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(54) **METHOD OF MULTICASTING**

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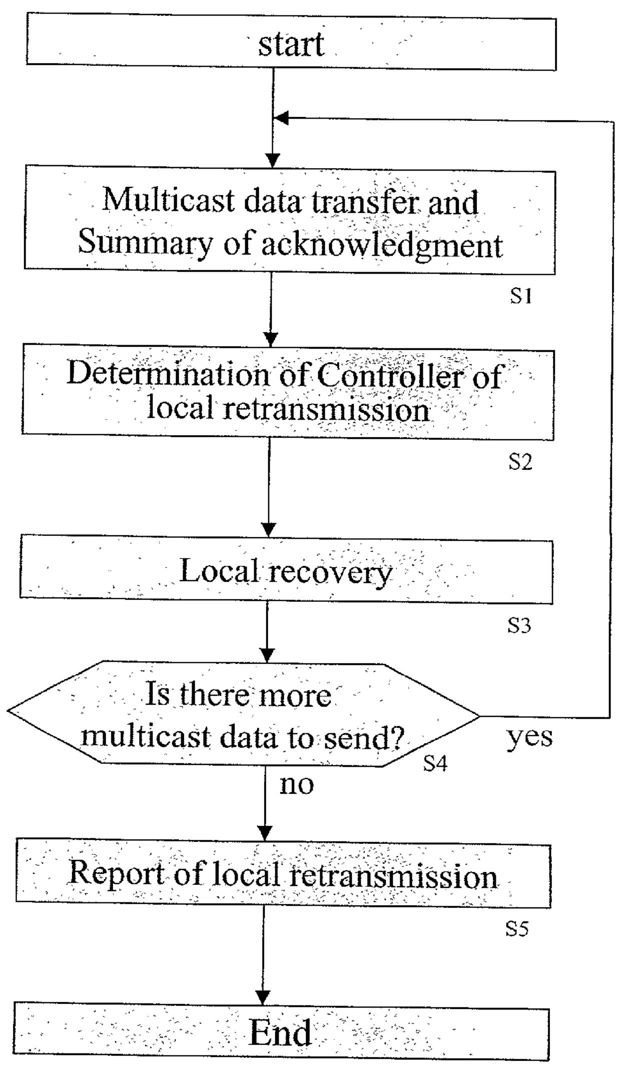
(52) **U.S. Cl.** **370/390**; 370/400; 370/432

(57) **ABSTRACT**

A method of multicasting data from a sender to first, second and third receivers through a network including first and second routers, the method comprising transmitting a data packet from said sender to said first, second and third receivers, detecting at said first, second and third receivers whether said data packet is properly received, transmitting a first reception information signal from said first receiver to said first router by a first path, transmitting a second reception information signal from said second receiver to said first router by a second path, determining, at said first router, in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and, if so, transmitting information relating to said first and second detection information signals to said second router, determining, at said second router, whether said third receiver requires re-transmission of said data packet and, if not, instructing said first router to re-transmit said data packet to said first and second receivers.



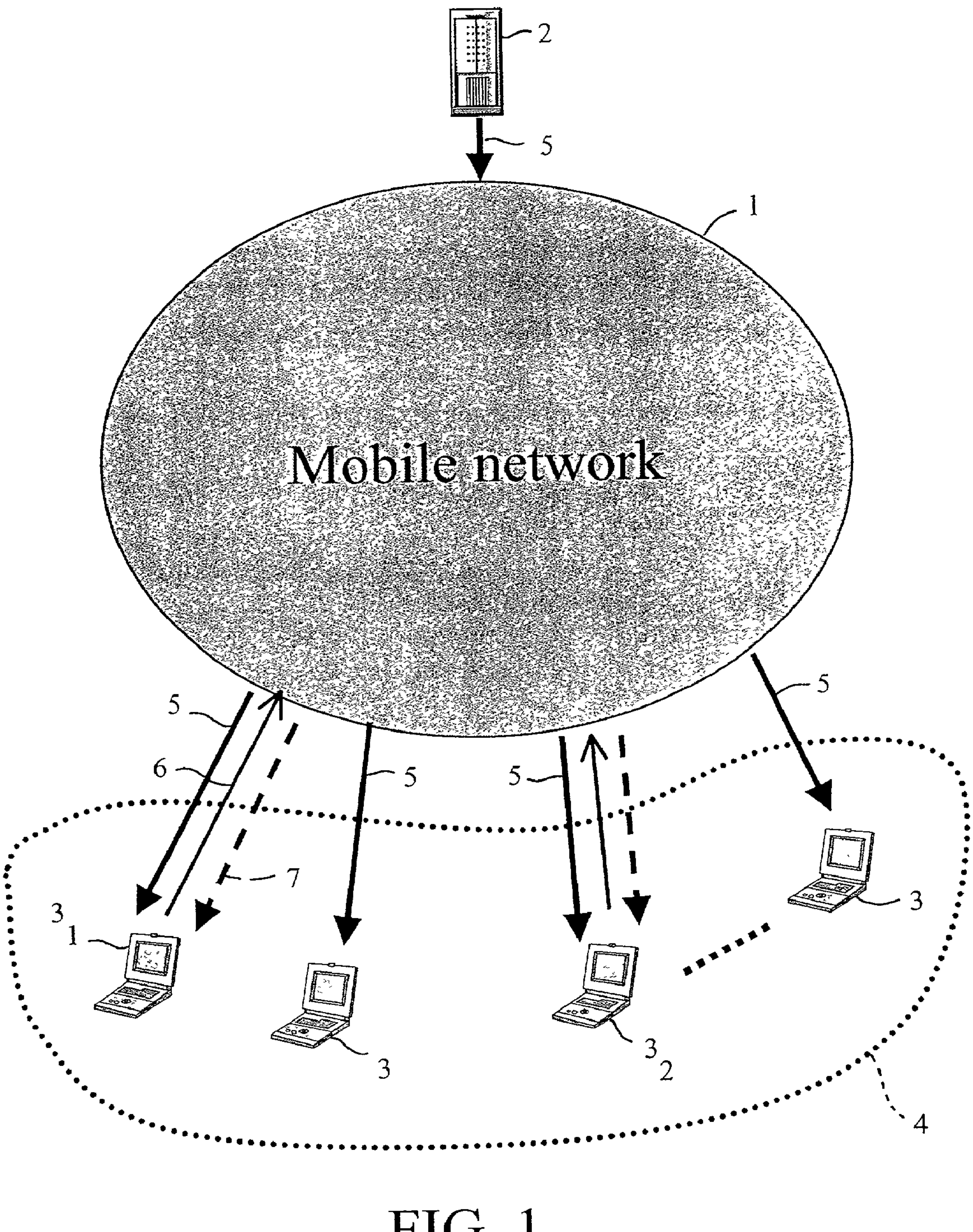


FIG. 1

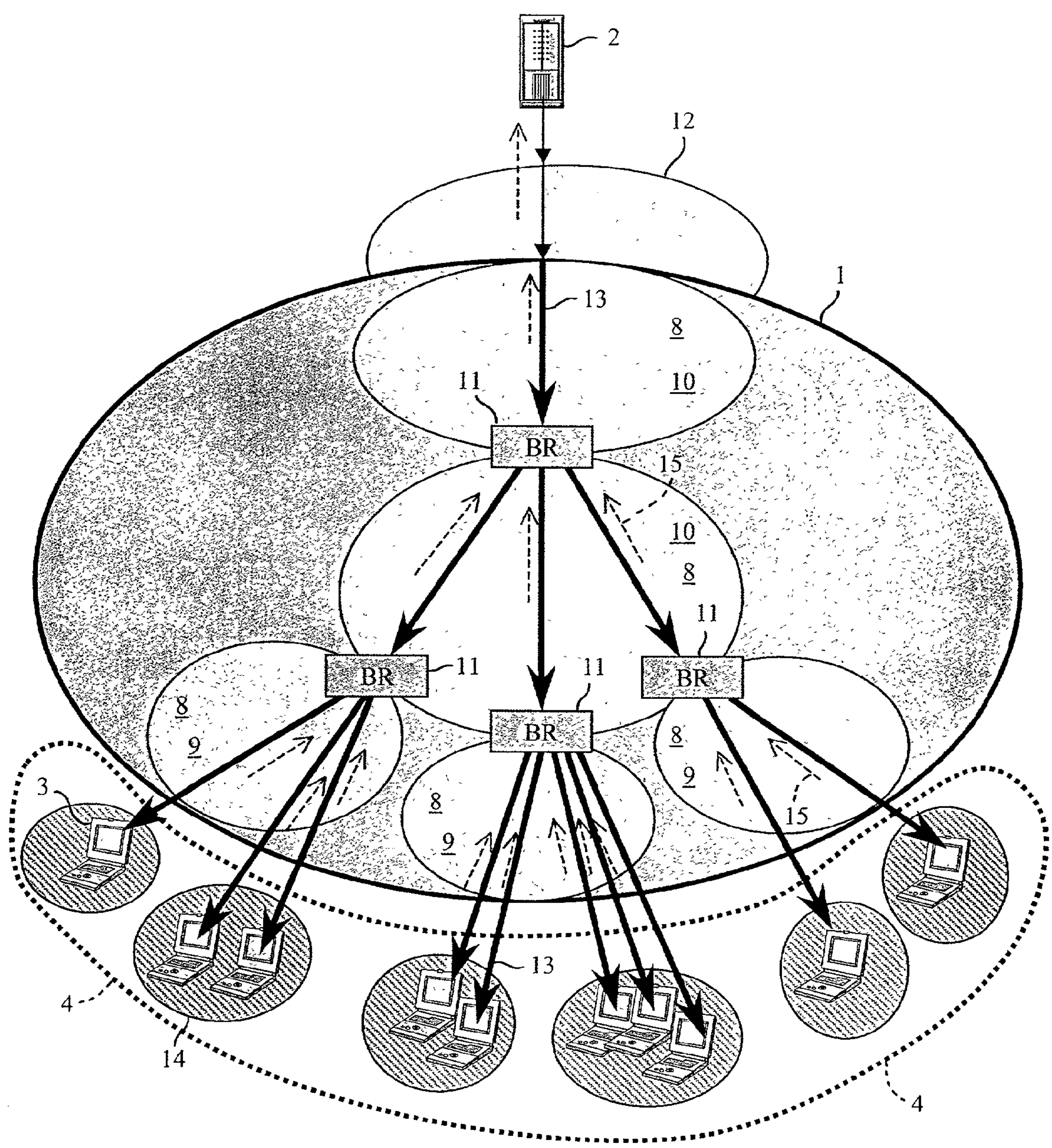


FIG. 2

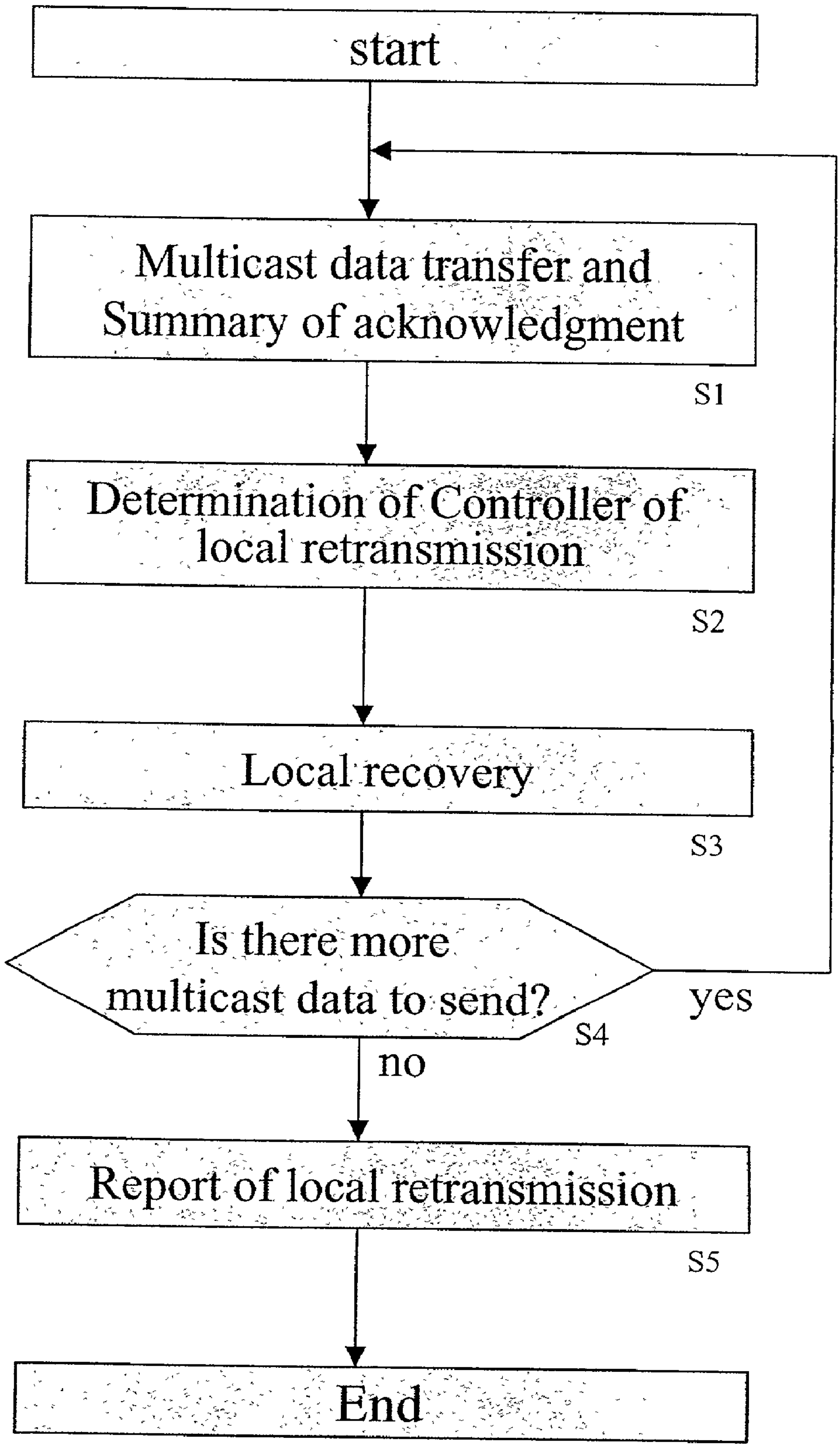

start
Multicast data transfer and Summary of acknowledgment
S1
Determination of Controller of local retransmission
S2
Local recovery
S3
Is there more multicast data to send?
S4
yes
no
Report of local retransmission
S5
End

FIG. 3

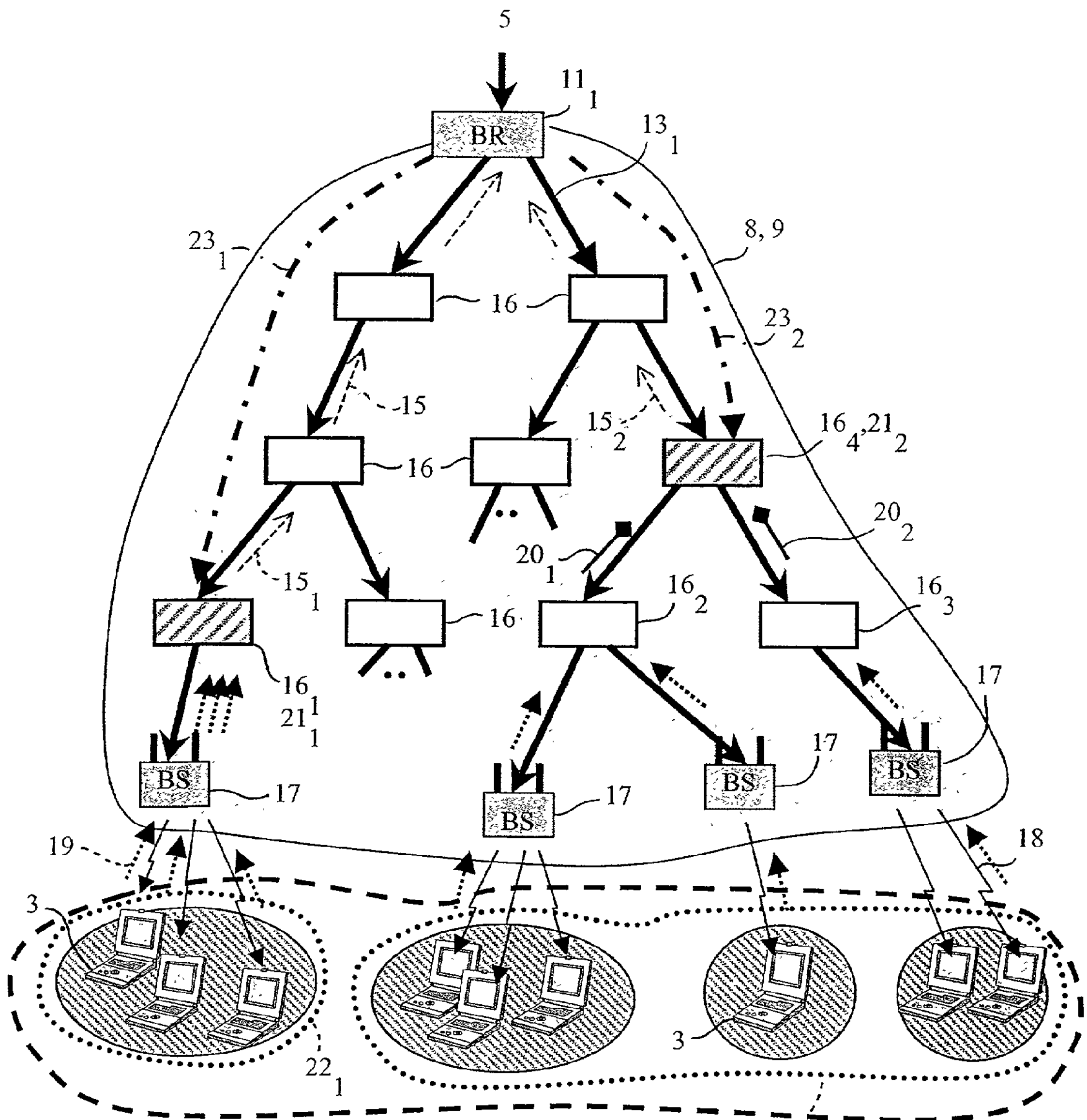

5
11 1
BR
13 1
8, 9
23 1
16
23 2
15
15 2
16
16 4,21 2
20 2
20 1
15 1
16
16 2
16 3
16 1
21 1
17
BS
BS
BS
BS
19
18
3
22 1
22 2
4 1

