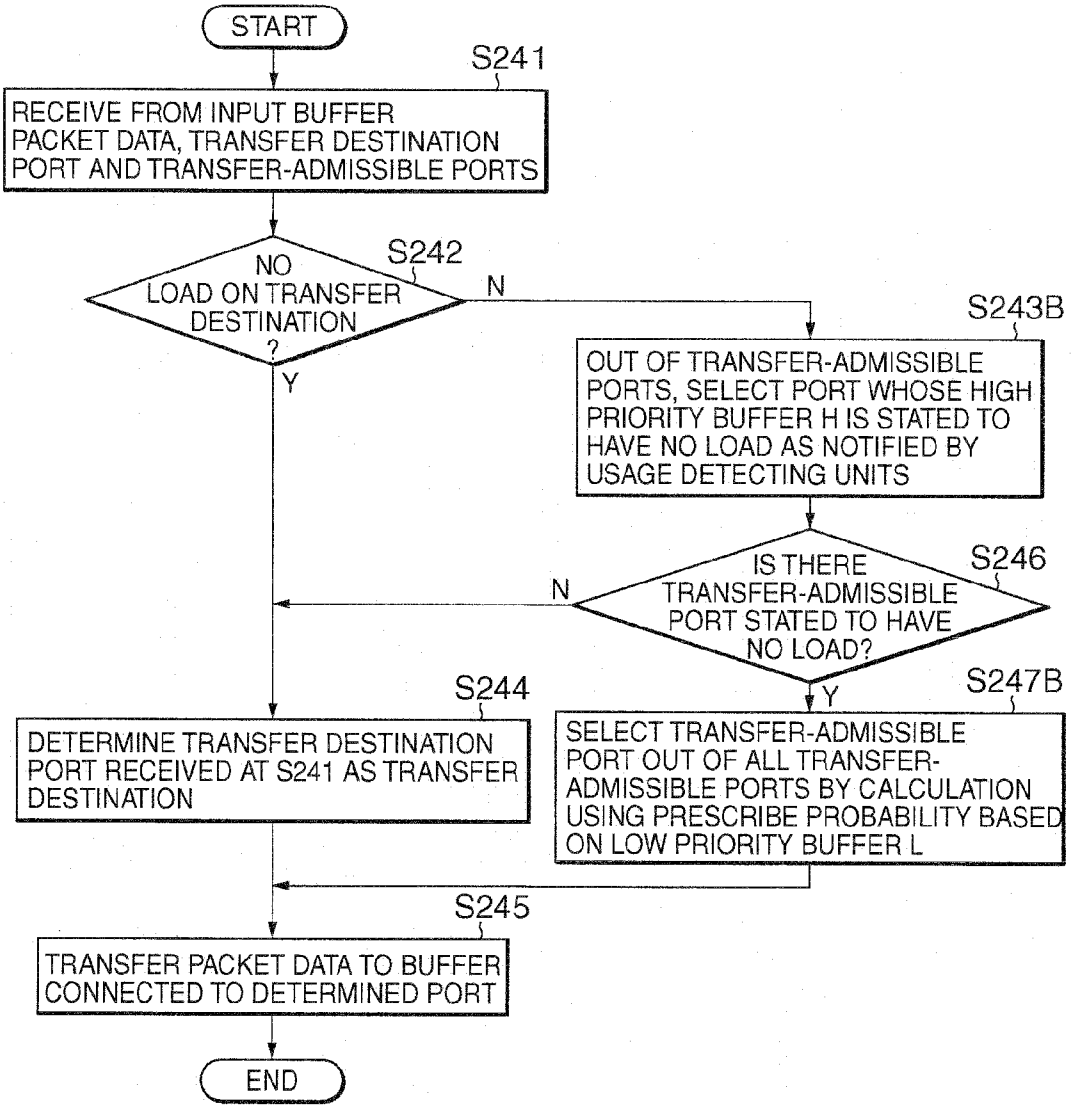
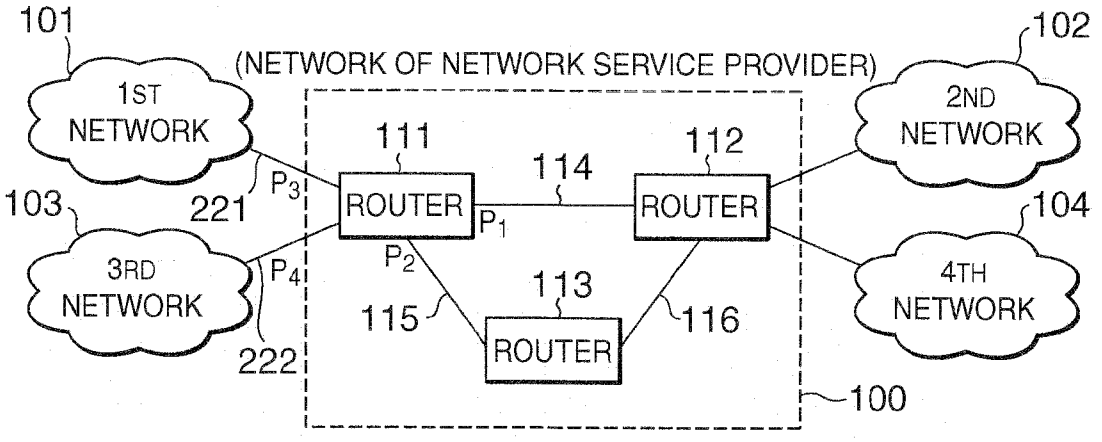

