US 20110222425A1

(19) United States

(12) Patent Application Publication

SHIBASAKI

(10) Pub. No.: US 2011/0222425 A1

(43) Pub. Date: Sep. 15, 2011

(54) **CONTROLLING NETWORK TRAFFIC**

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(21) Appl. No.: **13/115,567**

(22) Filed: **May 25, 2011**

Related U.S. Application Data

(63) Continuation of application No. 12/199,254, filed on Aug. 27, 2008, now Pat. No. 7,974,309, which is a continuation of application No. 11/686,590, filed on Mar. 15, 2007, now Pat. No. 7,433,369, which is a continuation of application No. 10/098,124, filed on Mar. 15, 2002, now Pat. No. 7,212,493.

(30) **Foreign Application Priority Data**

Mar. 15, 2001 (JP) 2001-074306

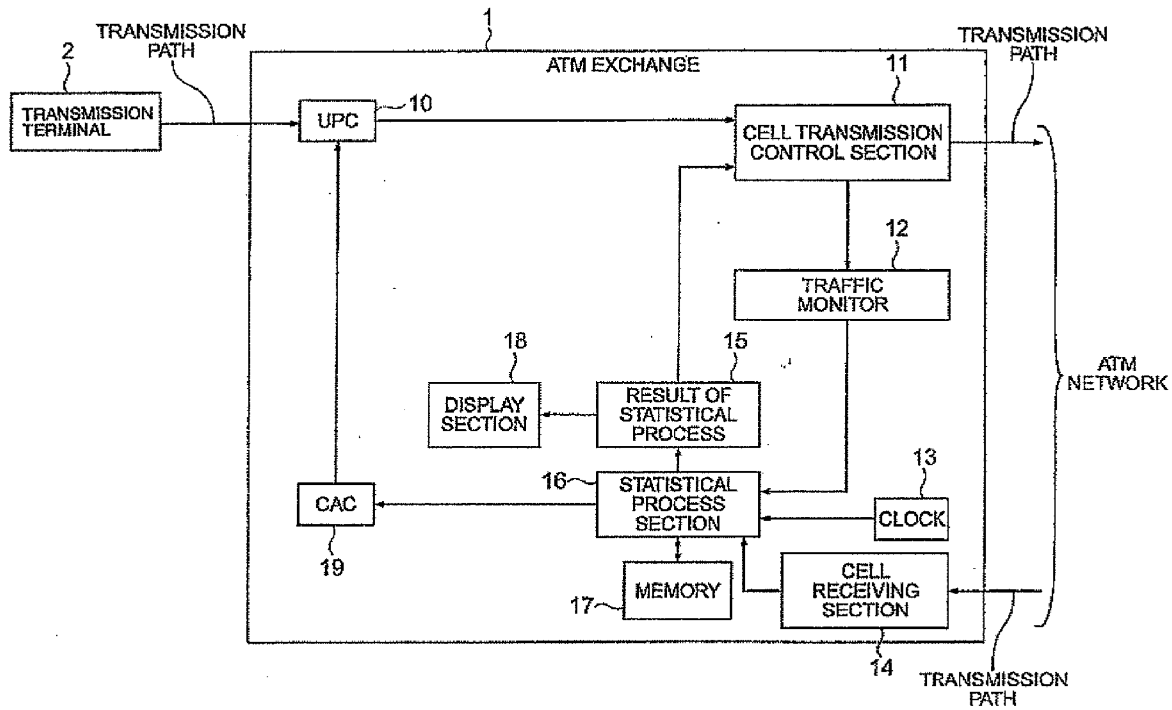
Publication Classification

(51) **Int. Cl.**
H04L 12/24 (2006.01)

(52) **U.S. Cl.** **370/252**

(57) **ABSTRACT**

In an ATM exchange, a cell transmission control section transmits an ATM cell to a transmission path of an ATM network. A traffic monitor monitors traffic of the cell transmissions. A statistical process section performs a temporal statistical process on the result of the traffic monitoring using a clock and a memory. A CAC produces an instruction for traffic control over a transmission terminal based on the result of the statistical process. A UPC controls traffic of a transmission path from the transmission terminal in accordance with the instruction.