FIG. 4

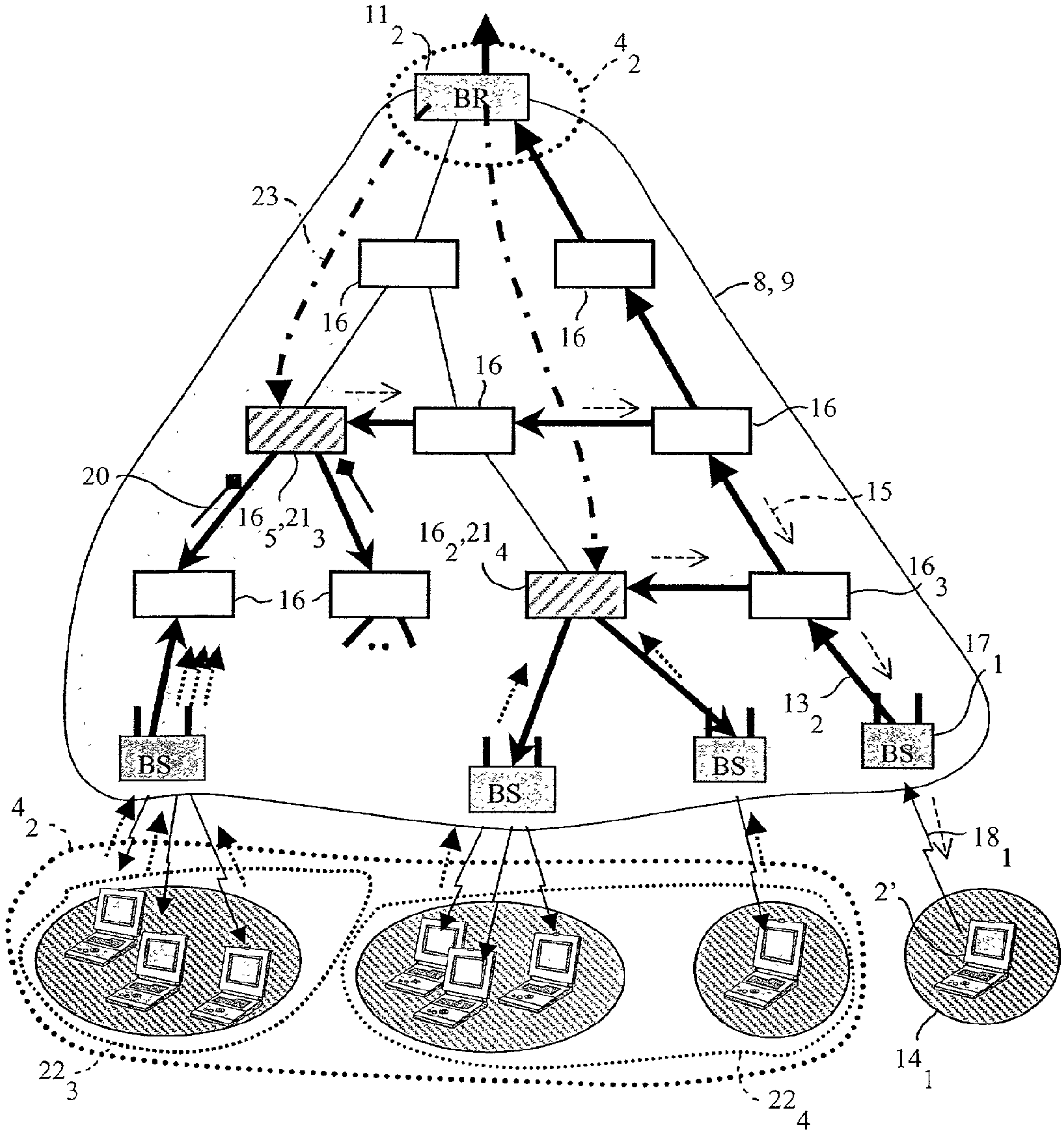

11 2
4 2
BR
23
8, 9
16
16
16
16
20
16 5, 21 3
16 2, 21 4
15
16
16 3
17 1
13 2
BS
BS
BS
BS
4 2
18 1
2'
22 3
22 4
14 1

FIG. 5

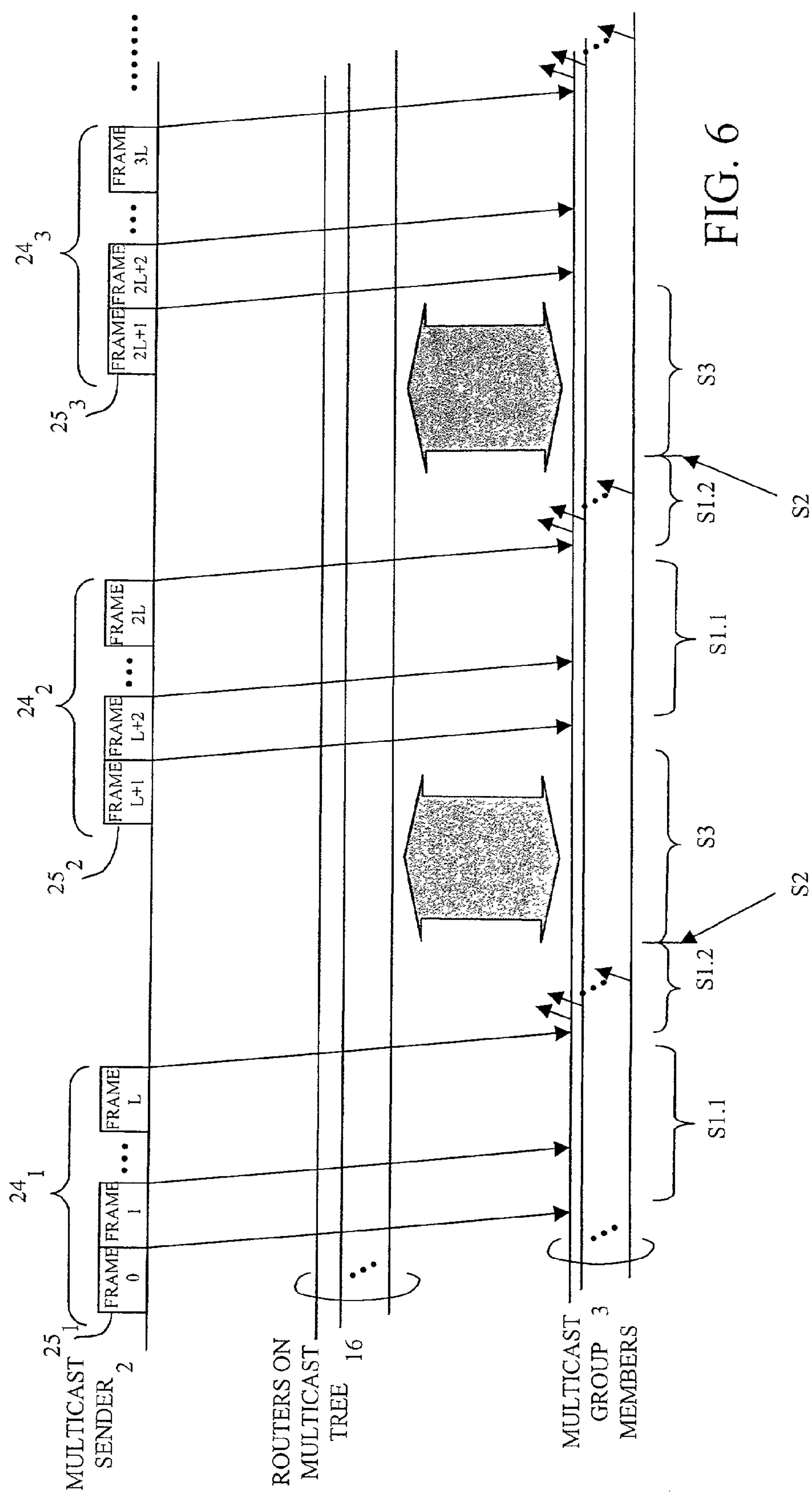

MULTICAST SENDER 2
25 1
FRAME 0
FRAME 1
FRAME L
24 1
ROUTERS ON MULTICAST TREE 16
MULTICAST GROUP MEMBERS 3
S1.1
S1.2
S2
S3
25 2
FRAME L+1
FRAME L+2
FRAME 2L
24 2
S1.1
S1.2
S2
S3
25 3
FRAME 2L+1
FRAME 2L+2
FRAME 3L
24 3

FIG. 6

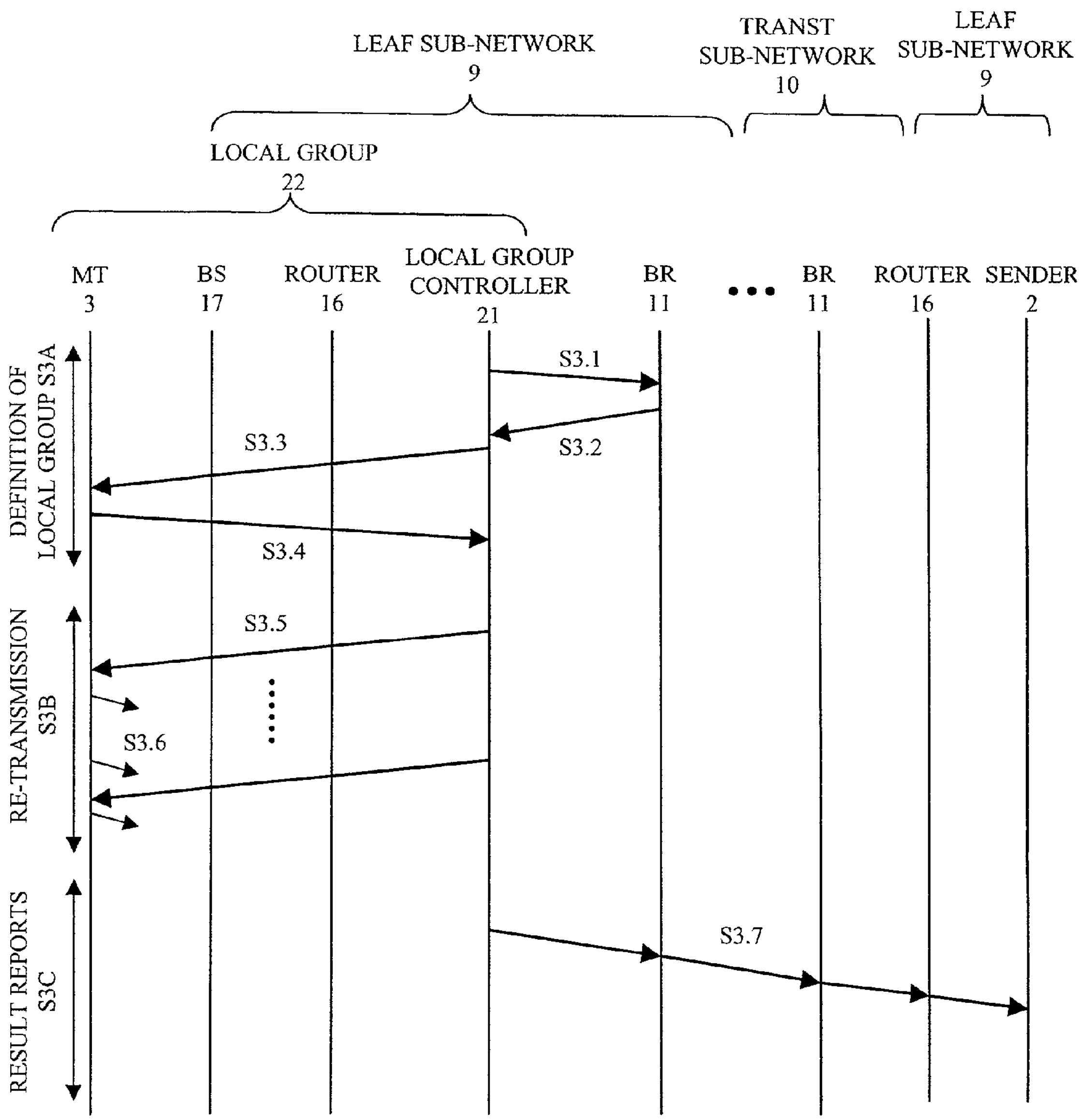

LEAF SUB-NETWORK
9
TRANST
SUB-NETWORK
10
LEAF
SUB-NETWORK
9
LOCAL GROUP
22
MT
3
BS
17
ROUTER
16
LOCAL GROUP
CONTROLLER
21
BR
11
BR
11
ROUTER
16
SENDER
2
DEFINITION OF
LOCAL GROUP S3A
RE-TRANSMISSION
S3B
RESULT REPORTS
S3C
S3.1
S3.2
S3.3
S3.4
S3.5
S3.6
S3.7