START
S241
RECEIVE FROM INPUT BUFFER PACKET DATA, TRANSFER DESTINATION PORT AND TRANSFER-ADMISSIBLE PORTS
S242
NO LOAD ON TRANSFER DESTINATION ?
N
Y
S243B
OUT OF TRANSFER-ADMISSIBLE PORTS, SELECT PORT WHOSE HIGH PRIORITY BUFFER H IS STATED TO HAVE NO LOAD AS NOTIFIED BY USAGE DETECTING UNITS
S246
IS THERE TRANSFER-ADMISSIBLE PORT STATED TO HAVE NO LOAD?
N
Y
S244
DETERMINE TRANSFER DESTINATION PORT RECEIVED AT S241 AS TRANSFER DESTINATION
S247B
SELECT TRANSFER-ADMISSIBLE PORT OUT OF ALL TRANSFER-ADMISSIBLE PORTS BY CALCULATION USING PRESCRIBE PROBABILITY BASED ON LOW PRIORITY BUFFER L
S245
TRANSFER PACKET DATA TO BUFFER CONNECTED TO DETERMINED PORT
END

Fig.11


101
(NETWORK OF NETWORK SERVICE PROVIDER)
102
1ST NETWORK
2ND NETWORK
111
112
114
ROUTER
ROUTER
221
P3
P1
103
104
3RD NETWORK
4TH NETWORK
P2
P4
113
115
116
ROUTER
222
100

PACKET DISTRIBUTING APPARATUS AND PACKET DISTRIBUTING METHOD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a packet distributing apparatus and a packet distributing method for determining routes to which packets are to be distributed, and more particularly to a packet distributing apparatus and a packet distributing method for making possible effective utilization of communication links.

[0003] 2. Description of the Related Art

[0004] In a network, such as the Internet, a packet sent by its sender reaches its destined recipient by successively going through a number of packet transfer apparatuses. The packet transfer apparatuses would be what are commonly known as routers, switches or hubs. The method of selecting the route over which a packet is to be sent is called routing.

[0005] A packet transfer apparatus references information periodically exchanged among nodes in the network, the required number of hops, transfer time, the presence or absence of trouble on the route and other information, and selects a single route that can provide each individual node with the shortest or the least expensive path.

[0006] FIG. **11** illustrates by way of example a network of a network service provider and first through fourth networks connected to it. It is supposed that first through fourth networks **101** through **104** are connected to a network **101** of the network service provider. Here, the first and third networks **101** and **103** are connected to a first router **111**, and the second and fourth networks **102** and **104** are connected to a second router **112**. The first router **111** and the second router **112** can be directly connected to each other by a link **114**. The first router and the second router **112** can as well be connected to each other via a third router **113** using links **115** and **116**.

[0007] Now it is supposed that the first network **101** and the second network **102** are connected to each other via the network **101** of the network service provider. If the routing is to be determined accorded to the number of hops, the route using the link **114** directly linking the first router **111** and the second router **112** will be set. Where routing is set between the first network **101** and the second network **102** in this manner, the set routing will never be changed unless network trouble such as a node failure arises, the network configuration is altered or the operator of any network changes the setting for itself. Therefore, supposing that a user (not shown) of the first and second networks **101** and **102** has a contract for exclusive use of the link **114** with the network service provider of the network **100**, even if the user A uses the link **114** with a load of far less than 100%, no other user B (not shown) can use the link **114**.

[0008] If the user B intends to establish a communication link (hereinafter referred to as simply "link") between the third network **103** and the fourth network **104**, the aforementioned contract will prevent this user from using the link **114**, and only the link **115** for linking the first router **111** and the third router **113** or the link **116** for linking the second router **112** and the third router **113** can be set for the user B. Thus, even when the link **114** is not used by the first and second networks **101** and **102**, this link **114** cannot be used by the user B.

[0009] As described above, the conventional method by which each user selects only one route and sends out packets on this route prevents the whole network from efficient utilization.

[0010] In view of this problem, there is proposed an idea of distributing loads in the whole network. For instance, to reduce the load on the node bearing the heaviest load in the network, the traffic can be distributed among a plurality of routes. This idea presupposes that all the users or traffics using the network are to be equal. If any inequality arises, loads on a plurality of links will be distributed in a calculated ratio.

[0011] By this proposed method, however, the ratio of load distribution among the plurality of links is fixed. Therefore, where a link is allocated exclusively or with priority to a specific user or a specific traffic, if there happens to arise a situation in which that link is not used, it will result in the same problem as with the prior art that the network cannot be effectively utilized.

SUMMARY OF THE INVENTION

[0012] An object of the present invention, therefore, is to provide a packet distributing apparatus and a packet distributing method which, in a situation in which a link can be allocated to a specific user or a specific traffic with priority, permit effective utilization of any unoccupied capacity that may arise on that link.