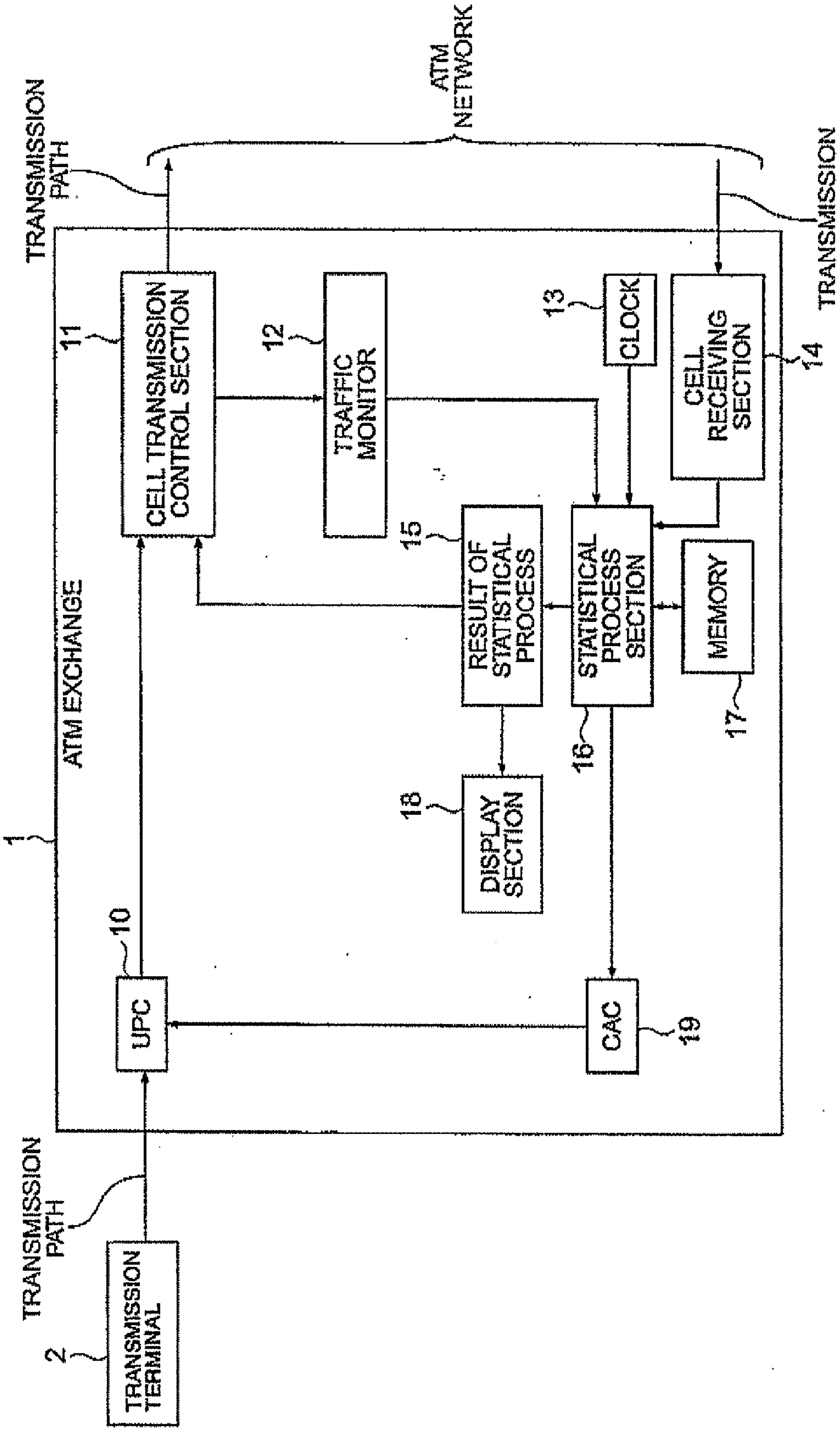

ATM NETWORK
TRANSMISSION PATH
TRANSMISSION PATH
TRANSMISSION PATH
ATM EXCHANGE
1
11
CELL TRANSMISSION CONTROL SECTION
12
TRAFFIC MONITOR
13
CLOCK
CELL RECEIVING SECTION
14
15
RESULT OF STATISTICAL PROCESS
STATISTICAL PROCESS SECTION
16
MEMORY
17
18
DISPLAY SECTION
10
UPC
CAC
19
2
TRANSMISSION TERMINAL

FIG. 1

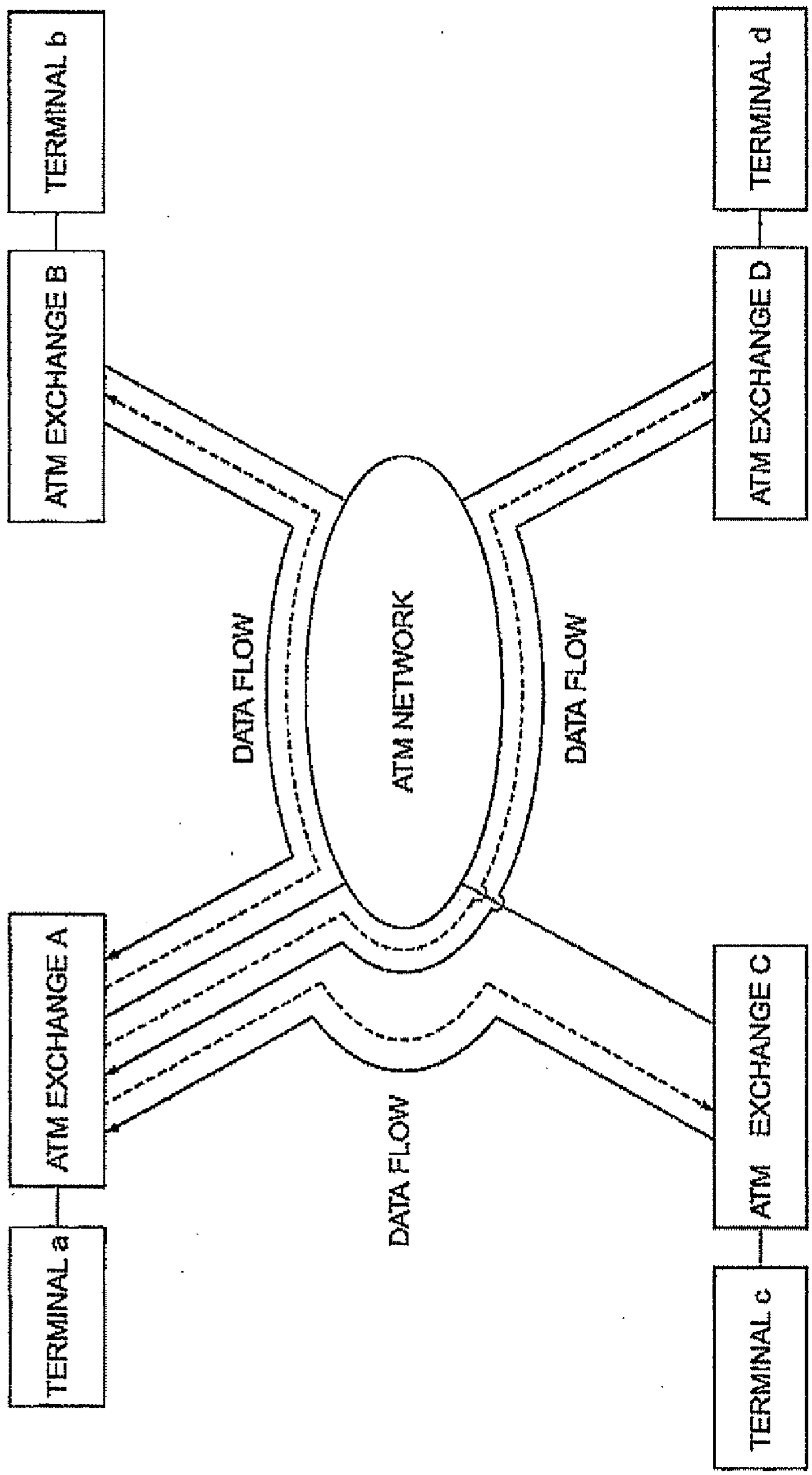

TERMINAL b
ATM EXCHANGE B
TERMINAL d
ATM EXCHANGE D
DATA FLOW
ATM NETWORK
DATA FLOW
ATM EXCHANGE A
TERMINAL a
DATA FLOW
ATM EXCHANGE C
TERMINAL c