FIG. 7

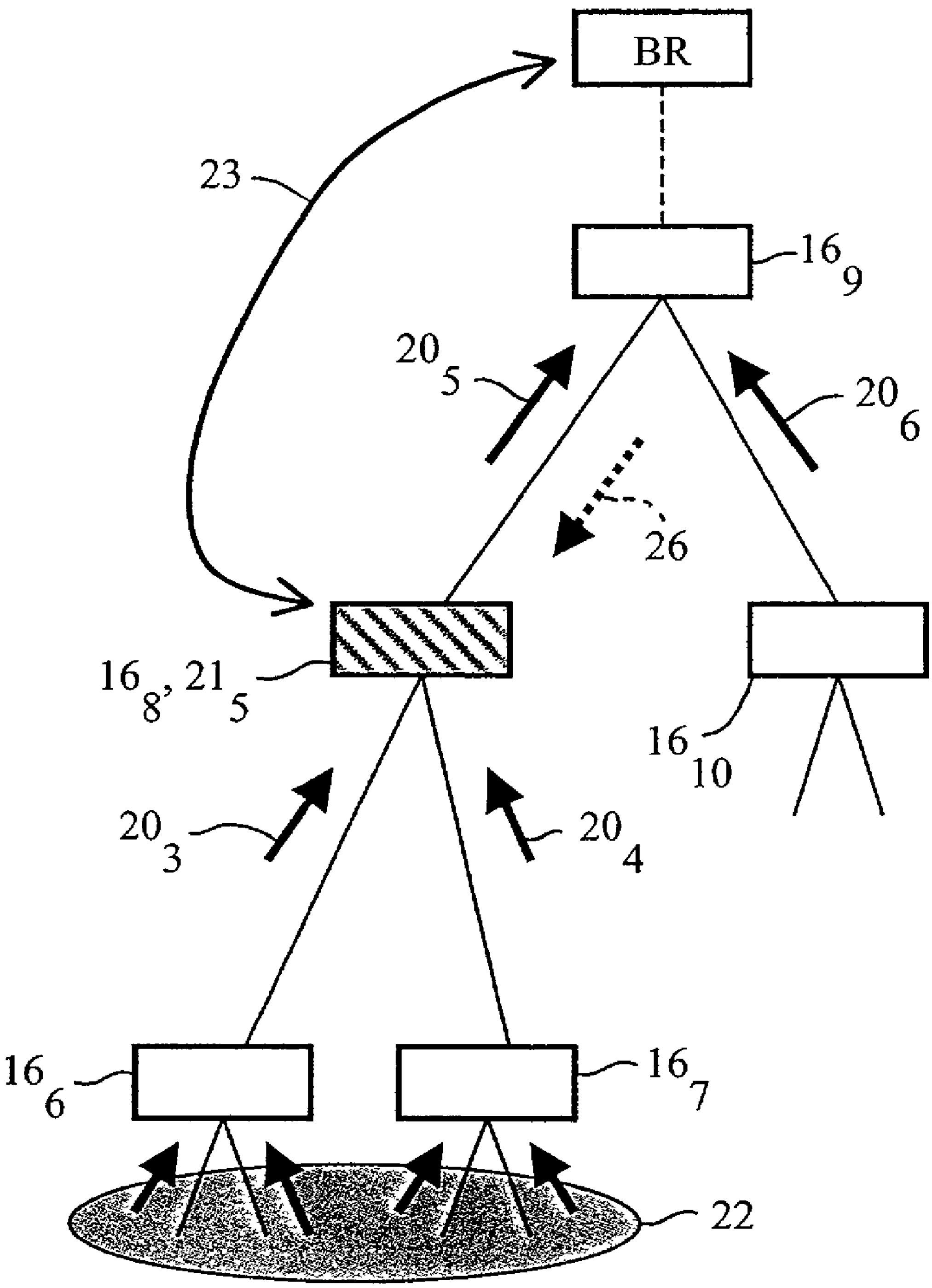


FIG. 8

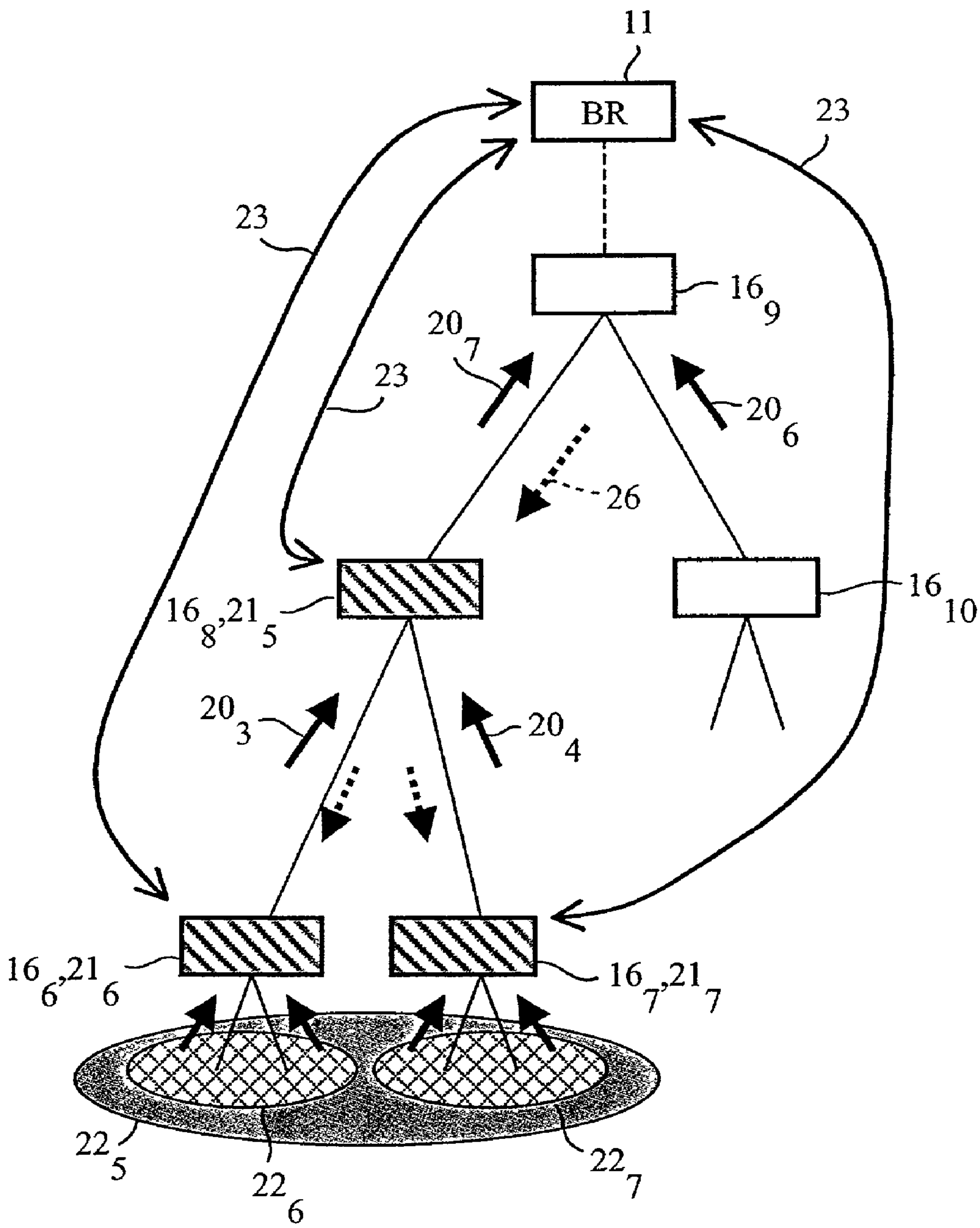

11
BR
23
23
23
16
9
20
7
20
6
26
16
8
,21
5
16
10
20
3
20
4
16
6
,21
6
16
7
,21
7
22
5
22
6
22
7

FIG. 9

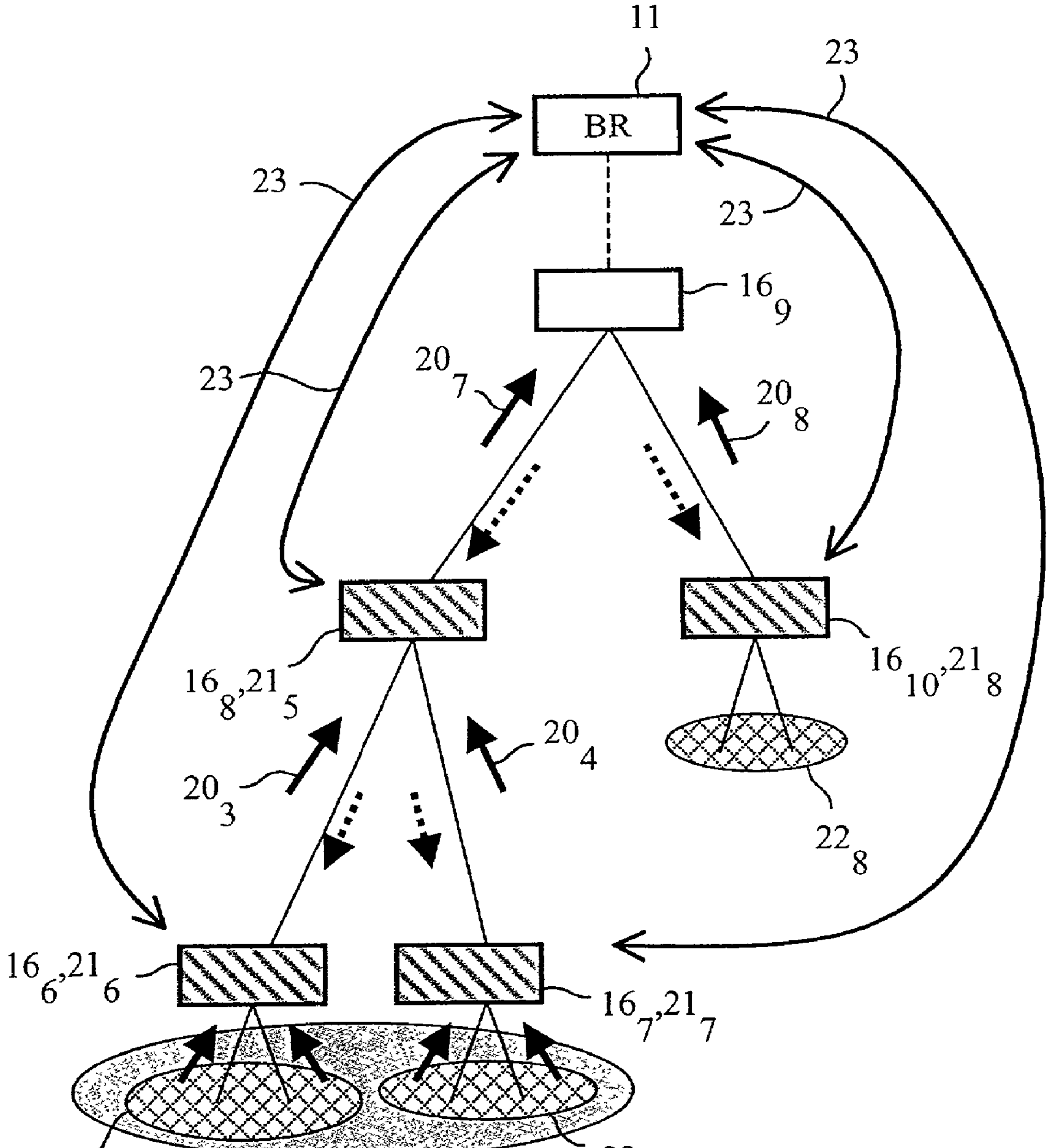

11
BR
23
23
23
23
16_9
20_7
20_8
16_8,21_5
16_{10},21_8
20_3
20_4
22_8
16_6,21_6
16_7,21_7
22_6
22_5
22_7

FIG. 10

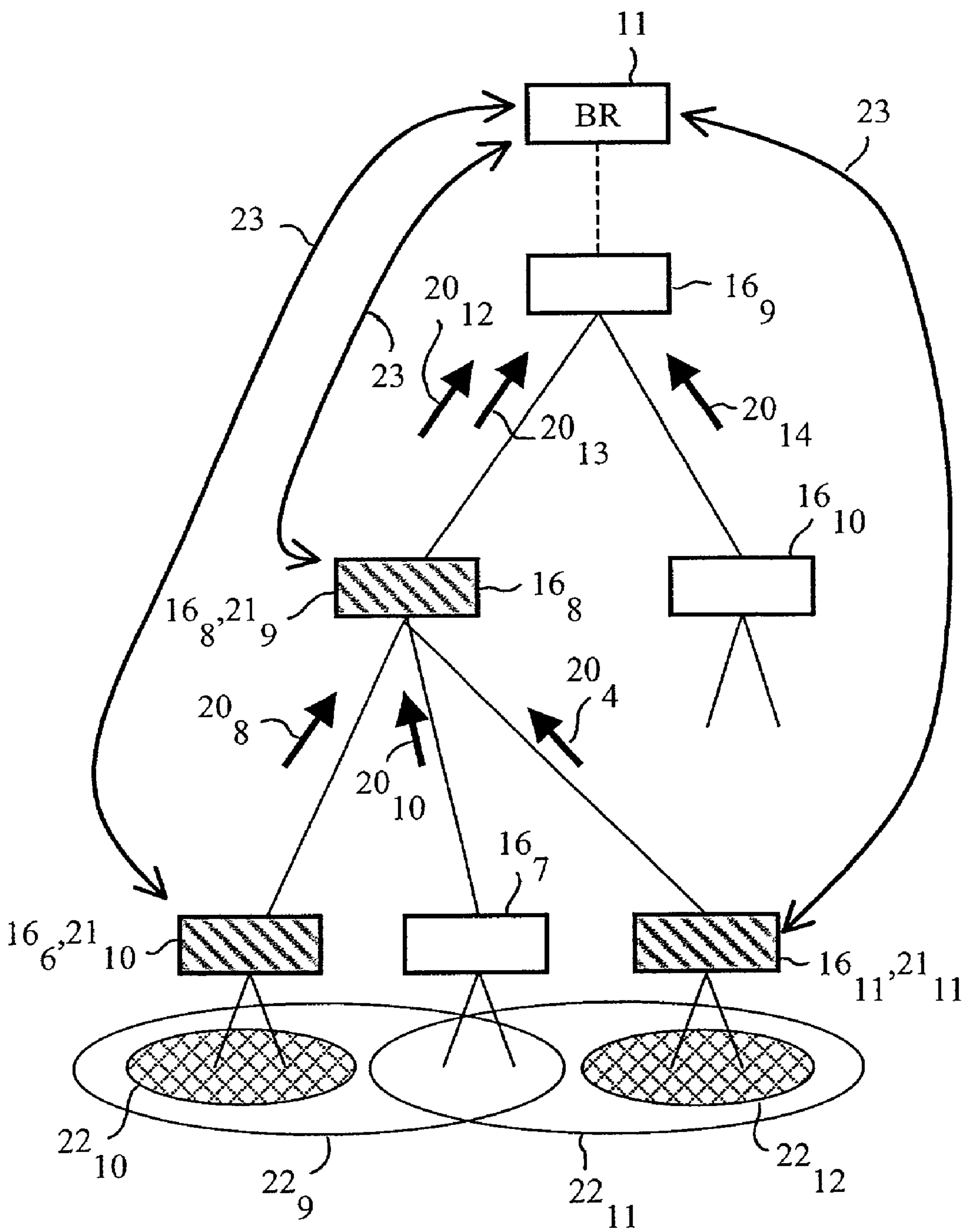

11
BR
23
23
23
23
20_{12}
16_9
20_{13}
20_{14}
16_{10}
16_8
$16_8,21_9$
20_4
20_8
20_{10}
16_7
$16_6,21_{10}$
$16_{11},21_{11}$
22_{10}
22_9
22_{11}
22_{12}

FIG. 11

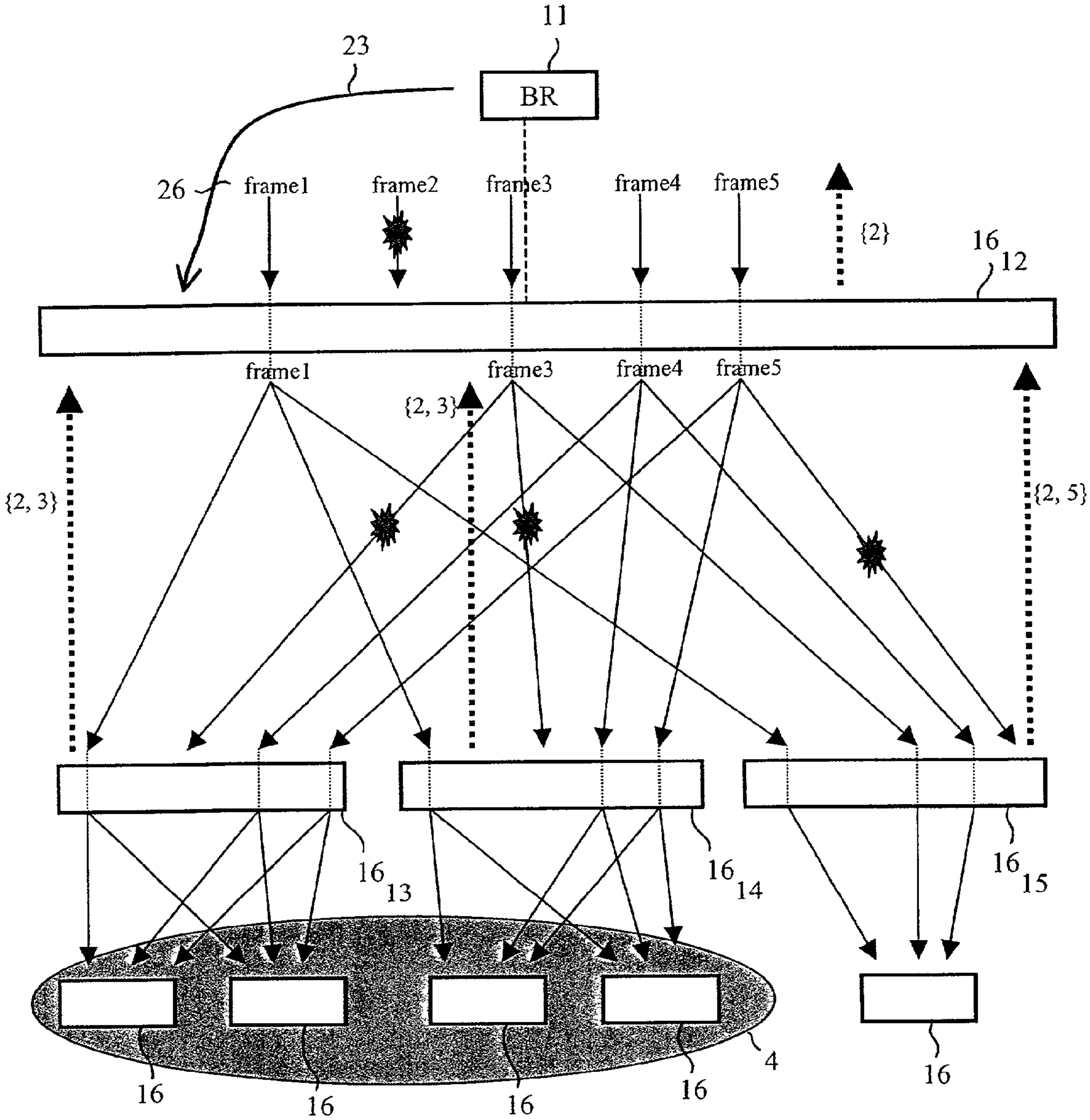

11
BR
23
26
frame1
frame2
frame3
frame4
frame5
{2}
16 12
frame1
frame3
frame4
frame5
{2, 3}
{2, 3}
{2, 5}
16 13
16 14
16 15
16
16
16
16
4
16

FIG. 12

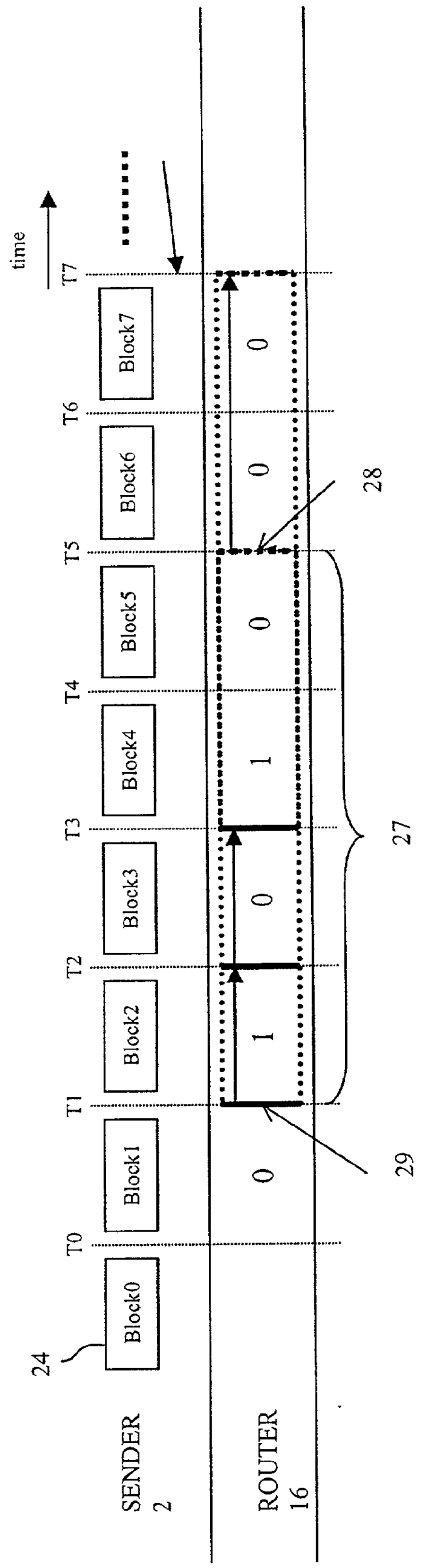

SENDER
2
ROUTER
16
24
Block0
Block1
Block2
Block3
Block4
Block5
Block6
Block7
T0
T1
T2
T3
T4
T5
T6
T7
time
0
1
0
1
0
0
0
27
28
29

FIG. 13

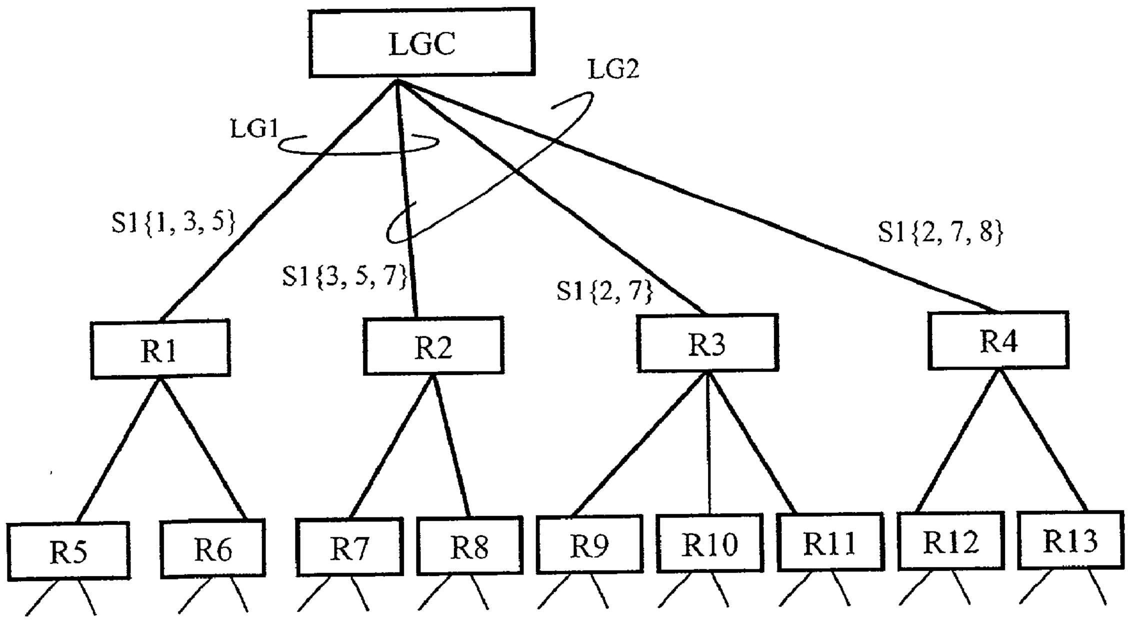

LGC
LG2
LG1
S1{1, 3, 5}
S1{3, 5, 7}
S1{2, 7}
S1{2, 7, 8}
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13