[0013] A packet distributing apparatus according to the invention is provided with a plurality each of input ports and output ports, prepared for inputting and outputting of packets and each linked to a different node;

[0014] transfer destination ports each to be selected with priority as an output port, on the basis of information inputted from the plurality of input ports, when the packet is to be sent to its destination;

[0015] a port information searching unit for searching for information regarding a transfer-admissible port as an output to which a transfer is possible as judged from the usage of the link;

[0016] packet storage buffers for temporarily storing the packet inputted from the plurality of input ports until it is outputted from the plurality of output ports, and one prepared on each of the plurality of output ports;

[0017] a transfer-admissible port loaded state judging unit for judging from the usage of the matching one of the packet storage buffers whether or not there is a less loaded transfer-admissible port, on which the load of packet output is less than a prescribed value, among the transfer-admissible ports; and

[0018] a packet sending unit for sending, when the transfer-admissible port loaded state judging unit has judged that there is a less loaded transfer-admissible port among the transfer-admissible ports, a packet stored in the packet storage buffer to the less loaded transfer-admissible port.

[0019] In this configuration, when a packet is inputted from an input port, the port information searching unit searches for two kinds of information including information on output ports each to be selected with priority according to information written in that packet (transfer destination ports) and output ports to which transferring is possible as judged from the link usage (transfer-admissible ports). The usage of each of the packet storage buffers prepared on the side of the plurality of output ports is checked, and if there is an output port bearing a less load of packet output than a prescribed

value among the transfer-admissible ports (less loaded transfer-admissible port), the packet is distributed to this less loaded transfer-admissible port, thereby making possible packet sending control matching the port load level from time to time and effective utilization of any unoccupied capacity on the link.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein:

[0021] FIG. **1** is a block diagram showing the configuration of a router as a packet distributing apparatus, which is a first preferred embodiment of the invention;

[0022] FIG. **2** shows an example of contents set in a user identification table in FIG. **1**;

[0023] FIG. **3** shows the contents of a transfer destination port table for all users in the first preferred embodiment of the invention;

[0024] FIG. **4** shows the contents of identifiers in the transfer destination port table in FIG. **3**;

[0025] FIG. **5** shows an example of contents set in a load detection setting table in FIG. **1**;

[0026] FIG. **6** is a flow chart showing the processing by a distributing circuit in the first embodiment of the invention;

[0027] FIG. **7** is a block diagram showing the configuration of a router in a second preferred embodiment of the invention;

[0028] FIG. **8** is a flow chart showing the processing by a distributing circuit in the second embodiment of the invention;

[0029] FIG. **9** is a block diagram showing the configuration of a router in a third preferred embodiment of the invention;

[0030] FIG. **10** is a flow chart showing the processing by a distributing circuit in the third embodiment of the invention; and

[0031] FIG. **11** shows a network configured of a network, consisting of a router which may be any of the embodiments of the invention, of a network service provider and first through fourth networks connected to this network.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] Modes of implementing the present invention in packet distributing apparatuses and packet distributing methods will be described below with reference to FIG. **1** through FIG. **11**.

[0033] FIG. **1** shows the configuration of a router as a packet distributing apparatus, which is a first preferred embodiment of the invention. A first router **111** is provided with first through Nth ports P_1 through P_N to be connected to match first through Nth nodes not shown. The first through Nth ports P_1 through P_N are connected to first through output interface circuits (IF) $\mathbf{202}_1$ through $\mathbf{202}_N$ and first through Nth input interface circuits (IF) $\mathbf{203}_1$ through $\mathbf{203}_N$ provided to match the respective ports.

[0034] The first through Nth input interface circuits $\mathbf{203}_1$ through $\mathbf{203}_N$ convert physical signals, such as electrical signals or optical signals inputted from respectively matching first through Nth ports P_1 through P_N into logical signals of Internet Protocol (IP) packet data or frame data (hereinafter collectively referred to as packet data). Signals converted by the input interface circuits $\mathbf{203}_1$ through $\mathbf{203}_N$ into packet data are transferred to an input buffer **204**.

[0035] The input buffer **204** is a circuit for temporarily storing packet data until the port of transfer destination is determined. The input buffer **204** is connected to a transfer destination searching unit **205** and a distributing circuit **206**.

[0036] The transfer destination searching unit **205** searches header information and the like contained in a packet for user identifying information and a transfer destination port, and instructs the input buffer **204** to transfer the retrieved information. To the transfer destination searching unit **205** are connected a user identification table **207** and a transfer destination port table **208**.

[0037] The user identification table **207** is a table for finding from header information and the like contained in a packet a user identifier by which a user can be unequivocally identified.

[0038] The transfer destination port table **208** is a table holding user identifying information, transfer destination ports matching destination addresses, and information on transfer-admissible ports.

[0039] The distributing circuit **206** receives from the input buffer **204**, after the transfer destination port is determined, packet data and the transfer destination port number. On the output side of the distributing circuit **206** are provided first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$ and first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ provided to match these output buffer units.