FIG. 2

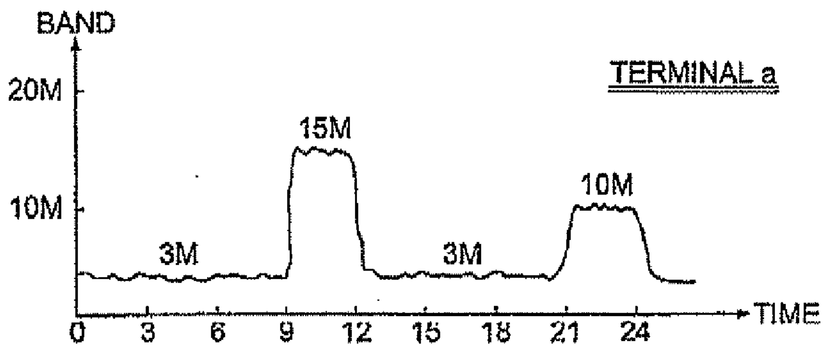


FIG. 3A

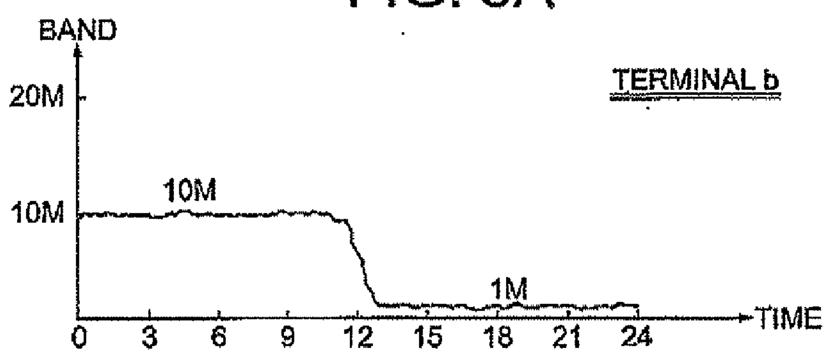


FIG. 3B

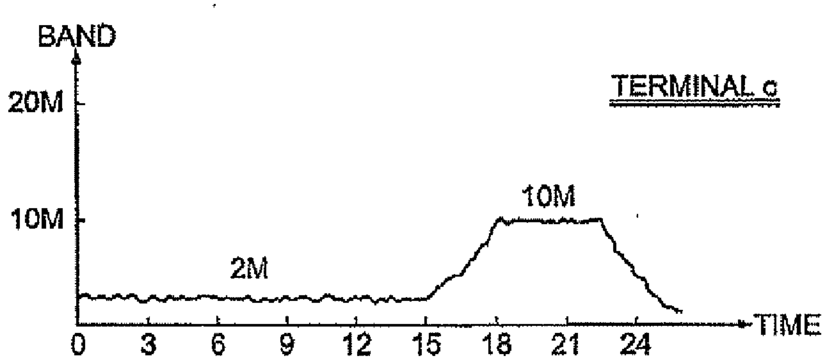


FIG. 3C

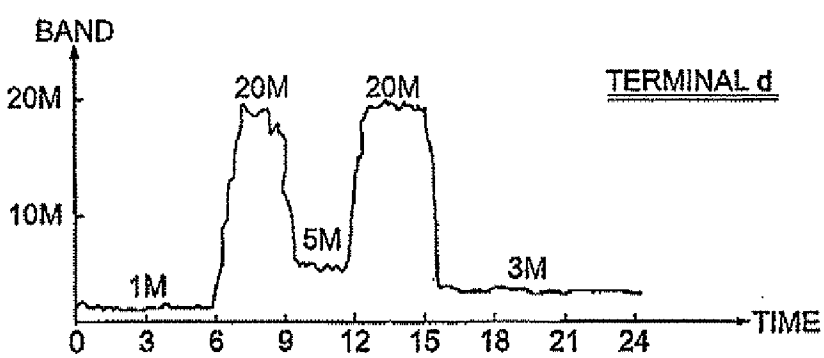
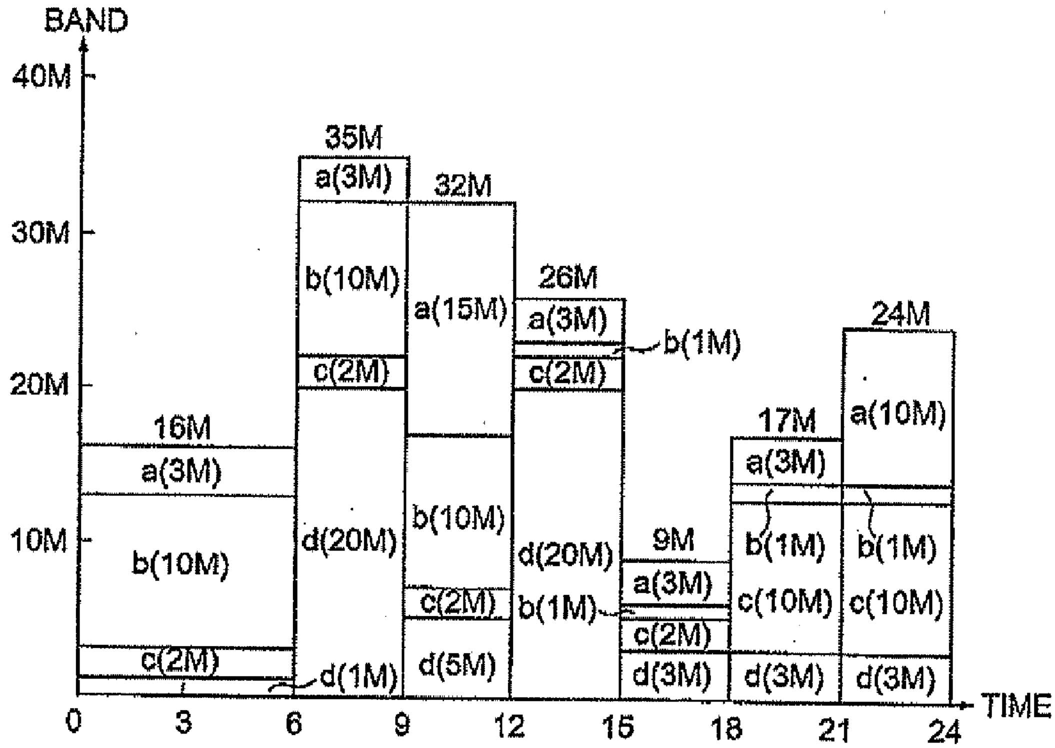