FIG. 14

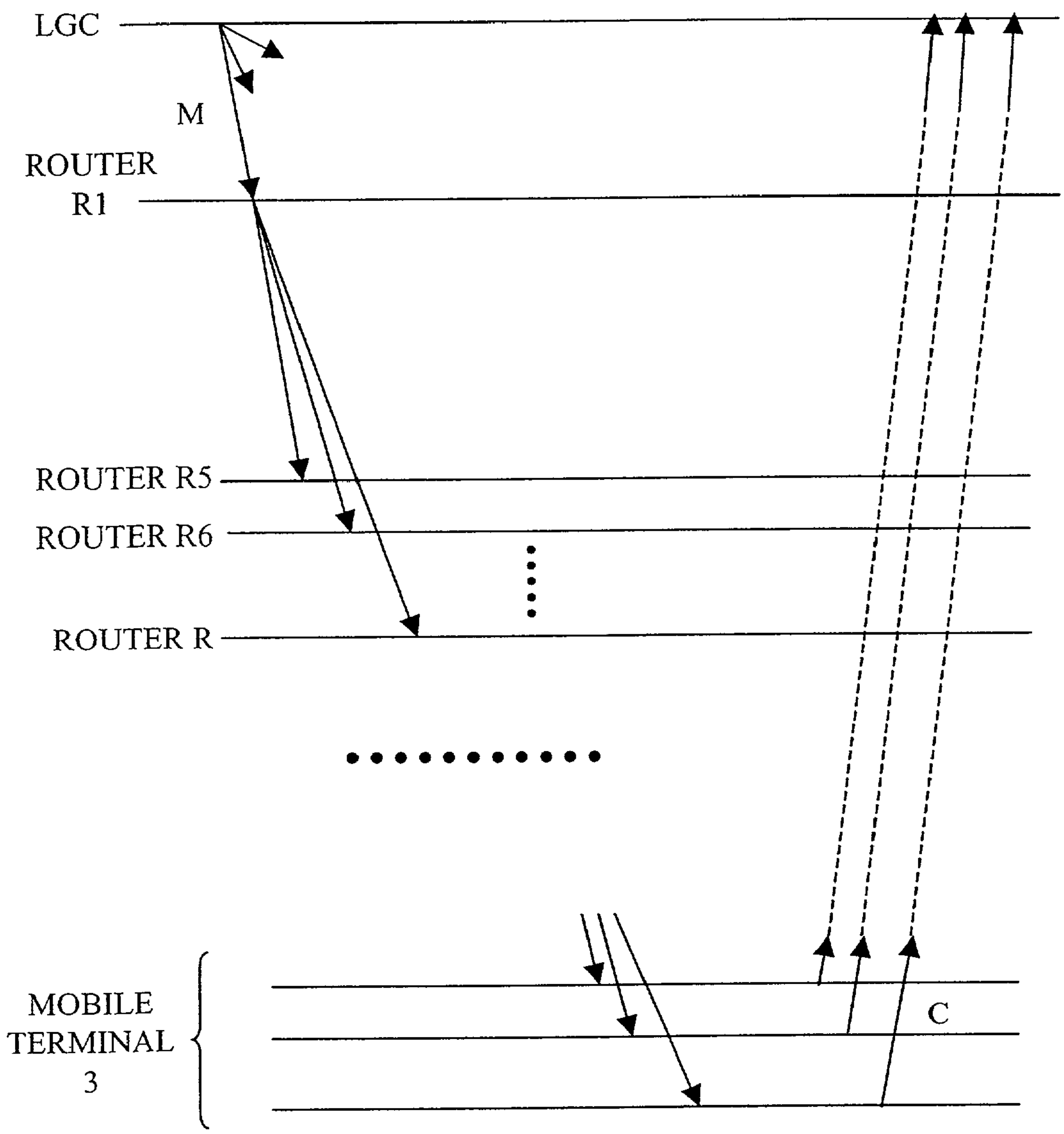

LGC
M
ROUTER
R1
ROUTER R5
ROUTER R6
ROUTER R
MOBILE
TERMINAL
3
C

FIG. 15

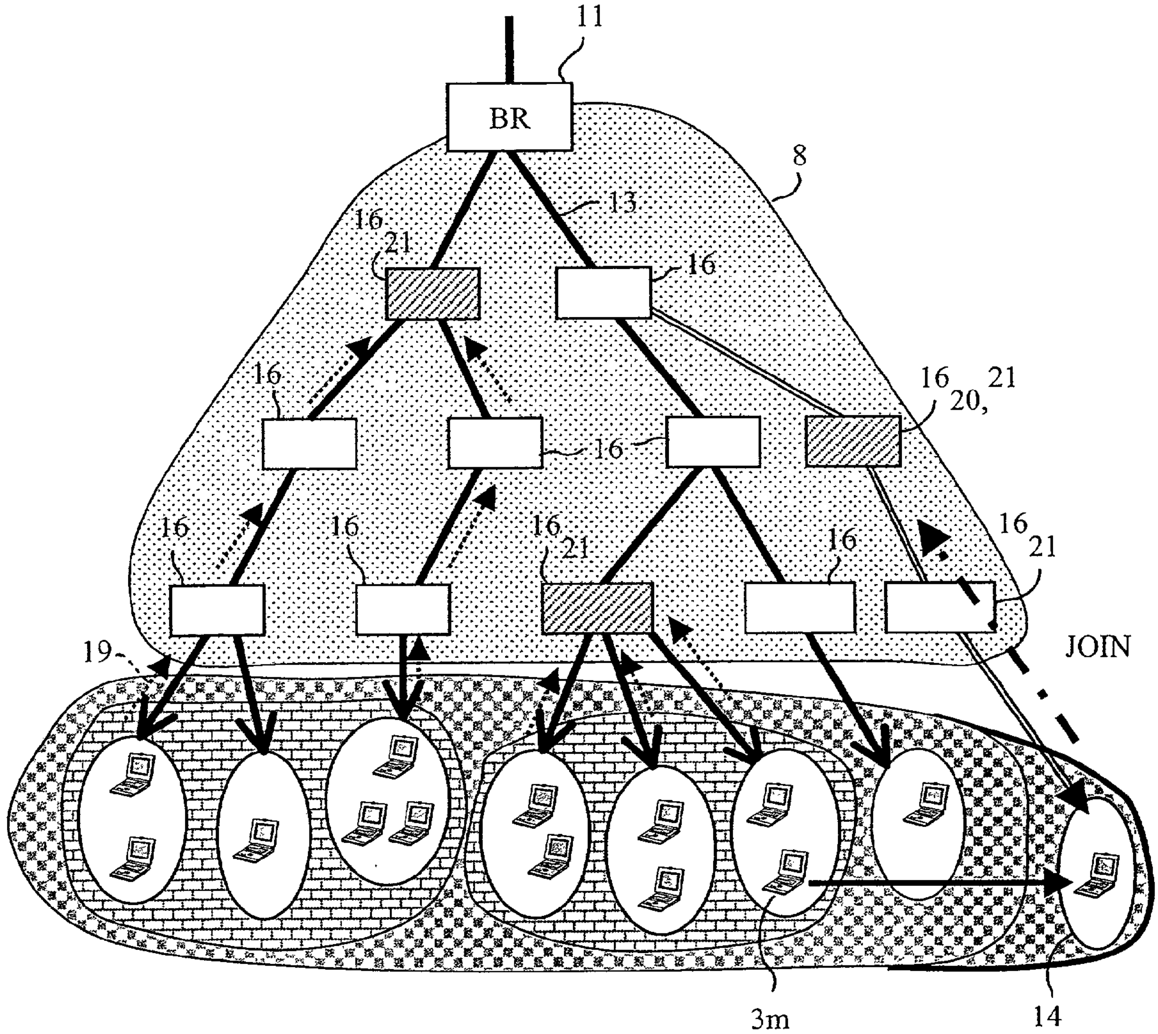


FIG. 16

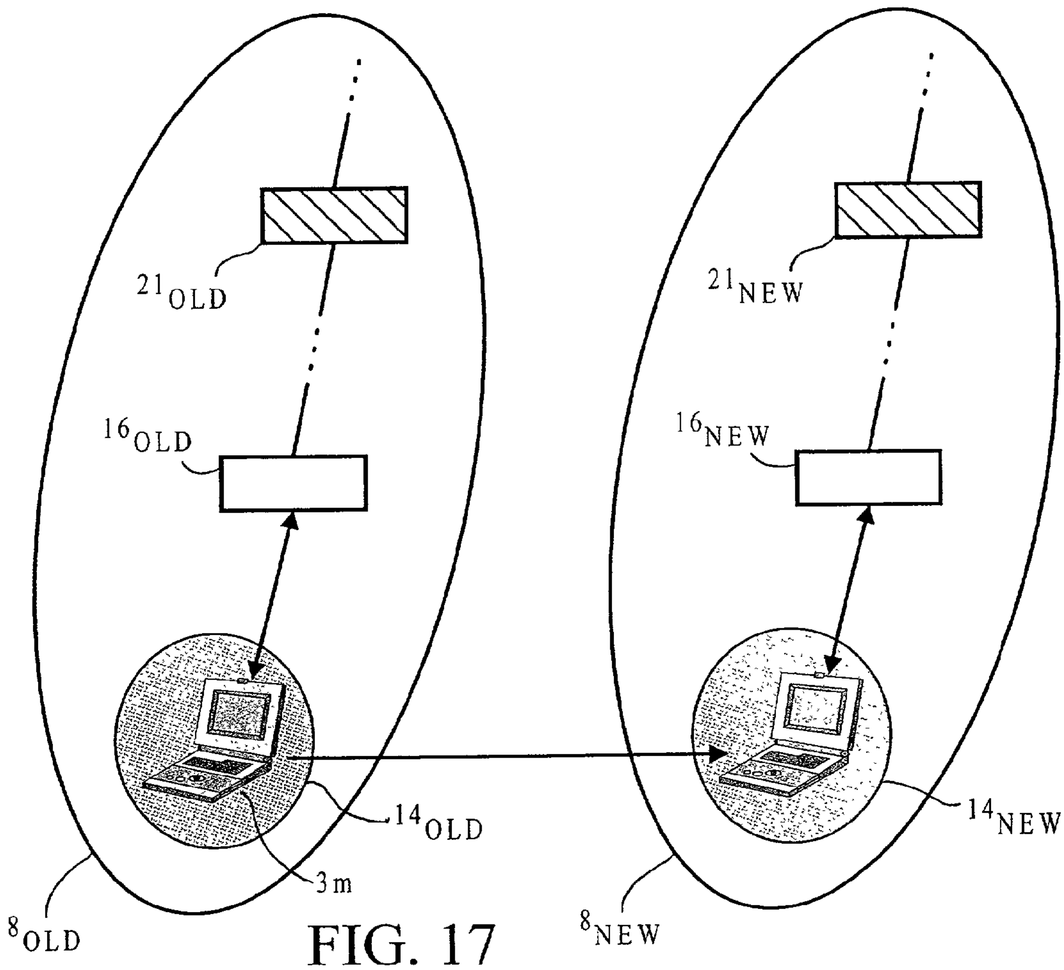


FIG. 17

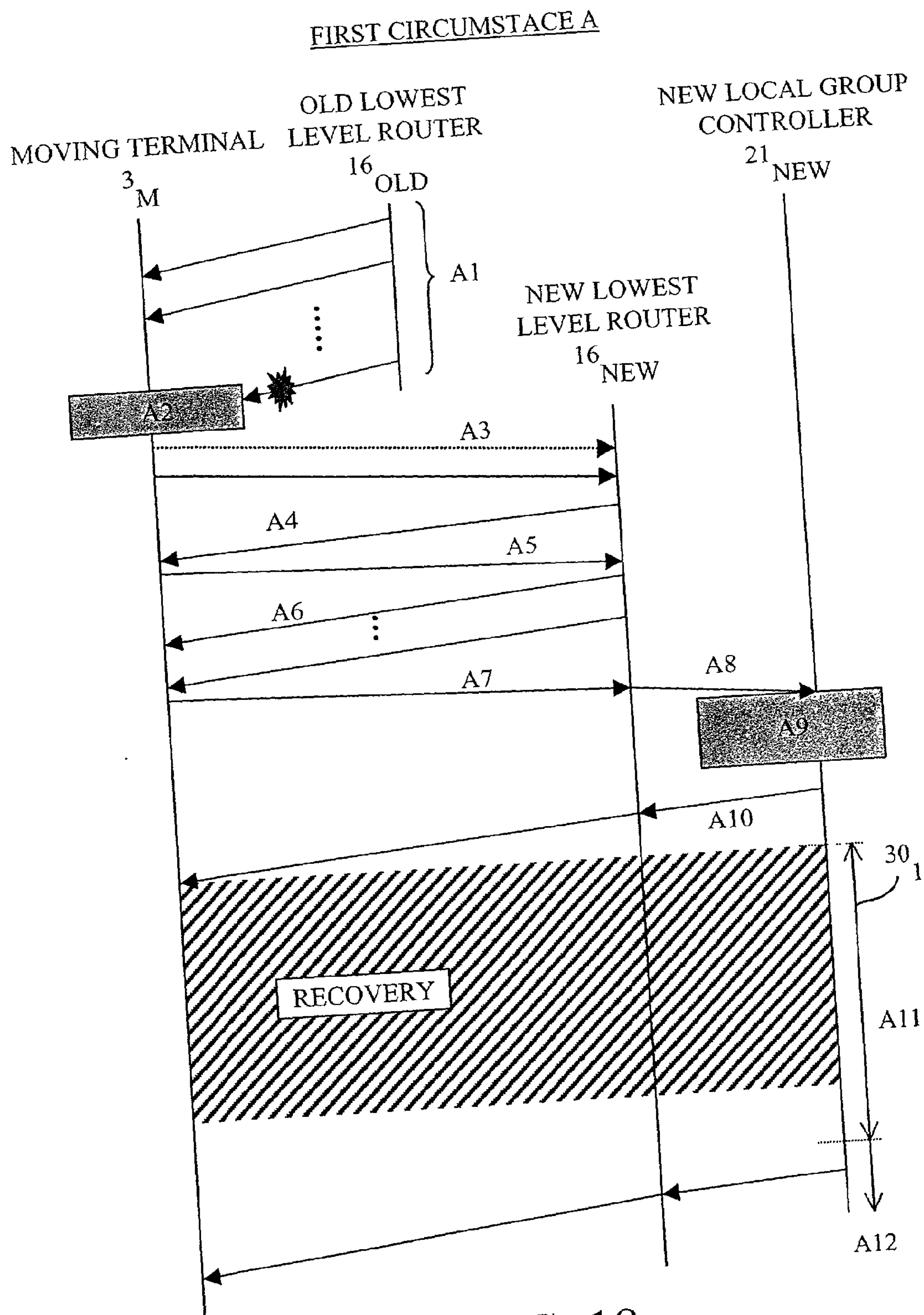

FIRST CIRCUMSTACE A
MOVING TERMINAL
3M
OLD LOWEST LEVEL ROUTER
16OLD
NEW LOCAL GROUP CONTROLLER
21NEW
NEW LOWEST LEVEL ROUTER
16NEW
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
301
RECOVERY
A11
A12

FIG. 18

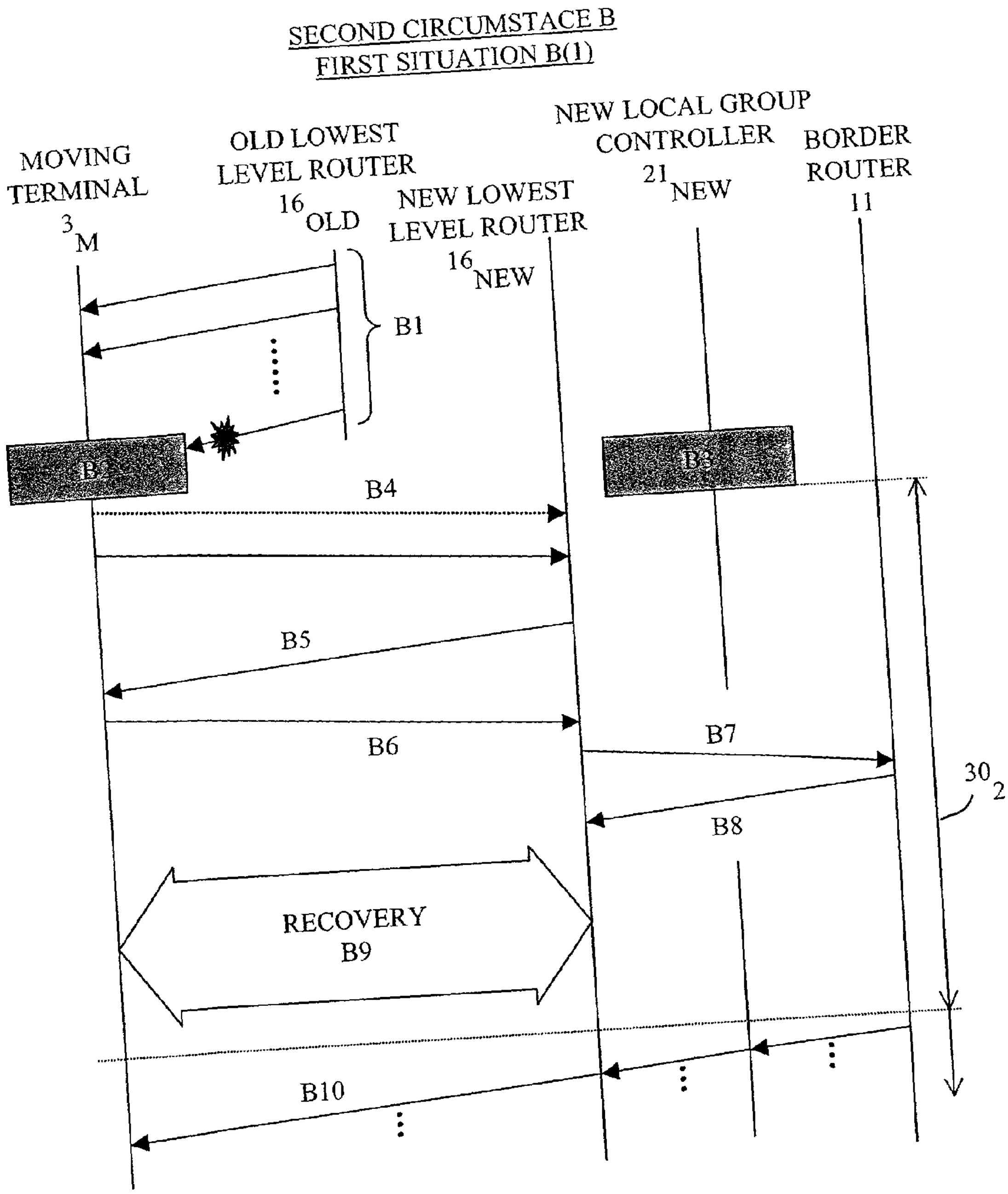

SECOND CIRCUMSTACE B
FIRST SITUATION B(1)
MOVING TERMINAL 3M
OLD LOWEST LEVEL ROUTER 16OLD
NEW LOWEST LEVEL ROUTER 16NEW
NEW LOCAL GROUP CONTROLLER 21NEW
BORDER ROUTER 11
B1
B2
B3
B4
B5
B6
B7
B8
RECOVERY
B9
B10
302