[0040] To the first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ is connected a load detection setting table **212**. The first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ read the usage (quantity of buffered packet data) of the matching one of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$, and notifies the distributing circuit **206** as to whether or not that value is above a preset value in the load detection setting table **212**.

[0041] Packets stored in the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$ are outputted to the respectively matching ones of first through Nth output interface circuits $\mathbf{202}_1$ through $\mathbf{202}_N$.

[0042] The first through Nth output interface circuits $\mathbf{202}_1$ through $\mathbf{202}_N$ convert logical signals, such as packet data, into physical signals, such as electrical signals or optical signals, and output converted signals.

[0043] FIG. **2** shows an example of contents set in the user identification table **207** explained with reference to FIG. **1**. The user identification table **207**, as described above, is intended for finding a user identifier by which a user can be unequivocally identified. As information for identifying a user, any field of packet data (e.g. the header information part) can be used if applicable. In this case, a sender address required for identifying one connection in the transmission control protocol (TCP) as a protocol used for communication between Internet hosts, a sender, a destination address and a destination port number are shown by way of example. Entries "any" in the user identification table **207** mean that whatever value in that field would specify a user identifier. Therefore, in the user identification table **207** of FIG. **2**, the user identifier is specified by the sender address alone.

[0044] FIG. **3** shows the contents of a transfer destination port table **208** for all users. This transfer destination port table **208** holds information for the transfer destination searching unit **205** shown in FIG. **1** to find a transfer destination port and transfer-admissible port from a user identifier and a destina-

tion address. The user identifier here can be found from the user identification table **207** shown in FIG. **2**.

[0045] The destination address is information indicating the destination node of transferred packet data. This corresponds to the "DESTINATION ADDRESS" field in the Internet Protocol prescribed in the request for comments (RFC) 791 put together by the (Internet Engineering Task Force (IETF), the standardization body for Internet-related technology.

[0046] In the column of the "transfer destination port" in the transfer destination port table **208** shown in FIG. **3**, one route determined according to the routing protocol used by the Internet is indicated as is the conventional practice. By the conventional router differing from this embodiment of the invention, packets are transferred solely according to information shown in this "transfer destination port" column. Unlike that, the transfer destination port table **208** in this embodiment has, in addition to this "transfer destination port", columns of a "first transfer-admissible port" through a "t-th transfer-admissible port". These "transfer-admissible ports" cannot be used for transferring when traffics having priority in their use are using these transfer-admissible ports. However, when no traffic having priority is using any of them, these transfer-admissible ports can be used for transferring. In the transfer destination port table **208**, these available ports are also listed.

[0047] FIG. **4** shows a part where the user identifier is "UID-1", extracted from the transfer destination port table shown in FIG. **3**. As shown in FIG. **4**, packet whose "destination address" is "10.1.x.x" can use the port "P_2" as the usual transfer destination port. Also, to make the port "P_1" also available as a transfer destination when this port "P_1" is not used, "P_1" is set in the column of the first transfer-admissible port.

[0048] To add, "x" in the transfer destination port table **208** of FIG. **4** can be any numerical value. Therefore, for instance "10.2.x.x" means that any address beginning with "10.2." can fit in.

[0049] FIG. **5** shows an example of configuration of the load detection setting table in FIG. **1**. In the load detection setting table **212**, the threshold of usage (the maximum number of buffered packets) is set for each of the first through Nth output buffer units **209**$_1$ through **209**$_N$. In the example shown in FIG. **5**, the threshold for the first output buffer unit **209**$_1$ is "100".

[0050] The operation of the router **111** as the packet distributing apparatus configured as described will be explained in detail below. In this embodiment, too, the same network configuration as what is shown in FIG. **11** is supposed to be used. Further, the second and third routers **112** and **113** are supposed to have the same internal configuration as that of the first router **111**.

[0051] As shown in FIG. **11**, the aforementioned first port P_1 of the first router **111** is supposed to be connected to the link **114**, and the second port P_2, connected to the link **115**. Further, the third port P_3 is supposed to be connected to a link **221**, the fourth port P_4, to a link **222**. The user identifier of the user belonging to the first network **101** and the second network **102** is supposed to be "UID-2", and that of the user belonging to the third network **103** and the fourth network **104**, to be "UID-1".

[0052] In this case, the user of the first network **101** is supposed to have an address beginning with "10.11" as shown in FIG. **3**, and the user of the second network **102**, an address beginning with "10.10". The user of third network **103** is supposed to have an address beginning with "10.2", and the user of the fourth network **104**, an address beginning with "10.1".

[0053] To look at the setting of the destination address "10.1x.x" as shown in FIG. **3**, the first router **111** on a normal occasion can transfer a packet to the second port P_2 using the user identifier "UID-1". It is shown that, when the first port P_1 is not used by the user having the user identifier "UID-2", the user having the user identifier "UID-1" can also use the first port P_1 as the first transfer-admissible port.

[0054] Next will be described in specific terms, by way of example, the operation that takes place when the user of the third network **103** in FIG. **11** transfers a packet to the first router **111**.

[0055] It is supposed that the user of the third network **103** transfers a packet to the user of the fourth network **104**. The address of the user of the third network **103** is supposed to begin with "10.2". Therefore, the sender address may be, for instance, "10.2.100.100". The destination, as it is the user of the fourth network **104**, will be "10.1.50.50" for instance.