FIG. 3D


BAND
40M
30M
20M
10M
TIME
0
3
6
9
12
15
18
21
24
16M
a(3M)
b(10M)
c(2M)
d(1M)
35M
a(3M)
b(10M)
c(2M)
d(20M)
32M
a(15M)
b(10M)
c(2M)
d(5M)
26M
a(3M)
b(1M)
c(2M)
d(20M)
b(1M)
9M
a(3M)
c(2M)
d(3M)
17M
a(3M)
b(1M)
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d(3M)
24M
a(10M)
b(1M)
c(10M)
d(3M)

FIG. 4

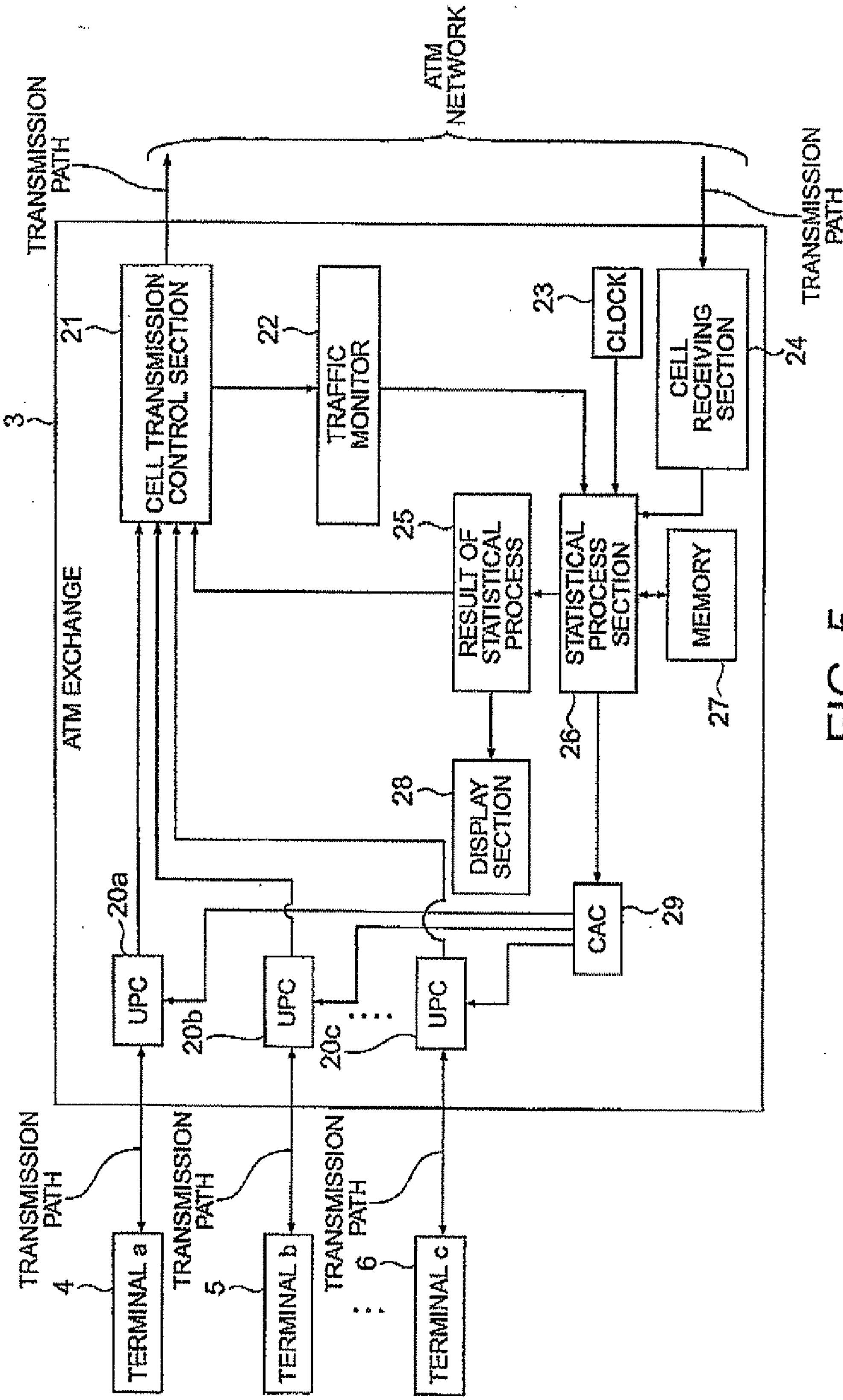
ATM NETWORK
TRANSMISSION PATH
TRANSMISSION PATH
3
ATM EXCHANGE
21
CELL TRANSMISSION CONTROL SECTION
22
TRAFFIC MONITOR
23
CLOCK
24
CELL RECEIVING SECTION
25
RESULT OF STATISTICAL PROCESS
26
STATISTICAL PROCESS SECTION
27
MEMORY
28
DISPLAY SECTION
29
CAC
20a
UPC
20b
UPC
20c
UPC
TRANSMISSION PATH
TRANSMISSION PATH
TRANSMISSION PATH
4
TERMINAL a
5
TERMINAL b
6
TERMINAL c