FIG. 19

SECOND CIRCUMSTACE B
SECOND SITUATION B(1)

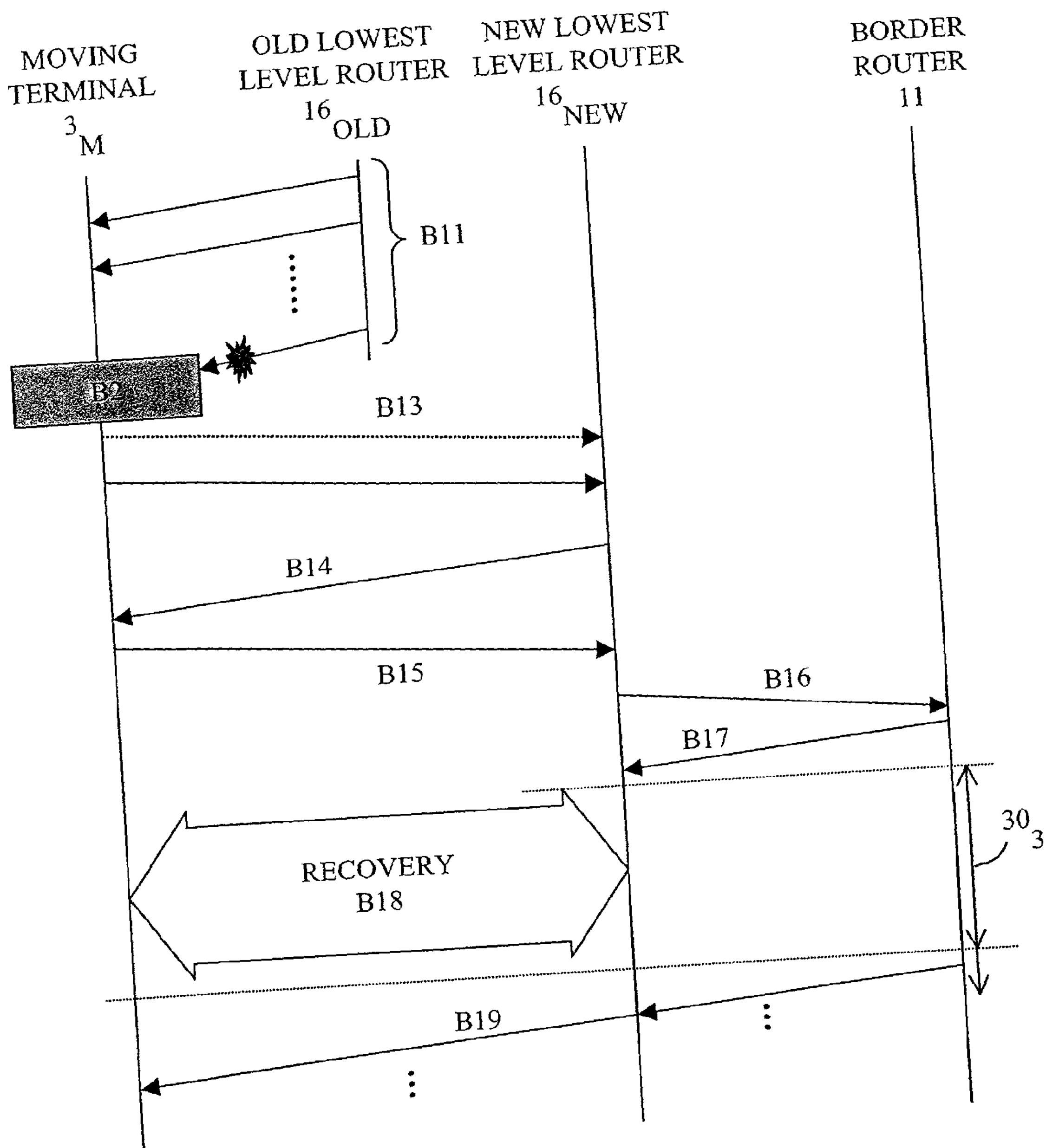


FIG. 20

THIRD CIRCUMSTACE C

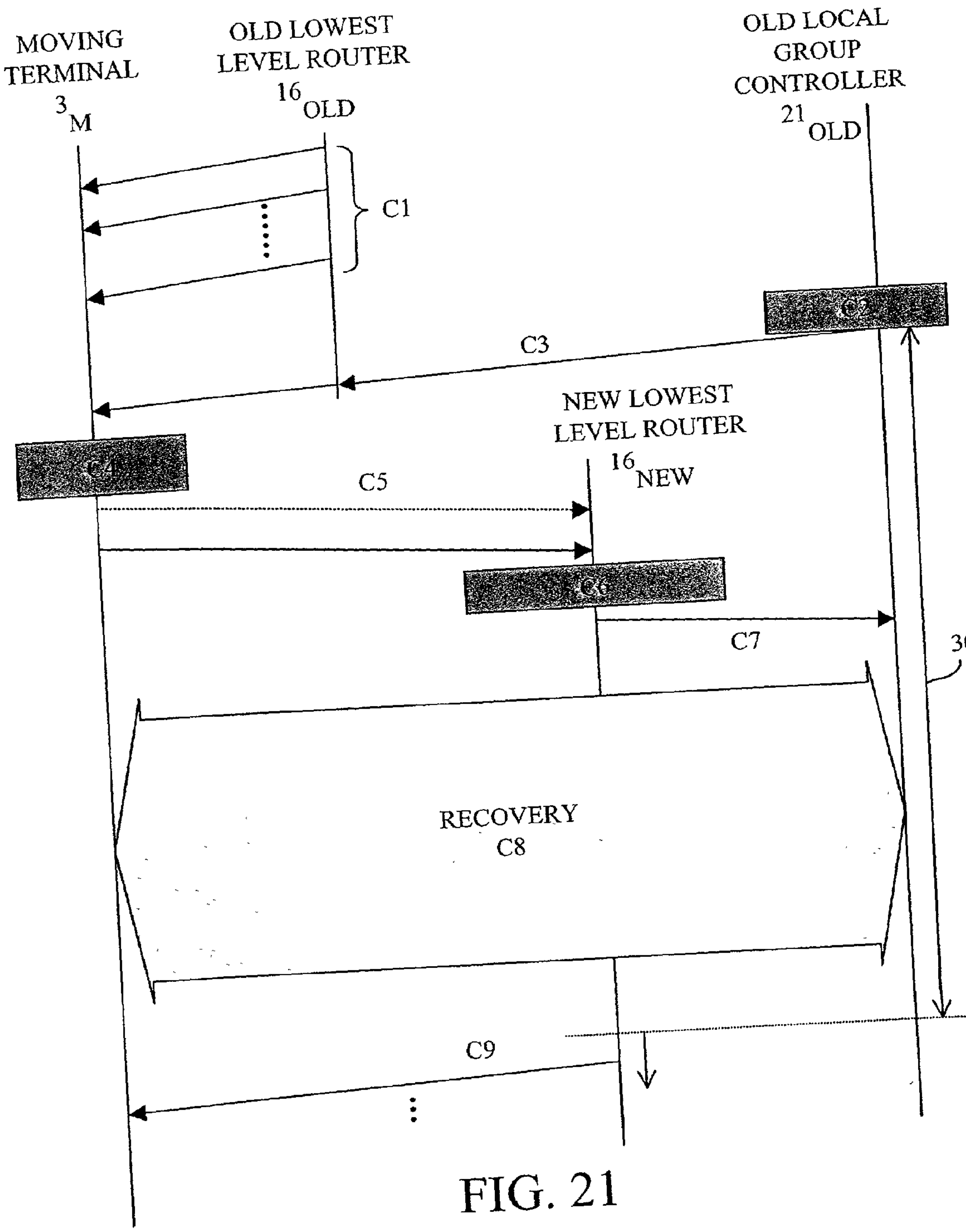


FIG. 21

FORTH CIRCUMSTACE D
FIRST SITUATION D(1)

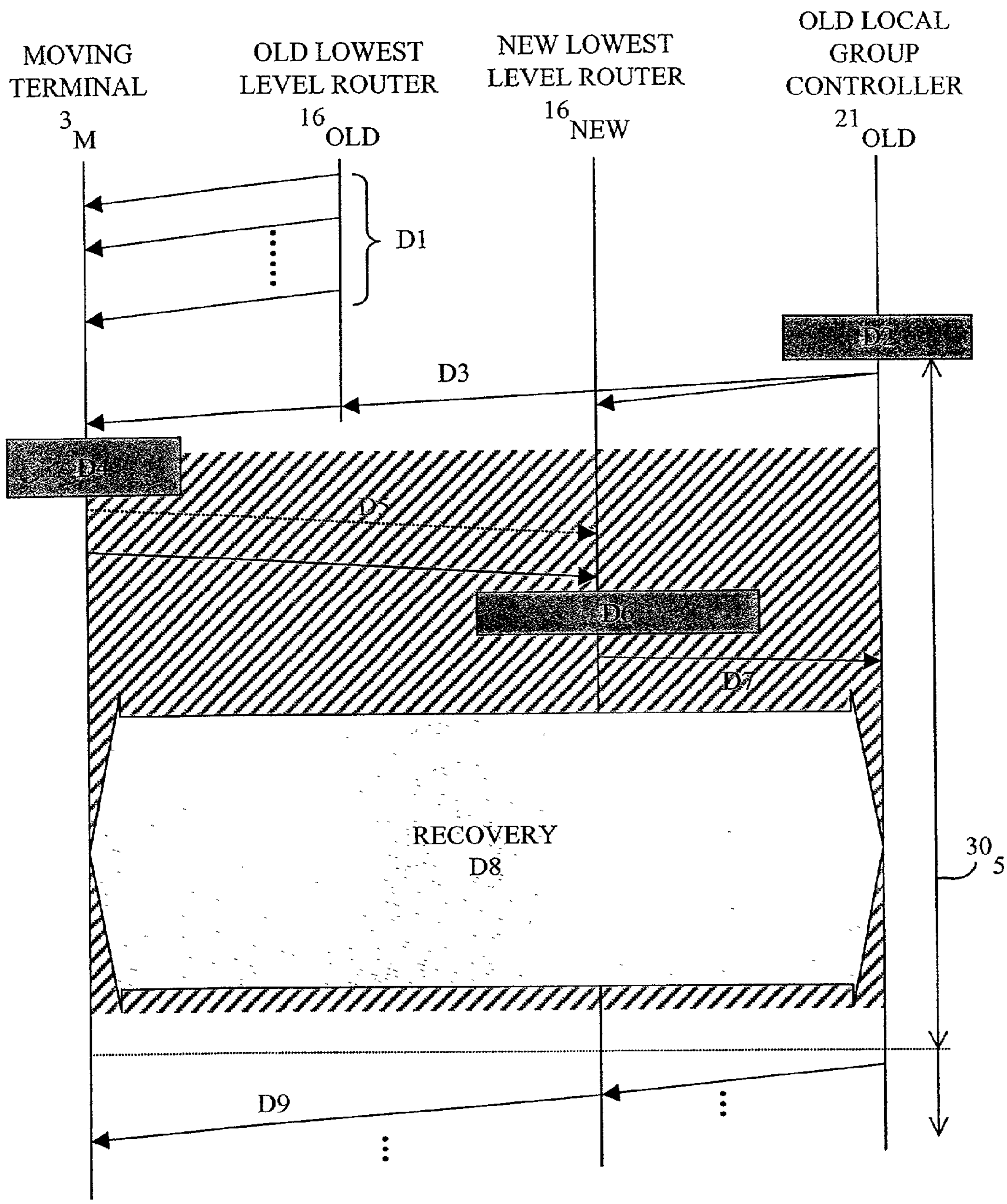


FIG. 22

FORTH CIRCUMSTACE D
SECOND AND THIRD SITUATION D(2), D(3)