[0056] The packet transmitted from the third network **103** arrives at the fourth port P_4 of the first router **111**. The data having arrived at the fourth port P**4** are converted by a fourth input interface circuit **203**$_4$ from physical signals into signals consisting of logical packet data. The converted data are transferred to the input buffer **204**. The input buffer **204** hands over to the transfer destination searching unit **205** the field of the packet data required by the transfer destination searching unit **205**. In this example, the information part having a sender address of "10.2.100.100" and a destination address of "10.1.50.50" is handed over to the transfer destination searching unit **205**. The input buffer **204** holds the packet data and waits until search processing by the transfer destination searching unit **205** is completed.

[0057] The transfer destination searching unit **205** searches for a setting identical with the sender address, the sender port number, the destination address and the destination port number notified from the input buffer **204**. Searching for the sender port number and the destination port number are set to fit any values as shown in the user identification table **207** of FIG. **2**. Therefore, description of the operation to search for the sender port number and the destination port number will be dispensed with.

[0058] Further, as the sender address is "10.2.100.100", it fits the setting on the second row of the user identification table **207** in FIG. **2**. Accordingly, it is identified to be the user having the user identifier "UID-1".

[0059] Next, a setting that fits these user identifier "UID-1" and destination address "10.1.50.50" are searched for in the transfer destination port table **208** shown in FIG. **1** and FIG. **4**. As a result of this search, the contents of the first row of the transfer destination port table **208** are found identical because the destination address is set to be "10.1.x.x" there. Therefore, the transfer destination port is found to be the second port P_2, and the transfer-admissible port, the first port P_1.

[0060] The transfer destination searching unit **205** hands over to the input buffer **204** the information thereby obtained. The input buffer **204** which has held the packet data and waited transfers, using the information from the transfer destination searching unit **205**, information indicating that the transfer destination port of the packet data is the second port P_2 and that the transfer-admissible port is the first port P_1 to the distributing circuit **206**.

[0061] FIG. **6** is a flow chart showing the processing by the distributing circuit **206** shown in FIG. **1**. The first router **111** is provided with a central processing unit (CPU) though not shown, and performs prescribed control of the distributing circuit **206** by executing a program stored on a recording medium such as a Read Only Memory (ROM) not shown either.

[0062] The distributing circuit **206** first receives from the input buffer **204** the packet data and information on the transfer destination port and the first through t-th transfer-admissible ports (step S**241**). In the instance described above, the distributing circuit **206** receives information indicating that the transfer destination port is the second port P_2 and that the transfer-admissible port is the first port P_1.

[0063] Next, it is judged whether or not the transfer destination port is stated to have "no load" (step S**242**). If it has "no load", the transfer destination port regarding which information was received at step S**241** is determined to be the transfer destination (step S**244**). Then, the packet data are transferred to the output buffer unit **209** (one of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$) connected to this determined transfer destination port (step S**245**) to end the processing (END).

[0064] Or if the transfer destination port is not stated to have "no load" at step S**242** ("N" at S**242**), the following processing will take place. First, the distributing circuit **206**, according to the information on the presence or absence of load on each port notified from the first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$, searches for a port in a state of "no load" out of the first through t-th transfer-admissible ports (step S**243**). Then it judges whether or not there is any port stated to have "no load" among the transfer-admissible ports (step S**246**). If every transfer-admissible port is loaded ("N" at S**246**), even if the transfer destination port is loaded, the transfer destination port is determined as the transfer destination (step S**244**). The sequence proceeds to step S**245** to transfer the packet data to the output buffer unit **209** connected to that transfer destination port.

[0065] On the other hand, if the transfer destination port itself is not stated to have "no load" and there is any transfer-admissible port stated to have "no load" ("Y" at S**246**), one of these transfer-admissible ports is selected in a probability equal to the reciprocal of the total number of the transfer-admissible ports selected as admitting a transfer (step S**247**). If, for instance, the total number of transfer-admissible ports is m, one of these transfer-admissible ports is selected at step S**247** at a probability of 1/m each time.

[0066] If this processing at step S**247** is done, the sequence proceeds to step S**245**, and the packet data are transferred to, out of the output buffer units **209** (one of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$), what is connected to the transfer-admissible port is selected at the aforementioned probability.

[0067] To add, in this embodiment of the invention, only the first port P**1** is the transfer-admissible port as shown in FIG. **4**. Therefore, at step S**246**, the packet data are transferred to the first output buffer unit $\mathbf{209}_1$ connected only to the first port P_1.

[0068] Next will be described the operation of a second preferred embodiment of the present invention.

[0069] FIG. **7** shows the configuration of a first router **111**A in the second preferred embodiment of the invention. The same constituent elements as in the first embodiment shown in FIG. **1** are assigned respectively the same reference signs, and their description will be dispensed with. In the first router **111** A in the second embodiment, first through Nth usage checking units $\mathbf{301}_1$ through $\mathbf{301}_N$ are arranged in place of the first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ in the first embodiment. In these usage checking units $\mathbf{301}_1$ through $\mathbf{301}_N$, in addition to the comparison of setpoints and buffered quantities in the load detection setting table **212** used in the first embodiment, the ratio of load using a function (f(x) to be explained afterwards) is also notified to the distributing circuit **206**.