FIG. 5

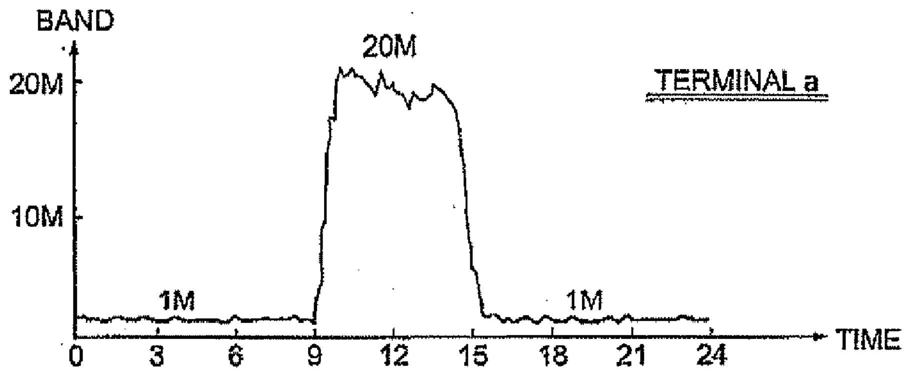

FIG. 6A

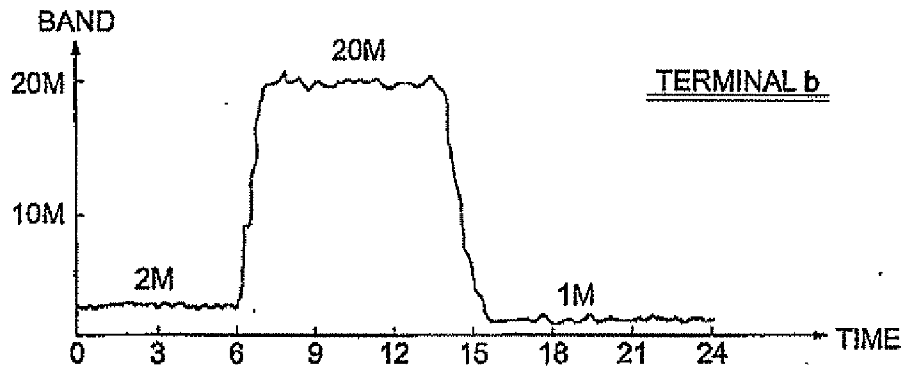

FIG. 6B

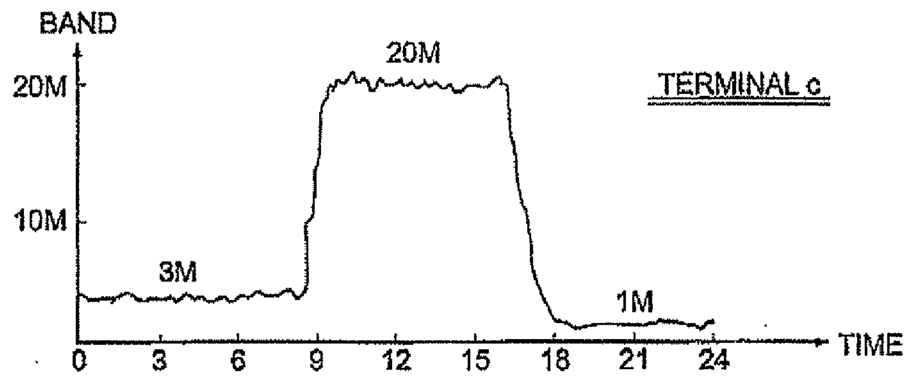

FIG. 6C

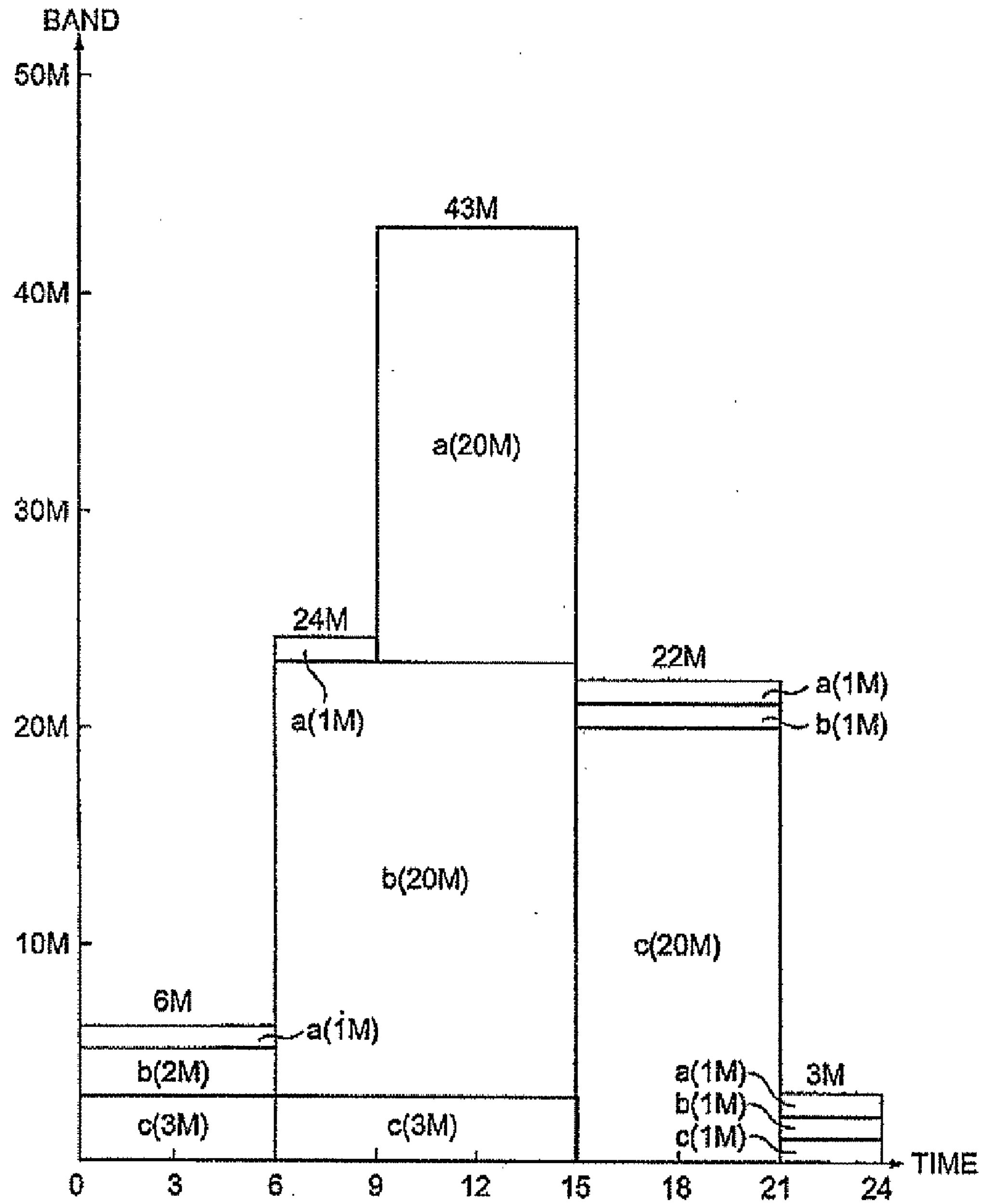
BAND
50M
40M
30M
20M
10M
43M
a(20M)
24M
a(1M)
22M
a(1M)
b(1M)
b(20M)
c(20M)
6M
a(1M)
b(2M)
c(3M)
c(3M)
a(1M)
b(1M)
c(1M)
3M
TIME
0
3
6
9
12
15
18
21
24