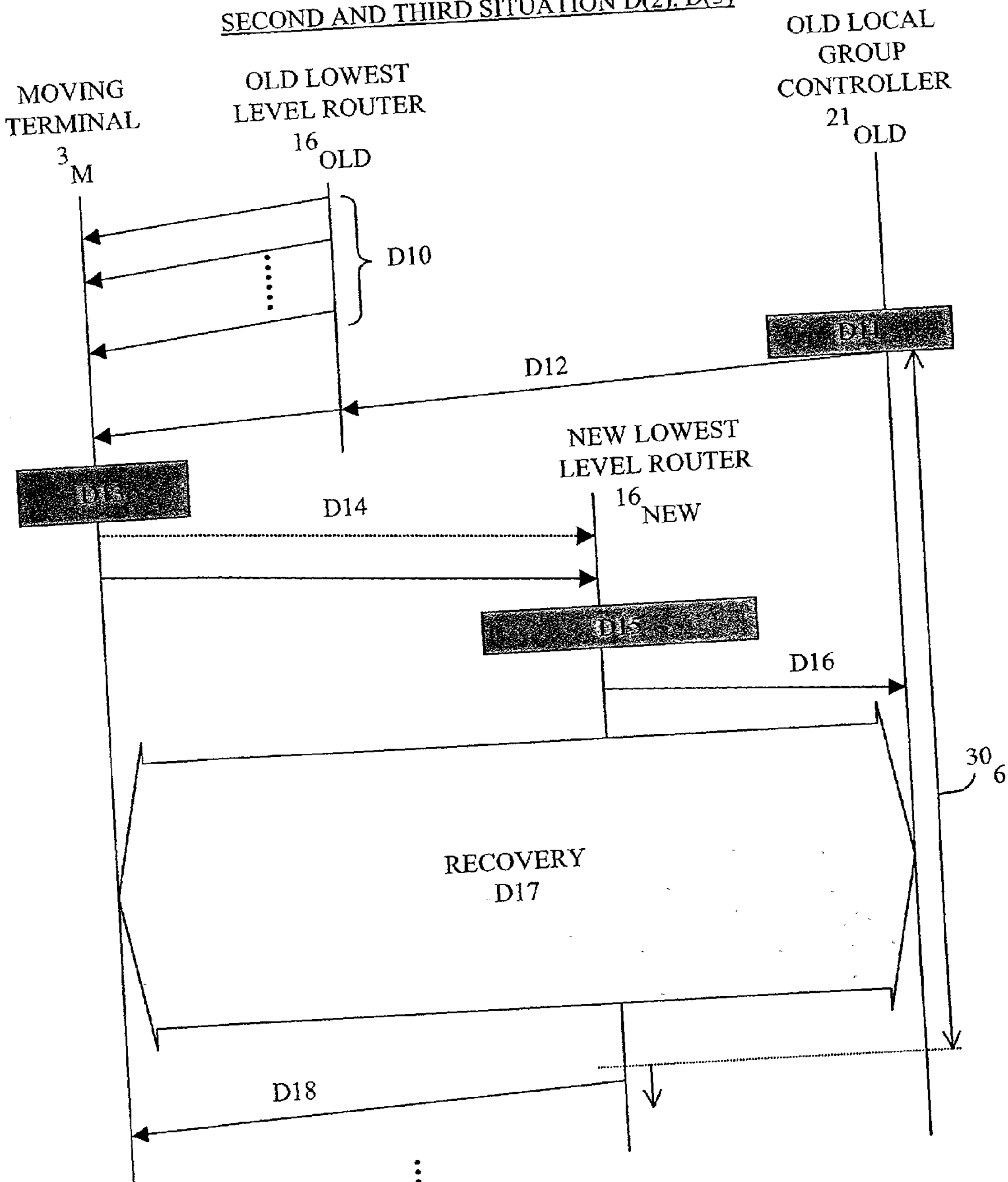


FIG. 23

FIFTH CIRCUMSTANCE E

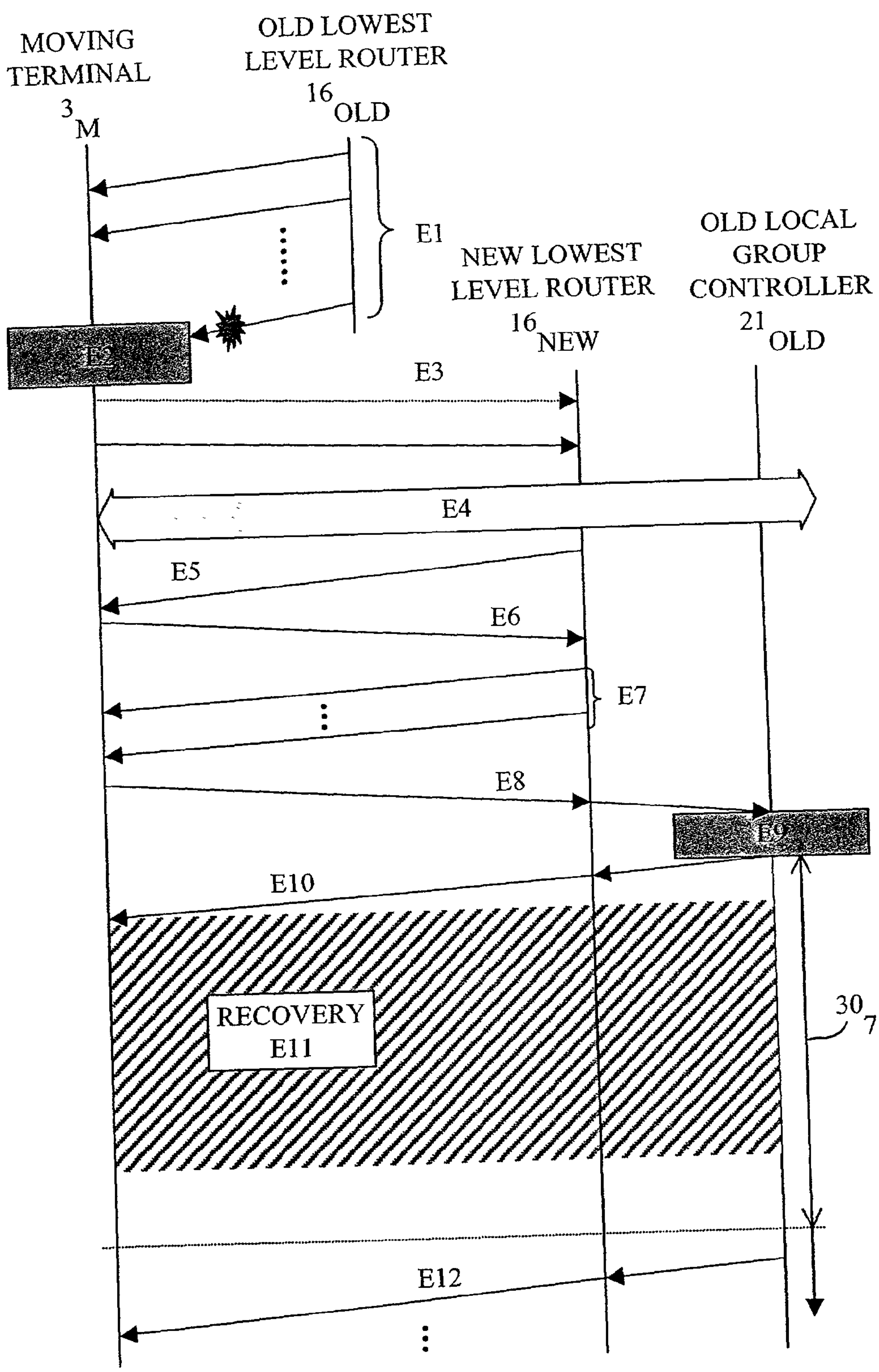


FIG. 24

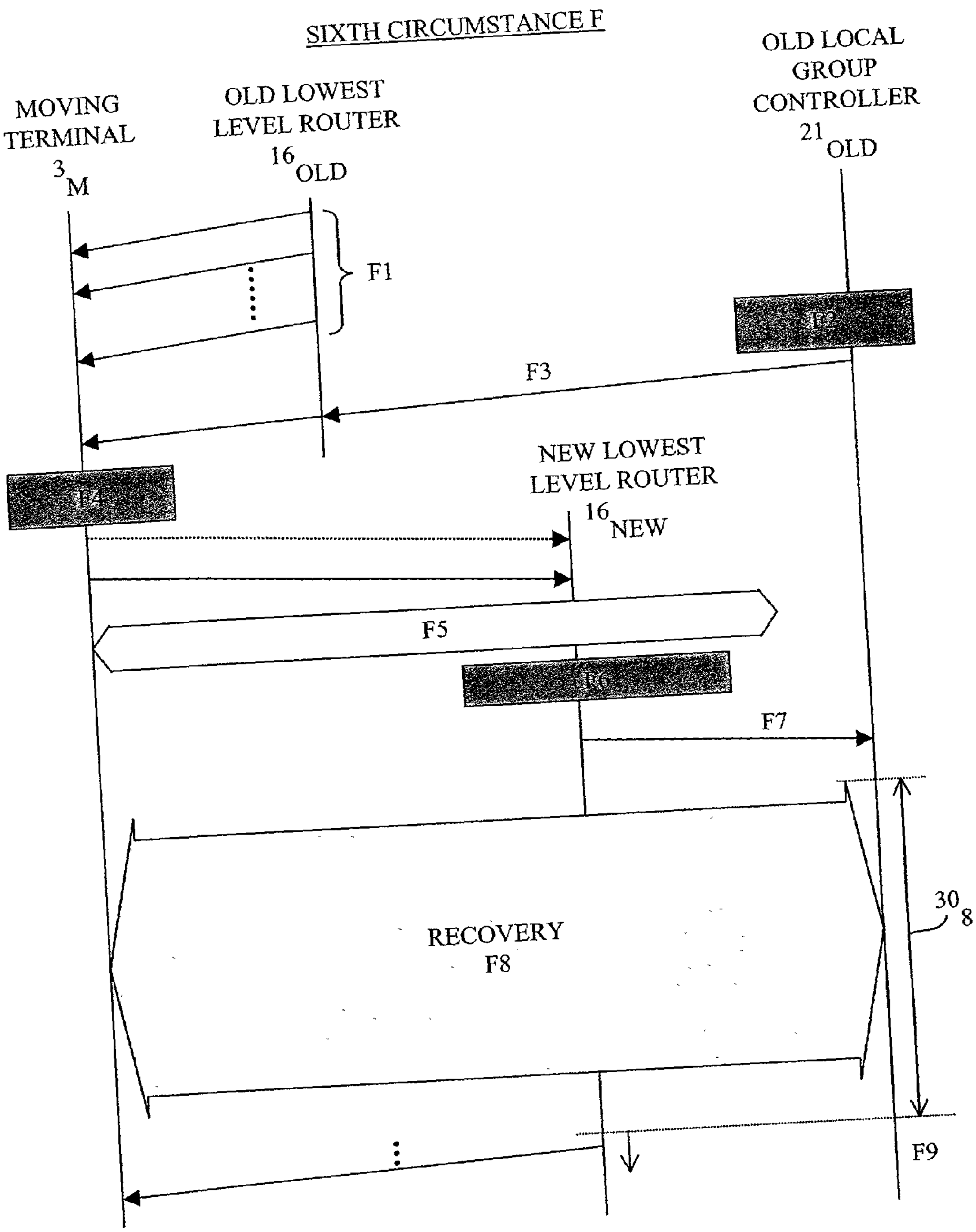

SIXTH CIRCUMSTANCE F
MOVING TERMINAL
3M
OLD LOWEST LEVEL ROUTER
16OLD
OLD LOCAL GROUP CONTROLLER
21OLD
F1
F2
F3
F4
NEW LOWEST LEVEL ROUTER
16NEW
F5
F6
F7
RECOVERY
F8
30
8
F9

FIG. 25

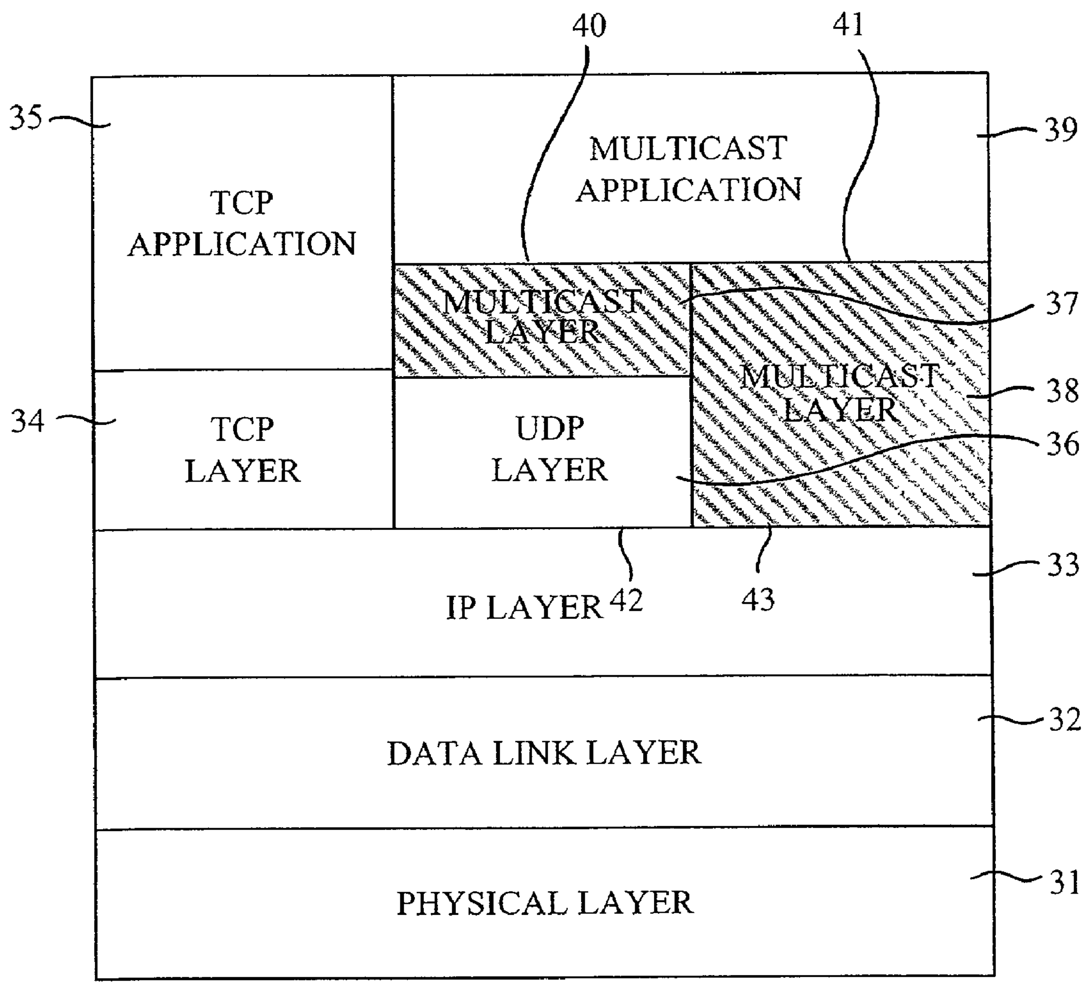

40
41
35
39
TCP
APPLICATION
MULTICAST
APPLICATION
MULTICAST
LAYER
37
MULTICAST
LAYER
38
34
TCP
LAYER
UDP
LAYER
36
33
IP LAYER
42
43
DATA LINK LAYER
32
PHYSICAL LAYER
31

FIG. 26

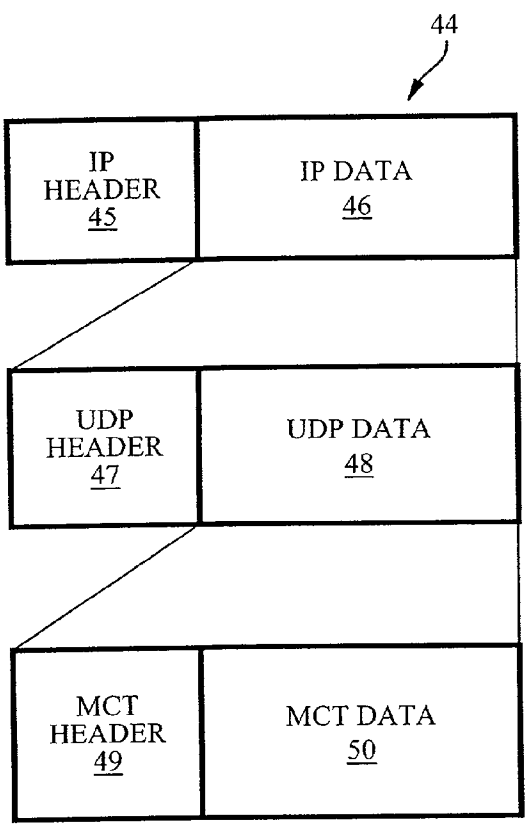


FIG. 27a

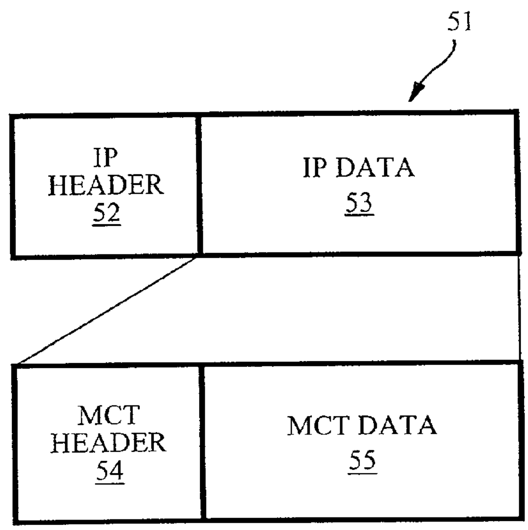


FIG. 27b

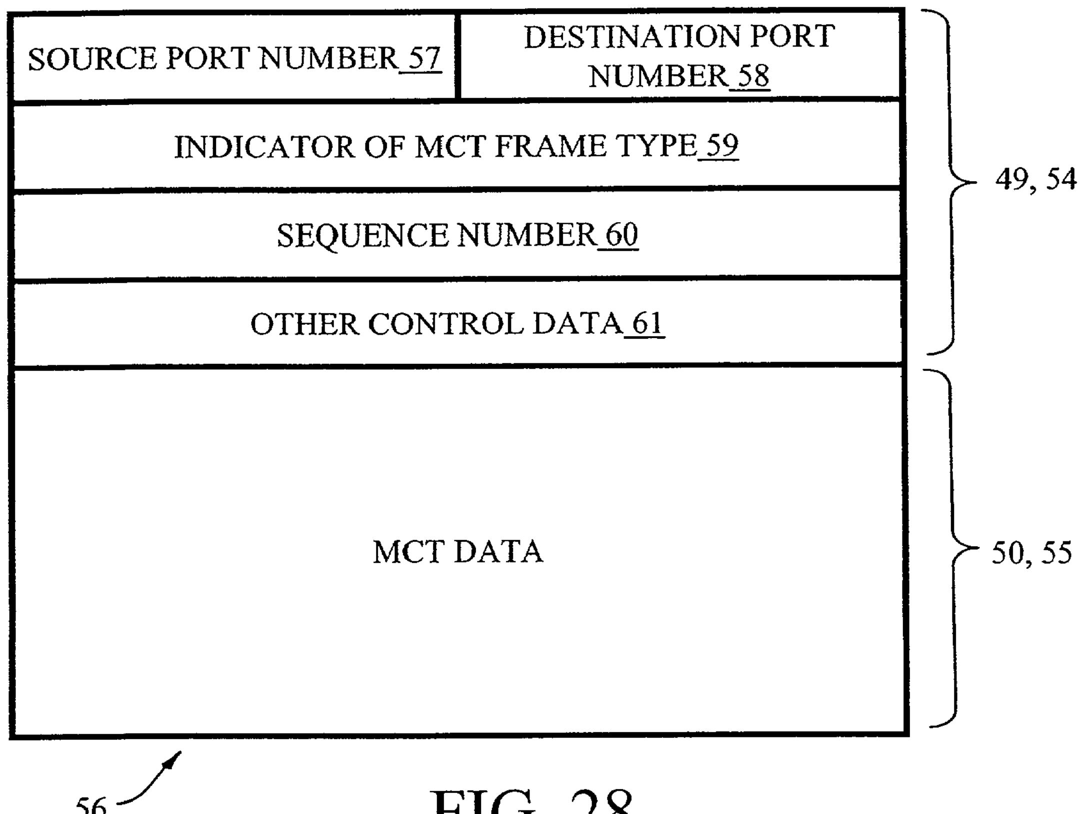

SOURCE PORT NUMBER 57
DESTINATION PORT NUMBER 58
INDICATOR OF MCT FRAME TYPE 59
SEQUENCE NUMBER 60
OTHER CONTROL DATA 61
MCT DATA
49, 54
50, 55
56

FIG. 28

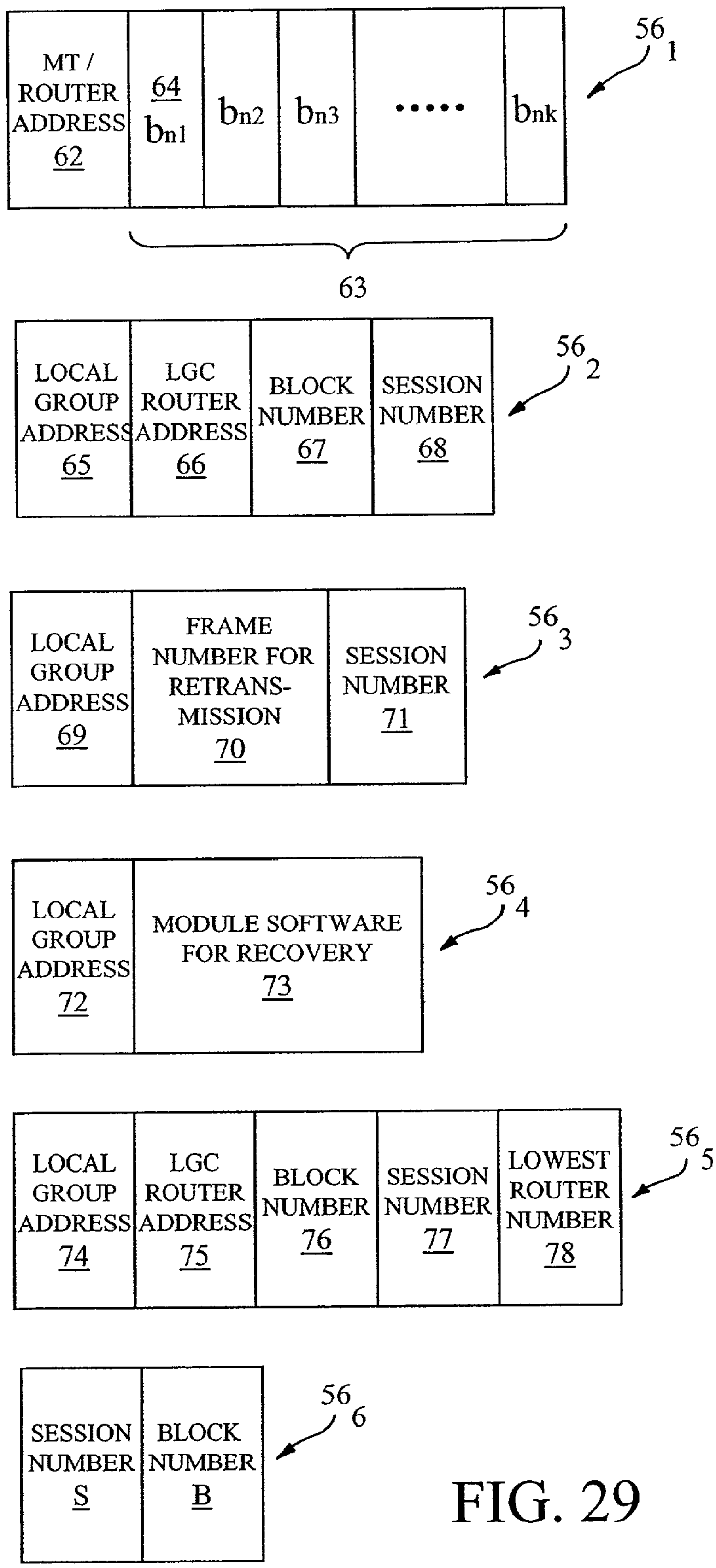

MT / ROUTER ADDRESS 62
64
bn1
bn2
bn3
.....
bnk
63
56 1
LOCAL GROUP ADDRESS 65
LGC ROUTER ADDRESS 66
BLOCK NUMBER 67
SESSION NUMBER 68
56 2
LOCAL GROUP ADDRESS 69
FRAME NUMBER FOR RETRANS-MISSION 70
SESSION NUMBER 71
56 3
LOCAL GROUP ADDRESS 72
MODULE SOFTWARE FOR RECOVERY 73
56 4
LOCAL GROUP ADDRESS 74
LGC ROUTER ADDRESS 75
BLOCK NUMBER 76
SESSION NUMBER 77
LOWEST ROUTER NUMBER 78
56 5
SESSION NUMBER S
BLOCK NUMBER B
56 6