[0070] For instance, the buffered quantity held by the buffer memories of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$ matching the first through Nth usage checking units $\mathbf{301}_1$ through $\mathbf{301}_N$ is represented by "x", and a function varies by this buffered quantity "x" is represented by a function f(x). This function f(x) shows the ratio of loads among the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$.

[0071] Incidentally, in the first embodiment, transfer-admissible ports are determined according to whether or not the threshold set in the load detection setting table **212** shown in FIG. **1** is surpassed, and selected each at the same probability (the reciprocal of the total number of transfer-admissible ports). Therefore, unlike in the second embodiment, it is impossible to vary the ratio of port selection according to the ratio of loads.

[0072] Now, possible functions f(x) representing loads include the following example. The maximum buffer length that can be held by each of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$ is represented by "M". Then, the function representing loads can be represented by the following Equations (1):

$$\text{If } x \leqq M, f(x)=x/M$$

$$\text{If } x>M, f(x)=1. \quad (1)$$

where "x" is the quantity of packet data held by each of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$.

[0073] Next will be described an instance in which the probability of port selection is varied with the ratio of loads. The ratio of loads at the first port P_1 is represented by $f(x_1)$. The ratio of loads at the second port P**2** is represented by $f(x_2)$, and that at the third port P_3, by $f(x_3)$. Further, it is supposed that $f'(x)=1/f(x)$.

[0074] Then, the probability R_1 of selecting the first port P_1 is calculated by the following Equation (2):

$$R_1=f'(x_1)/\{f'(x_1)+f'(x_2)+f'(x_3)\} \quad (2)$$

[0075] The probability R_2 of selecting the second port P_2 and the probability R_3 of selecting the third port P_3 are calculated by the following Equations (3) and (4), respectively:

$$R_2=f'(x_2)/\{f'(x_1)+f'(x_2)+f'(x_3)\} \quad (3)$$

$$R_3=f'(x_3)/\{f'(x_1)+f'(x_2)+f'(x_3)\} \quad (4)$$

where the sign "x" represents the buffer usage of the first output buffer unit **2091** matching the first port P_1. Similarly, the sign "x_2" or "x_3" represents the buffer usage of the second or third output buffer unit $\mathbf{209}_2$ or $\mathbf{209}_3$ matching the second port P_2 or the third port P_3, respectively.

[0076] FIG. **8** is a flow chart showing the processing by the distributing circuit in the second embodiment of the invention. In this FIG. **8**, the same parts as in FIG. **6** are assigned respectively the same reference signs.

[0077] The distributing circuit **206** first receives from the input buffer **204** packet data and information regarding the transfer destination port and the first through t-th transfer-

admissible ports (step S**241**). In the second embodiment, as in the first embodiment, the distributing circuit **206** receives information indicating that the transfer destination port is the second port P_2 and the transfer-admissible port is the first port P_1.

[0078] Next, it is judged whether or not the transfer destination port is stated to have "no load" (step S**242**). If it is, the transfer destination port regarding which information was received at step S**241** is determined as the transfer destination (step S**244**). Then the packet data are transferred to the output buffer unit **209** (one of the first through Nth output buffer units **2091** through **209**N) connected to this determined transfer destination port (step S**245**) to end the processing (END).

[0079] Or if the transfer destination port is not stated to have "no load" at step S**242** ("N" at S**242**), the following processing will take place. First, the distributing circuit **206**, according to the information on the presence or absence of load on each port notified from the first through t-th usage detecting units $\mathbf{301}_1$ through $\mathbf{301}_N$, searches for a port in a state of "no load" out of the first through t-th transfer-admissible ports (step S**243**A). Then it judges whether or not there is any port stated to have "no load" among the transfer-admissible ports (step S**246**). If every transfer-admissible port is loaded ("N" at S**246**), even if the transfer destination port is loaded, the transfer destination port is determined as the transfer destination (step S**244**). The sequence proceeds to step S**245** to transfer the packet data to the output buffer unit **209** connected to that transfer destination port.

[0080] On the other hand, if the transfer destination port itself is not stated to have "no load" and there is any transfer-admissible port stated to have "no load" ("Y" at S**246**), one of these transfer-admissible ports is selected according to a calculated probability (step S**247**A).

[0081] If this processing at step S**247**A is done, the sequence proceeds to step S**245**, and the packet data are transferred to the output buffer unit **209** connected to the transfer-admissible port selected at the aforementioned probability (one of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$).

[0082] Incidentally, the reciprocal of the load ratio can be represented by the following Equation (5), where f(x) is the load ratio of a port x:

$$f'(x)=1/f(x) \tag{5}$$

[0083] In this case, the probability of selecting a port P_i (i=1, 2, . . . m) can be represented by the following formula (6):

$$f'(p_i')/\{f'(p_1')+f'(p_2')+\ldots+f'(p_m')\} \tag{6}$$

For instance, the probability of selecting the first port P_1 will be as represented by the following formula (7):

[0084]

$$f'(p_1')/\{f'(p_1')+f'(p_2')+\ldots+f'(p_m')\} \tag{7}$$

[0085] Next will be described the operation of a third preferred embodiment of the present invention.