FIG. 7

CONTROLLING NETWORK TRAFFIC

RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 11/686,590 filed Mar. 15, 2007, which was a continuation of U.S. patent application Ser. No. 10/098,124 filed Mar. 15, 2002, now U.S. Pat. No. 7,212,493 which claims priority under 35 U.S.C. 119 based on Japanese Patent Application No. 2001-074306 filed Mar. 15, 2001, each of which is incorporated by reference herein.

BACKGROUND

[0002] This invention broadly relates to a method of controlling traffic between ATM (Asynchronous Transfer Mode) exchanges in an ATM network having a plurality of terminals connected via the ATM exchanges, and in particular, to a method of effectively utilizing transmission paths of the ATM network.

[0003] In case where a transmission terminal communicates with another terminal via an ATM network connected to ATM exchanges, amount of transmission (traffic) is controlled between the transmission terminal and the ATM exchange. In general, the transmission terminal subscribes traffic bands to be used, and the ATM exchange controls so that the transmission terminal uses a transmission path within the transmission bands. The traffic bands are fixed to the bands at the time of subscription.

[0004] Under such circumstances, the ATM exchange includes a CAC (Connection Admission Controller) and a UPC (Usage Parameter Controller). With this structure, the CAC judges whether or not a band is held within the subscription bands of the transmission path connected to the UPC as well as whether or not the ATM exchange can be connected to the ATM network (in other words, whether it is a usable band or not). Therefore, the availability of the band depends on a traffic state of the ATM network at that time.

SUMMARY

[0005] It is therefore an object of this invention to provide a method of controlling traffic of an ATM exchange which is capable of effectively utilizing a transmission path.

[0006] It is another object of this invention to provide a method of controlling traffic of an ATM exchange which is capable of distributing traffic loads of an ATM network.

[0007] Other objects of this invention will become clear as the description proceeds.

[0008] According to a first aspect of this invention, there is provided an ATM exchange having a terminal comprising a cell transmission control section which transmits an ATM cell to a transmission path of an ATM network; a traffic monitor which monitors traffic of the ATM cell transmitted by the cell transmission control section; a statistical process section which performs a temporal statistical process on a result of the traffic monitoring; a clock and a memory which perform the temporal statistical process; a connection admission controller which recognizes a maximum value of a subscription traffic band of the connected terminal and which judges traffic bands usable by the terminal based on the result of the statistical process to issue a command; and a usage parameter controller which controls the traffic bands allocated to the terminal in time sequence based on the command issued from the connection admission controller.

[0009] According to a second aspect of this invention, in the ATM exchange according to the first aspect, a plurality of the terminals are connected to the ATM exchange, the usage parameter controller is connected to each of the connected terminals, the traffic monitor monitors cell transmission bands of each of the terminals via the cell transmission control section, the statistical process section performs the temporal statistical process for the result and reports the result to the connection admission controller, and the connection admission controller determines the traffic bands usable by each of the terminals and issues the command to each of the usage parameter controllers.

[0010] According to a third aspect of this invention, there is provided an ATM network in which a plurality of the ATM exchanges according to the first aspect are connected to each other, one of the ATM exchanges serves as a main ATM exchange, each of the other ATM exchanges has means for reporting the traffic result of the statistical process of the terminal connected thereto to the main ATM exchange; and the main ATM exchange determines the traffic bands usable in time sequence in accordance with the reported traffic results of the statistical process at every ATM exchanges and reports the results to the other ATM exchanges.

[0011] According to a fourth aspect of this invention, there is provided an ATM network including the ATM exchanges according to the first aspect and terminals connected to thereto, the ATM exchanges have means for transmitting traffic bands in time sequence allocated to the terminal connected thereto to the terminal, and the terminal has means for displaying the allocated traffic bands in time sequence.

[0012] According to a fifth aspect of this invention, there is provided a method of controlling traffic in an ATM exchange having a terminal, the method comprising the steps of monitoring traffic of a ATM cell transmitted to a transmission path of an ATM network; performing a temporal statistical process on a result of the traffic monitoring; judging traffic bands usable by the terminal based on the result of the statistical process and a maximum value of a subscription traffic band of the connected terminal; and controlling the traffic bands to be allocated to the terminal in time sequence.

[0013] According to a sixth aspect of this invention, there is provided a method of controlling traffic in an ATM network in which a plurality of ATM exchanges are connected to each other, the method comprising the steps of serving one ATM exchange as a main ATM exchange; reporting a result of a statistical process on traffic of terminals connected thereto from the other ATM exchange to the main ATM exchange; and determining traffic bands usable in time sequence for each ATM exchange based on the reported result of the statistical process on traffic by the main ATM exchange so as to report the result to the other ATM exchanges.

[0014] In accordance with this invention, traffic bands can be effectively utilized without allocating unnecessary bands to the ATM network because the traffic bands can be controlled in time sequence in the ATM network.

[0015] Further, a terminal user can recognize usable bands and time allocated to the user. Consequently, a transmission path can be used when use of the ATM network is permitted.