FIG. 29

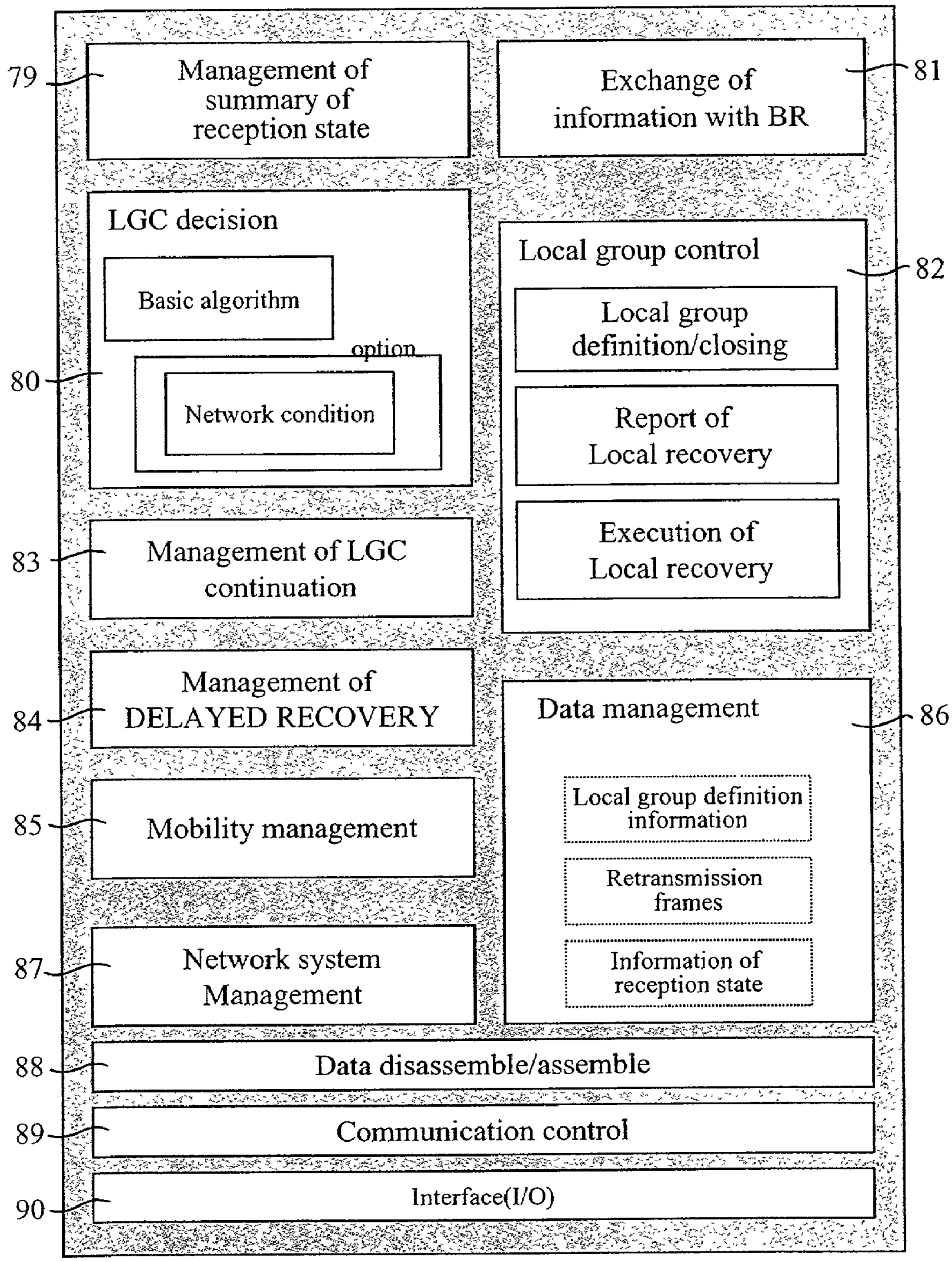

79
Management of summary of reception state
Exchange of information with BR
81
LGC decision
Basic algorithm
option
80
Network condition
Local group control
82
Local group definition/closing
Report of Local recovery
Execution of Local recovery
83
Management of LGC continuation
84
Management of DELAYED RECOVERY
Data management
86
85
Mobility management
Local group definition information
Retransmission frames
Information of reception state
87
Network system Management
88
Data disassemble/assemble
89
Communication control
90
Interface(I/O)

FIG. 30

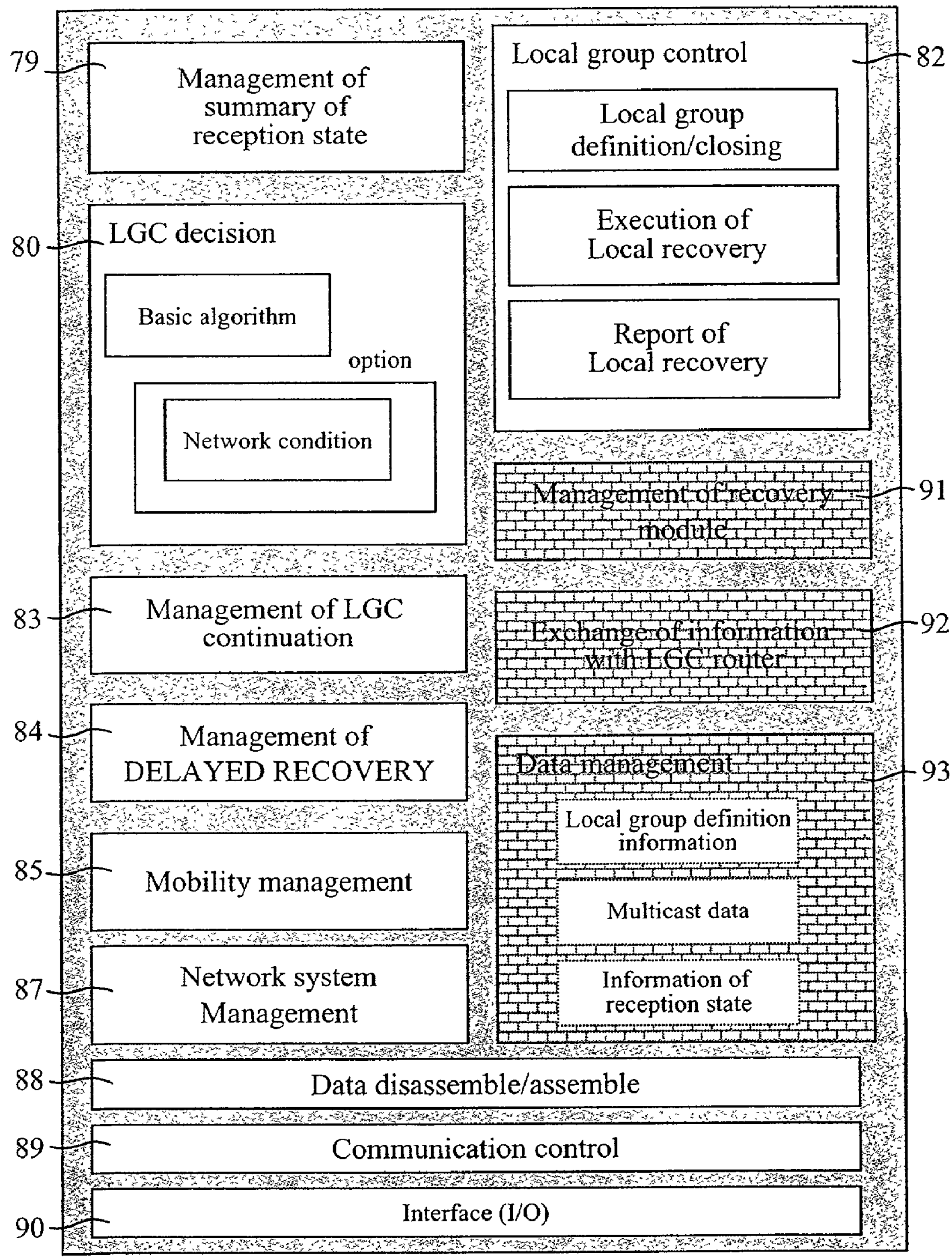

79
Management of summary of reception state
80
LGC decision
Basic algorithm
option
Network condition
83
Management of LGC continuation
84
Management of DELAYED RECOVERY
85
Mobility management
87
Network system Management
Local group control
82
Local group definition/closing
Execution of Local recovery
Report of Local recovery
Management of recovery module
91
Exchange of information with LGC router
92
Data management
93
Local group definition information
Multicast data
Information of reception state
88
Data disassemble/assemble
89
Communication control
90
Interface (I/O)

FIG. 31

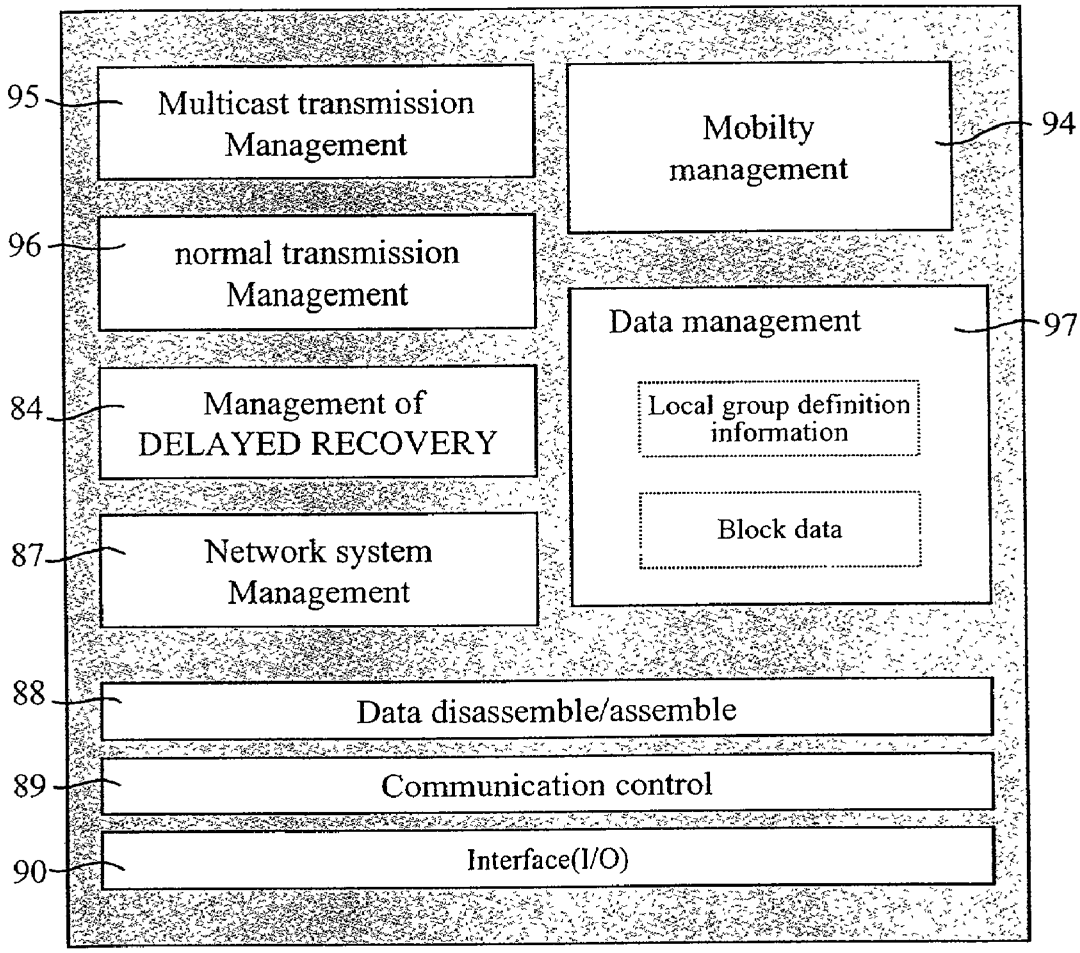

95
Multicast transmission Management
94
Mobilty management
96
normal transmission Management
97
Data management
Local group definition information
Block data
84
Management of DELAYED RECOVERY
87
Network system Management
88
Data disassemble/assemble
89
Communication control
90
Interface(I/O)

FIG. 32

FIG. 33

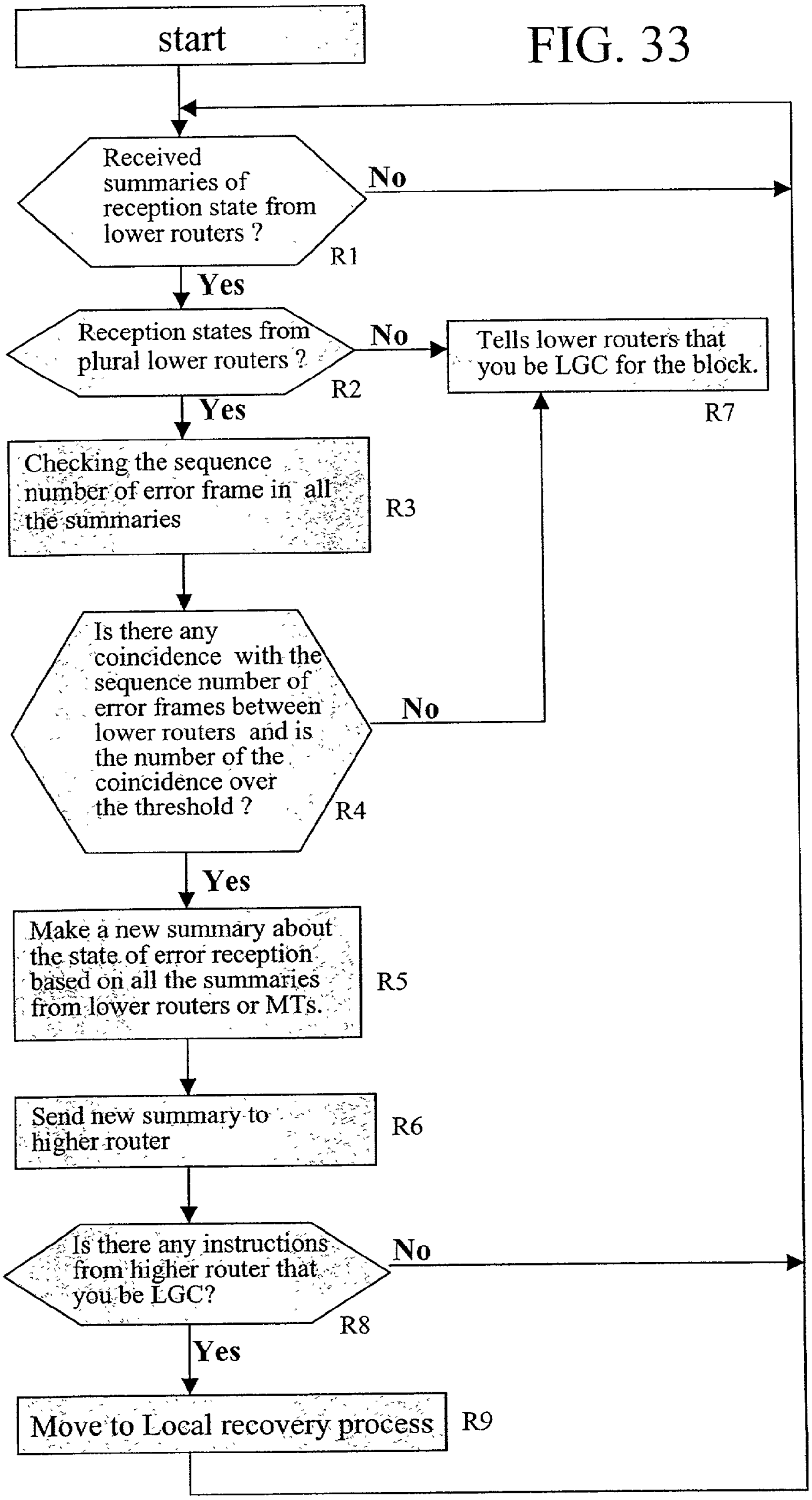
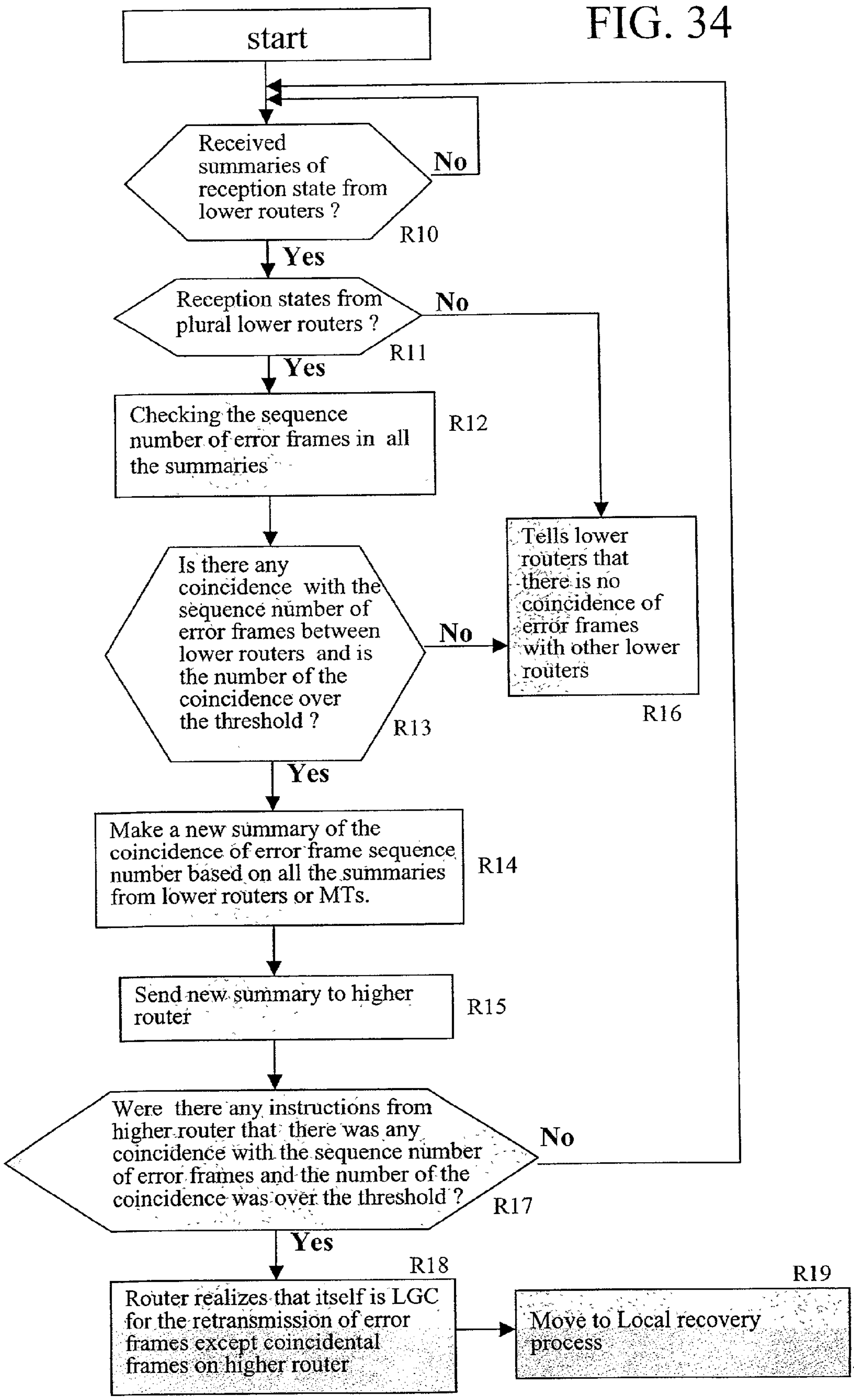

start
Received summaries of reception state from lower routers ?
R1
No
Yes
Reception states from plural lower routers ?
R2
No
Tells lower routers that you be LGC for the block.
R7
Yes
Checking the sequence number of error frame in all the summaries
R3
Is there any coincidence with the sequence number of error frames between lower routers and is the number of the coincidence over the threshold ?
R4
No
Yes
Make a new summary about the state of error reception based on all the summaries from lower routers or MTs.
R5
Send new summary to higher router
R6
Is there any instructions from higher router that you be LGC?
R8
No
Yes
Move to Local recovery process
R9