[0086] FIG. **9** showing the configuration of a first router **111**B in the third preferred embodiment of the invention. For the router **111**B in this third embodiment, the same constituent elements as in the first embodiment shown in FIG. **1** are assigned respectively the same reference signs, and their description will be dispensed with. Each of first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$ of the router **111**B in this second embodiment consists of a high priority buffer H and a low priority buffer L. While the high priority buffer H and the low priority buffer L can store packets at the same time, when packets are stored at the same time, a packet is always taken out first from the high priority buffer H, and outputted to the matching one of the first through Nth output interface circuits $\mathbf{202}_1$ through $\mathbf{202}_N$. The low priority buffer L outputs packet stored therein to the matching one of the first through Nth output interface circuits $\mathbf{202}_1$ through $\mathbf{202}_N$ only when there is no packet in the high priority buffer H.

[0087] The first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ read the usage (the quantity of buffered packet data) of the high priority buffer H and that of the low priority buffer L for each of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$. The first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ notify the distributing circuit **206** whether or not the usage of the high priority buffer H and that of the low priority buffer L have surpassed the value set in the load detection setting table **212**. The first through Nth output interface circuits $\mathbf{202}_1$ through $\mathbf{202}_N$ convert logical signals, such as packet data, into physical signals, such as electrical signals or optical signals, and output converted signals.

[0088] The user's packet which should be transferred in its own right in the router **111**B of this third embodiment is transferred to the high priority buffer H of the matching one of first through Nth output buffer units **2091** through **209**N. On the other hand, a packet transferred to a port selected as a transfer-admissible port is stored in the low priority buffer L of the matching one of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$. Managing the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$ with discrimination between the high priority buffer H and the low priority buffer L in such a manner makes possible efficient transferring of packets without affecting the user's packet which should be transferred in its own right.

[0089] In this third embodiment, the first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ notify the distributing circuit **206** of information as to whether or not the usage of the high priority buffer H (fh(x)) has surpassed the threshold set in the load detection setting table **212**. The first through Nth usage detecting units $\mathbf{211}_1$ through $\mathbf{211}_N$ also notify the distributing circuit **206** of the load ratio of the low priority buffer L (fl(x)).

[0090] FIG. **10** is a flow chart showing the processing by the distributing circuit in the third embodiment of the invention. In this FIG. **10**, the same parts as in FIG. **6** and FIG. **8** are assigned respectively the same reference signs.

[0091] The distributing circuit **206** first receives from the input buffer **204** packet data and information regarding the transfer destination port and the first through t-th transfer-admissible ports (step S**241**).

[0092] Next, it is judged whether or not the transfer destination port is stated to have "no load" (step S**242**). If it is, the transfer destination port regarding which information was received at step S**241** is determined as the transfer destination (step S**244**). Then the packet data are transferred to the output buffer unit **209** (one of the first through Nth output buffer units $\mathbf{209}_1$ through $\mathbf{209}_N$) connected to this determined transfer destination port (step S**245**) to end the processing (END).

[0093] Or if the transfer destination port is not stated to have "no load" at step S**242** ("N" at S**242**), the following processing will take place. First, the distributing circuit **206**, according to the information regarding the load on the high priority buffer H of each port notified from the first through

Nth usage detecting units **211**$_1$ through **211**$_N$ searches for a port of which the high priority buffer H has "no load" out of the first through t-th transfer-admissible ports (step S**243**B). Then it judges whether or not there is a port of which the high priority buffer H is stated to have "no load" out of the transfer-admissible ports (step S**246**). If there is a load on the high priority buffer H of every transfer-admissible port ("N" at S**246**), even if there is a load on the transfer destination port, the transfer destination port is determined as the transfer destination (step S**244**). The sequence proceeds to step S**245**, and the packet data are transferred to the output buffer unit **209** connected to that transfer destination port.

[0094] On the other hand, if the transfer destination port itself is not stated to have "no load" and there is any transfer-admissible port stated to have "no load" ("Y" at S**246**), one out of all these transfer-admissible ports is selected according to a probability calculated on the basis of the load on the low priority buffer L of each transfer-admissible port (step S**247**B). As the numerical expressions for calculating this probability here are the same as those presented for the second embodiment except for the use of low priority buffers L, their description is dispensed with.

[0095] If this processing at step S**247**B is done, the sequence proceeds to step S**245**, and the packet data are transferred to the output buffer unit **209** connected to the transfer-admissible port selected at the aforementioned probability (one of the first through Nth output buffer units **209**$_1$ through **209**$_N$).

[0096] Although in the first through third embodiments, two kinds of table, including the user identification table **207** and the transfer destination port table **208**, are used, but they can as well be combined into a single table, which may be searched for the same purpose.

[0097] While the invention has been described with reference to tables as such, but they may as well be structured as lists.

[0098] Also, similar searching can be done using an associative memory, such as a contents address memory (CAM).