[0016] Moreover, it is possible to control traffic bands of terminals connected to respective ATM exchanges via the ATM network so as to distribute the load of the traffic.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a configuration diagram of an ATM exchange according a first embodiment of the invention;

[0018] FIG. 2 is a diagram showing an ATM network to which four ATM exchanges are connected;

[0019] FIGS. 3A through 3D are diagrams showing temporal states upon using traffic bands of terminals a, b, c and d;

[0020] FIG. 4 is a diagram showing allocation of traffic bands usable by the terminals a, b, c and d;

[0021] FIG. 5 is a diagram showing an example of a configuration in which a plurality of terminals are connected to a single ATM exchange according to a second embodiment of this invention;

[0022] FIGS. 6A through 6C are diagrams showing temporal states upon using traffic bands of terminals a, b, and c; and

[0023] FIG. 7 is a diagram showing allocation of traffic bands usable by the terminals a, b and c.

DETAILED DESCRIPTION

[0024] Referring now to FIG. 1, description will be made about a first embodiment of this invention.

[0025] Generally, a CAC (Connection Admission Controller) in an ATM exchange controls admission of connection between an ATM exchange and a terminal connected thereto ,and judges whether a band can be used or not when a transmission terminal is going to use the band to issue a command specifying whether the use of the band is permitted or not. A UPC (Usage Parameter Controller) actually controls the band of the terminal on the basis of the command from the CAC.

[0026] An ATM exchange 1 includes a cell transmission control section 11 for transmitting ATM cells to a transmission path of an ATM network, a traffic monitor 12 for monitoring traffic of cell transmissions from the cell transmission control section 11, and a statistical process section 16 for performing a temporal statistical process on the result of the traffic monitoring. Further, the ATM exchange comprises a clock 13 and a memory 17 for temporally performing a statistical process, a statistical processing result section 15 for reporting a result of the statistical process, and a display section 18 for displaying the result. In addition, it has a cell receiving section 14 for receiving cells from the ATM network.

[0027] According to the first embodiment of this invention, a CAC 19 produces an instruction for controlling traffic of a transmission terminal 2 based on the result of the statistical process at the statistical process section 16. A UPC 10 controls traffic of a transmission path given from the transmission terminal 2 in response to the instruction from the CAC 19.

[0028] It is assumed here that the CAC 19 of the ATM exchange 1 recognizes a maximum band value of subscription traffic bands of the transmission terminal 2 as the first condition. The statistical process section 16 performs a temporal statistical process upon traffic bands within the maximum traffic band. The traffic monitor 12 monitors quantity of cells transmitted from the cell transmission control section 11 and reports the result to the statistical process section 16. In the statistical process section 16, the quantity of cells and time information from the traffic monitor 12 is stored in the memory 17 in time sequence.

[0029] For example, such data are stored for 24 hours and are then totalized at the statistical process section 16, and the result is reported to the CAC 19 and the statistical process result section 15.

[0030] The CAC 19 controls the traffic bands of the transmission terminal 2 in time sequence via the UPC 10. In the meantime, the statistic process result section 15 transmits the statistical result to the display section 18 and transmits statistic result information to the terminal of interest via the cell transmission control section 11. The display section 18 displays how the traffic bands are controlled in time sequence.

[0031] Referring to FIG. 2, four ATM exchanges A, B, C and D are connected to one ATM network. In this example, the ATM exchange A manages the four ATM exchanges as a main ATM exchange. The other ATM exchanges B, C and D report traffic bands that have been used by respective terminals connected thereto in time sequence to the ATM exchange A.

[0032] The ATM exchange A totalizes the statistic of its own traffic and the statistics of the traffic bands of the other ATM exchanges B, C and D and determines traffic bands that can be used by each of the ATM exchanges in time sequence. The result of the determination is reported to the other ATM exchanges B, C and D. Thus, traffic bands are allocated so that the terminals connected to the four ATM exchanges can use temporally.

[0033] Subsequently, description will be made about an operation of the above-mentioned example. Referring to FIG. 2, terminals a, b, c and d are connected to the ATM exchanges A, B, C and D, respectively, and an example of temporal use of traffic bands by the terminals a through d is shown in FIGS. 3A to 3D.

[0034] For example, statistics of average usage of traffic bands at the terminal a in a few days have revealed that traffic bands of 3 Mbps, 15 Mbps, 3 Mbps and 10 Mbps are used in time zones of 0:00 to 9:00, 9:00 to 12:00, 12:00 to 21:00 and 21:00 to 24:00, respectively. Similarly, statistics of the usage of traffic bands at the terminals b, c and d in a few days are obtained, as illustrated in FIG. 3.

[0035] Referring back to FIG. 2, when the ATM exchange B obtains statistics of traffic bands used by the terminal b in the few days, it reports the information to the ATM exchange A using an ATM cell. Similarly, the ATM exchanges C and D also report statistical information upon traffic bands used by the terminals connected thereto for the ATM exchange A.

[0036] The ATM exchange A allocates traffic bands usable for the respective terminals a, b, c, and d in time sequence on the basis of statistics of traffic bands of the terminal a connected to itself and the statistical information on the traffic bands of the terminals b, c and d.

[0037] As allocated in FIG. 4, the ATM exchange A reports the result to the ATM exchanges B, C and D. The ATM exchanges B, C and D can recognize traffic bands usable in time sequence from the report so that they control traffic bands under such conditions. For example, the terminal d can use the 20 Mbps band from 6:00 to 9:00. Therefore, the ATM exchange D performs communication within the above-mentioned band.

[0038] If traffic bands usable in time sequence are reported to the terminals a through d connected to the respective ATM exchanges, each of the terminals can recognize traffic bands which can be used by own itself in time sequence. By displaying such information to the terminal user, the user can recognize time zones at which the user most frequently can use as well as time zones at which the user cannot use.

[0039] Referring to FIG. 5, description will be made about a second embodiment of this invention. In the second embodiment, a plurality of terminals are connected to a single ATM exchange and control of traffic bands are carried out by each of the terminals connected to the ATM exchange. As illustrated in FIG. 5, three terminals a, b and c are connected to a single ATM exchange.

[0040] An ATM exchange **3** includes UPCs **20***a*, **20***b* and **20***c* associated with terminals a (**4**), b(**5**) and c(**6**), respectively, and a traffic monitor **22** monitors cell transmission bands of the respective terminals a, b and c via a cell transmission control section **21**. The result of monitoring is subjected to a temporal statistical process at a statistical process section **26** so as to be to a CAC **29**. The CAC **29** issues instructions to the UPCs **20***a*, **20***b* and **20***c* upon traffic bands to be controlled for the respective terminals a, b and c.

[0041] For example, let us assume that states of traffic bands used by the terminals a, b and c are as shown in FIGS. **6**A to **6**C. Then, if the maximum traffic band capable of controlling by the ATM exchange **3** is equal to 50 Mbps, the total of the traffic bands which can be used by the terminals a, b, and c, becomes 60 Mbps in the time zone from 9:00 to 15:00, and exceeds the maximum traffic band.

[0042] Based on the result of a statistical process at the statistical process section **26**, the CAC **29** therefore controls so that the traffic of the terminal c is shifted beyond 15:00. As a result, the traffic bands are subjected to load distribution as shown in FIG. **7**, and the terminals a, b and c use transmission paths in accordance with the load distribution.

[0043] While this invention has thus far been disclosed in conjunction with several embodiments thereof, it will be readily possible for those skilled in the art to put this invention into practice in various other manners.

1-19. (canceled)

20. A method comprising:

determining, by a network device, whether an aggregate of bandwidth usage of a plurality of other network devices exceeds a maximum bandwidth usage, where the aggregate bandwidth usage and the maximum bandwidth usage are associated with a particular portion of a periodically occurring time period; and

shifting, by the network device and when the aggregate of the observed bandwidth usage exceeds the maximum bandwidth usage, bandwidth allocated to fewer than all of the plurality of other network devices, from a corresponding particular portion of a subsequent time period to another portion of the subsequent time period.

21. The method of claim **20**, where the corresponding particular portion and the other portion comprise adjacent portions within the subsequent time period.

22. The method of claim **20**, where determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage is based on temporal states of bandwidth usage associated with each of the plurality of other network devices.

23. The method of claim **22**, further comprising:

determining an average bandwidth usage for each of the plurality of other network devices; and

determining, based on the determined average bandwidth usage, the temporal states of bandwidth usage associated with each of the plurality of other network devices.

24. The method of claim **20**, where shifting the bandwidth allocated to fewer than all of the plurality of other network devices is based on a bandwidth usage of the plurality of other network devices during the particular portion of the time period and one or more additional portions of the time period.

25. The method of claim **20**, where determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage is based on a quantity of data transmitted by each of the plurality of other network devices.

26. The method of claim **20**, further comprising:

determining, prior to determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage, a maximum bandwidth subscription value for each of the fewer than all of the plurality of other network devices, and

where determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage includes:

determining whether the bandwidth usage of the each of the fewer than all of the plurality of other network devices exceeds the corresponding determined maximum subscription value.

27. A system comprising:

a network device to:

determine whether an aggregate of bandwidth usage of a plurality of other network devices exceeds a maximum bandwidth usage, where the aggregate bandwidth usage and the maximum bandwidth usage are associated with a particular portion of a periodically occurring time period, and

shift, when the aggregate of the observed bandwidth usage exceeds the maximum bandwidth usage, bandwidth allocated to fewer than all of the plurality of other network devices, from a corresponding particular portion of a subsequent time period to another portion of the subsequent time period.

28. The system of claim **27**, where the corresponding particular portion and the other portion comprise adjacent portions within the subsequent time period.

29. The system of claim **27**, where the network device is further to:

determine whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage is based on temporal states of bandwidth usage associated with each of the plurality of other network devices.

30. The system of claim **29**, where the network device is further to:

determine an average bandwidth usage for each of the plurality of other network devices, and

determine, based on the determined average bandwidth usage, the temporal states of bandwidth usage associated with each of the plurality of other network devices.

31. The system of claim **27**, where the network device shifts the bandwidth allocated to fewer than all of the plurality of other network devices based on a bandwidth usage of the plurality of other network devices during the particular portion of the time period and one or more additional portions of the time period.

32. The system of claim **27**, where the network device determines whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage based on a quantity of data transmitted by each of the plurality of other network devices.

33. The system of claim **27**, where the network device is further to:

determine, prior to determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage, a maximum bandwidth subscription value for each of the fewer than all of the plurality of other network devices, and

where, when determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage, the network device is further to:

determine whether the bandwidth usage of the each of the fewer than all of the plurality of other network devices exceeds the corresponding determined maximum subscription value.

34. A non-transitory computer-readable memory that stores computer-executable instructions, the non-transitory computer-readable memory comprising:

one or more instructions to determine, by a network device, whether an aggregate of bandwidth usage of a plurality of other network devices exceeds a maximum bandwidth usage, where the aggregate bandwidth usage and the maximum bandwidth usage are associated with a particular portion of a periodically occurring time period; and

one or more instructions to shift, by the network device and when the aggregate of the observed bandwidth usage exceeds the maximum bandwidth usage, bandwidth allocated to fewer than all of the plurality of other network devices, from a corresponding particular portion of a subsequent time period to another portion of the subsequent time period.

35. The non-transitory computer-readable memory of claim **34**, where the corresponding particular portion and the other portion comprise adjacent portions within the subsequent time period.

36. The non-transitory computer-readable memory of claim **34**, where the one or more instructions to determine whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage includes:

one or more instructions to determine an average bandwidth usage for each of the plurality of other network devices; and

one or more instructions to determine, based on the determined average bandwidth usage, temporal states of bandwidth usage associated with each of the plurality of other network devices.

37. The non-transitory computer-readable memory of claim **34**, where shifting the bandwidth allocated to fewer than all of the plurality of other network devices is based on a bandwidth usage of the plurality of other network devices during the particular portion of the time period and one or more additional portions of the time period.

38. The non-transitory computer-readable memory of claim **34**, where determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage is based on a quantity of data transmitted by each of the plurality of other network devices.

39. The non-transitory computer-readable memory of claim **34**, further comprising:

one or more instructions to determine, prior to determining whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage, a maximum bandwidth subscription value for each of the fewer than all of the plurality of other network devices, and

where the one or more instructions to determine whether the aggregate of the bandwidth usage of the plurality of other network devices exceeds the maximum bandwidth usage includes:

one or more instructions to determine whether the bandwidth usage of the each of the fewer than all of the plurality of other network devices exceeds the corresponding determined maximum subscription value.

* * * * *