[0099] Although no particular explanation was made with reference to the first through third embodiments, it is also conceivable to require users higher in the order of priority, for instance, to pay a higher charge to the network manager than other users to secure a band and/or to be guaranteed against a delay, and the invention can be applied to privilege such user. It is further possible to apply the invention not only to such arrangements but also to all traffics higher in the order of priority in accordance with some network policy or another.

[0100] The present invention can provide the following advantages. First, when two kinds of information are read from what is written in a packet, including information on output ports selectable with priority (transfer destination ports) and output ports to which transferring is possible as judged from the link usage (transfer-admissible ports), if there is no load on any transfer-admissible port, the packet is distributed to that transfer-admissible port. It is thereby made possible to possible to positively utilize unoccupied links and to use network resources more effectively.

[0101] Moreover, if a judging unit for the loaded state of transfer-admissible ports determines the presence of a plurality of transfer-admissible ports bearing less loads than a prescribed level with respect to the sending of packets, a packet is distributed to one of these transfer-admissible ports. Therefore, loads can be more dispersed than where they are distributed to one specific transfer-admissible port.

[0102] Furthermore, by classifying packet storage buffers into two kinds including low priority buffers and high priority buffers, read-out from which is given priority over the low priority buffers, and distributing packets to low priority buffers as well, it is made possible to reduce impacts on users who are given priority in using ports matching low priority buffers.

[0103] While this invention has been described with reference to certain preferred embodiments thereof, it is to be understood that the subject matter encompassed by this invention is not limited to those specific embodiments. Instead, it is intended for the subject matter of the invention to include all such alternatives, modifications and equivalents as can be included within the spirit and scope of the following claims.

1. A packet distributing apparatus for distributing each of packets inputted from a plurality of input ports to one of a plurality of output ports, comprising:

a port information searching unit for searching, on the basis of information written in said packet, for a transfer destination output port to be selected with priority as an output port and for transfer-admissible output ports;

packet storage buffers for temporarily storing said packet;

a transfer-admissible port loaded state judging unit for searching for a less loaded one of said transfer-admissible output ports in which the quantity of buffered packet data is less than a prescribed value, on the basis of the usage of the matching one of said packet storage buffers; and

a packet sending unit for sending, when the load on said transfer destination port is heavy, said packet stored in said packet storage buffer to said less loaded one of said transfer-admissible output ports which has been detected.

2. The packet distributing apparatus as claimed in claim **1**, wherein:

said packet storage buffers include low priority buffers and high priority buffers, from which read-out is given priority over the low priority buffers.

3. A router comprising the packet distributing apparatus claimed in claim **1**.

4. A network comprising a plurality of routers connected to one another, wherein each of said routers comprises the packet distributing apparatus claimed in claim **1**.

5. A packet distributing apparatus for distributing each of packets inputted from a plurality of input ports to one of a plurality of output ports, comprising:

a port information searching unit for searching, on the basis of information written in said packet, for a transfer destination output port to be selected with priority as an output port and for transfer-admissible output ports;

packet storage buffers for temporarily storing said packet;

a transfer-admissible port loaded state judging unit for searching for a less loaded one of said transfer-admissible output ports in which the quantity of buffered packet data is less than a prescribed value, on the basis of the usage of the matching one of said packet storage buffers; and

a packet sending unit for distributing, if said less loaded one of said transfer-admissible output ports is detected, the packet stored in said packet storage buffers to said less loaded one of said transfer-admissible output ports or, if said less loaded one of said transfer-admissible output ports is not detected, the packet stored in said packet storage buffers to said transfer destination port.

6. The packet distributing apparatus as claimed in claim **5**, wherein:

said packet storage buffers include low priority buffers and high priority buffers, from which read-out is given priority over the low priority buffers.

7. A packet distributing method for distributing each of packets inputted from a plurality of input ports to one of a plurality of output ports, comprising:

a port information searching step of searching, on the basis of information written in said packet, for a transfer destination output port to be selected with priority as an output port and for transfer-admissible output ports;

a transfer-admissible output port loaded state judging step of searching for a less loaded one of said transfer-admissible output ports in which the quantity of buffered packet data in packet storage buffers each provided on said output port side for temporarily storing said packet is less than a prescribed value, on the basis of the usage of the matching one of said packet storage buffers; and

a packet sending step of sending, when the load on said transfer destination port is heavy, the packet stored in said packet storage buffer to said less loaded transfer-admissible output port which has been detected.

8. A packet distributing method for distributing each of packets inputted from a plurality of input ports to one of a plurality of output ports, comprising:

a port information searching step of searching, on the basis of information written in said packet, for a transfer destination output port to be selected with priority as an output port and for transfer-admissible output ports;

a transfer-admissible output port loaded state judging step of searching for a less loaded one of said transfer-admissible output ports in which the quantity of buffered packet data in packet storage buffers each provided on said output port side for temporarily storing said packet is less than a prescribed value, on the basis of the usage of the matching one of said packet storage buffers; and

a packet sending step of distributing, if said less loaded transfer-admissible output port is detected, the packet stored in said packet storage buffers to said less loaded transfer-admissible output port or, if said less loaded transfer-admissible output port is not detected, the packet stored in said packet storage buffers to said transfer destination port.

* * * * *