FIG. 34


start
Received summaries of reception state from lower routers ?
No
R10
Yes
Reception states from plural lower routers ?
No
R11
Yes
Checking the sequence number of error frames in all the summaries
R12
Is there any coincidence with the sequence number of error frames between lower routers and is the number of the coincidence over the threshold ?
No
R13
Tells lower routers that there is no coincidence of error frames with other lower routers
R16
Yes
Make a new summary of the coincidence of error frame sequence number based on all the summaries from lower routers or MTs.
R14
Send new summary to higher router
R15
Were there any instructions from higher router that there was any coincidence with the sequence number of error frames and the number of the coincidence was over the threshold ?
No
R17
Yes
R18
Router realizes that itself is LGC for the retransmission of error frames except coincidental frames on higher router
R19
Move to Local recovery process

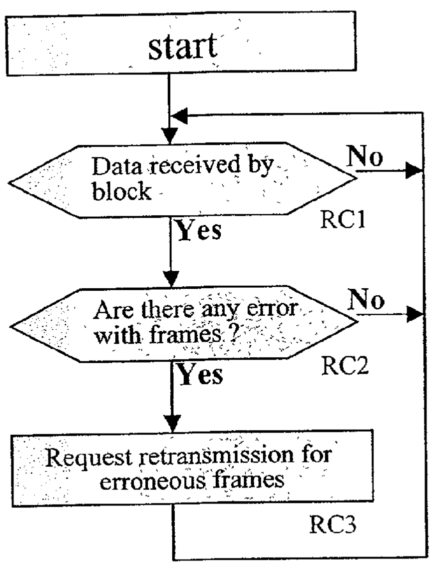


FIG. 35a

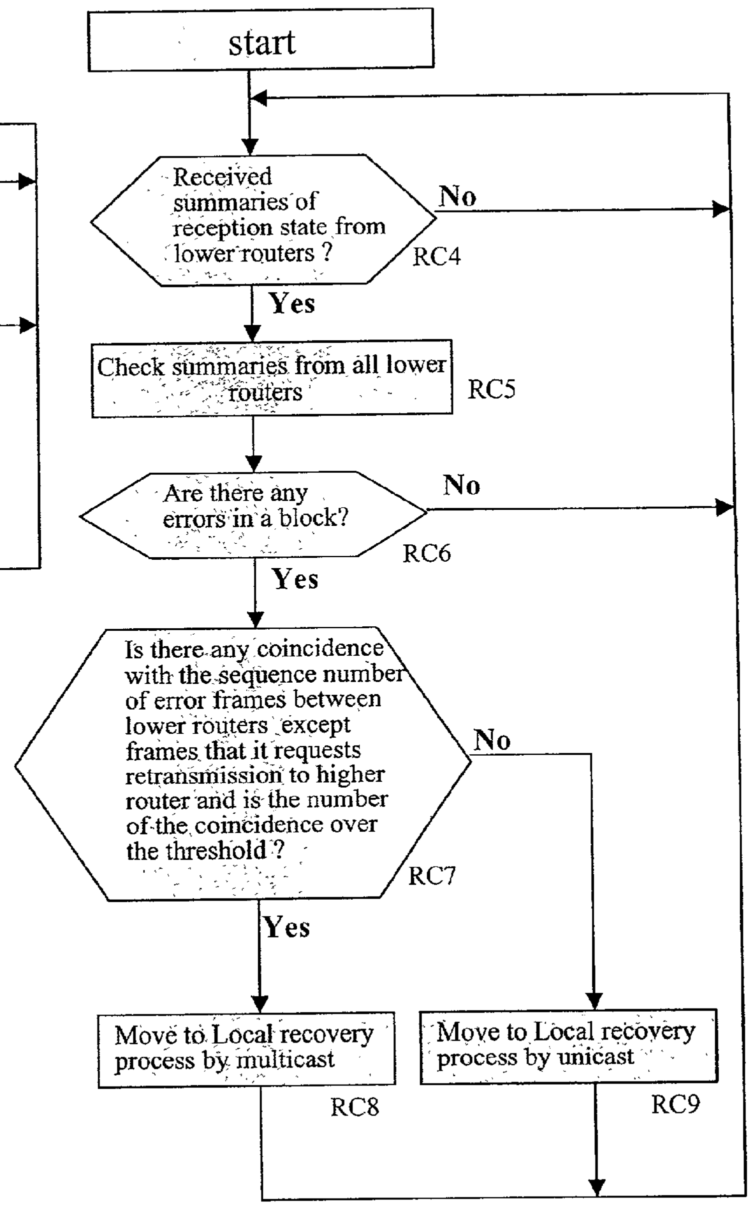


FIG. 35b

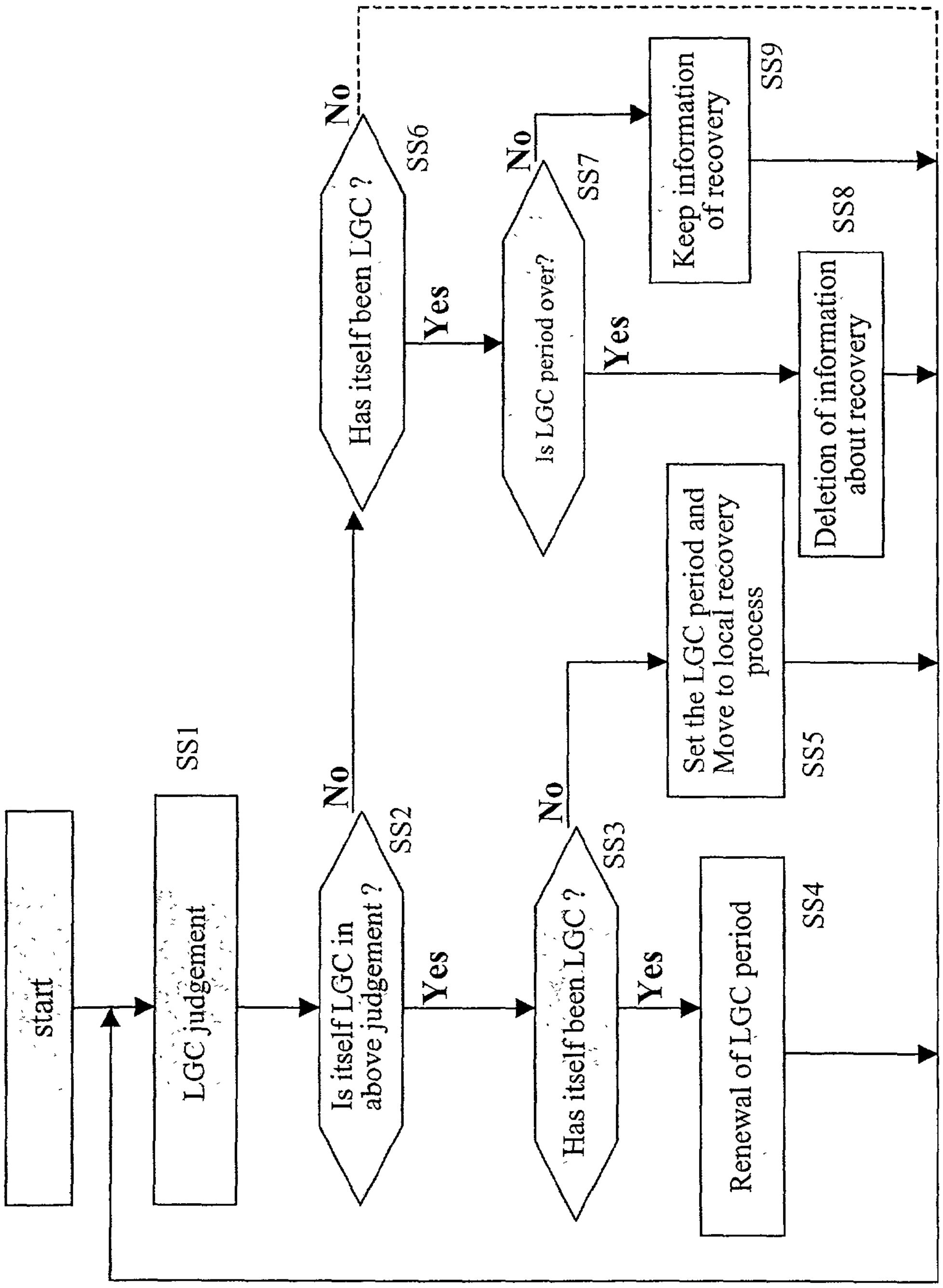

start
LGC judgement
SS1
Is itself LGC in above judgement ?
SS2
Yes
No
Has itself been LGC ?
SS3
Yes
No
Renewal of LGC period
SS4
Set the LGC period and Move to local recovery process
SS5
Has itself been LGC ?
SS6
Yes
No
Is LGC period over?
SS7
Yes
No
Deletion of information about recovery
SS8
Keep information of recovery
SS9

FIG. 36

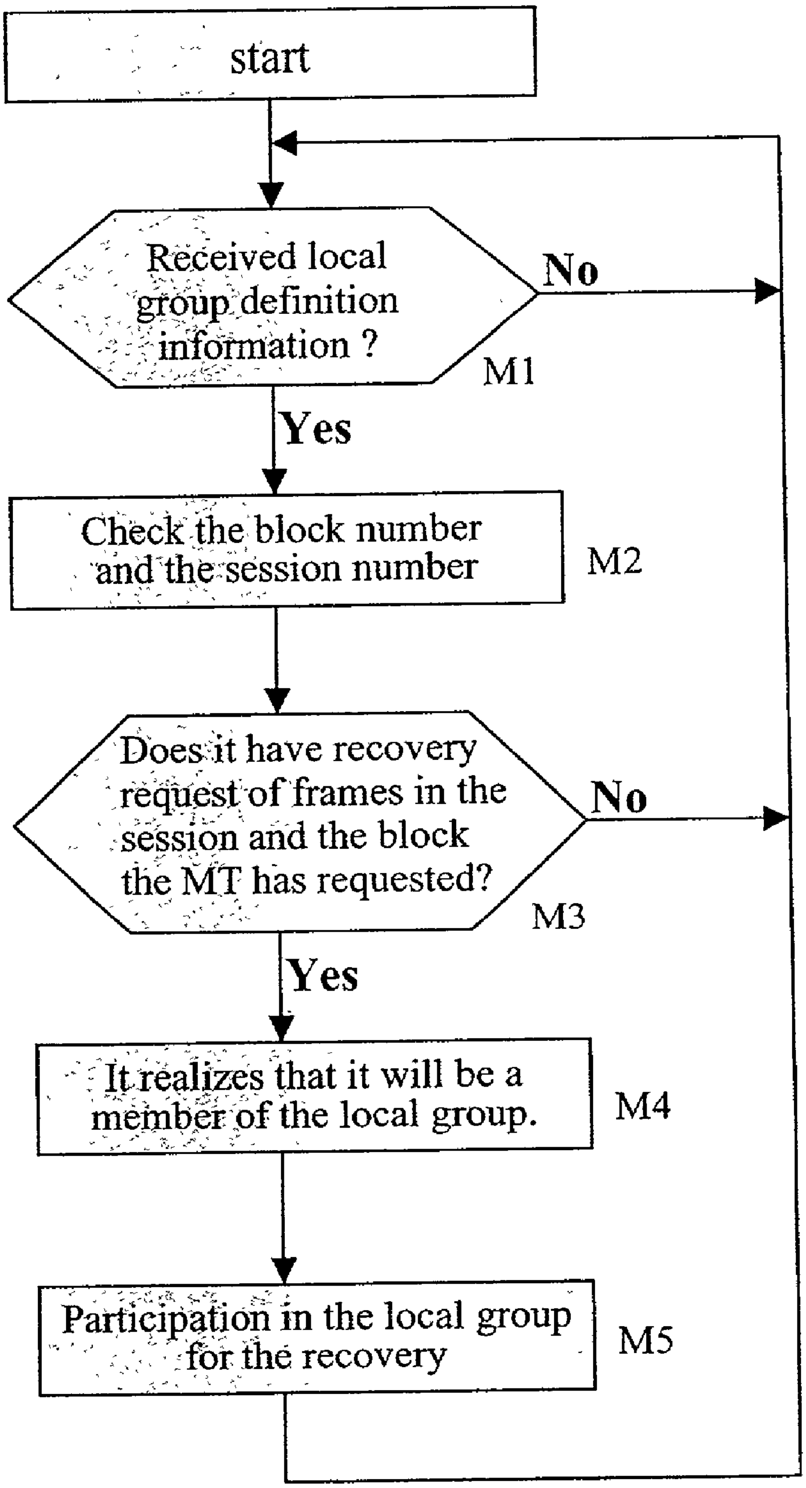

start
Received local group definition information ?
No
M1
Yes
Check the block number and the session number
M2
Does it have recovery request of frames in the session and the block the MT has requested?
No
M3
Yes
It realizes that it will be a member of the local group.
M4
Participation in the local group for the recovery
M5

FIG. 37

FIG. 38

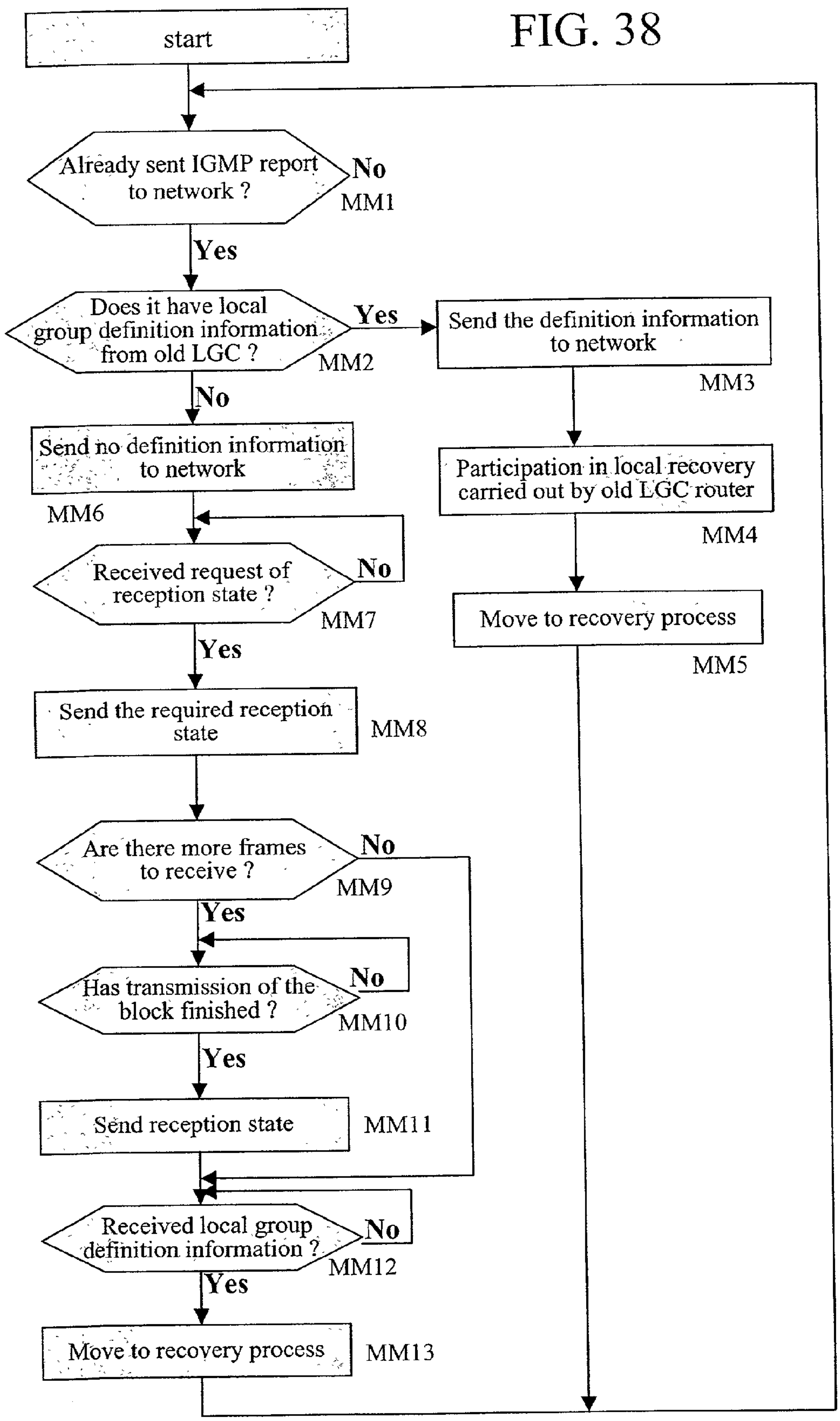
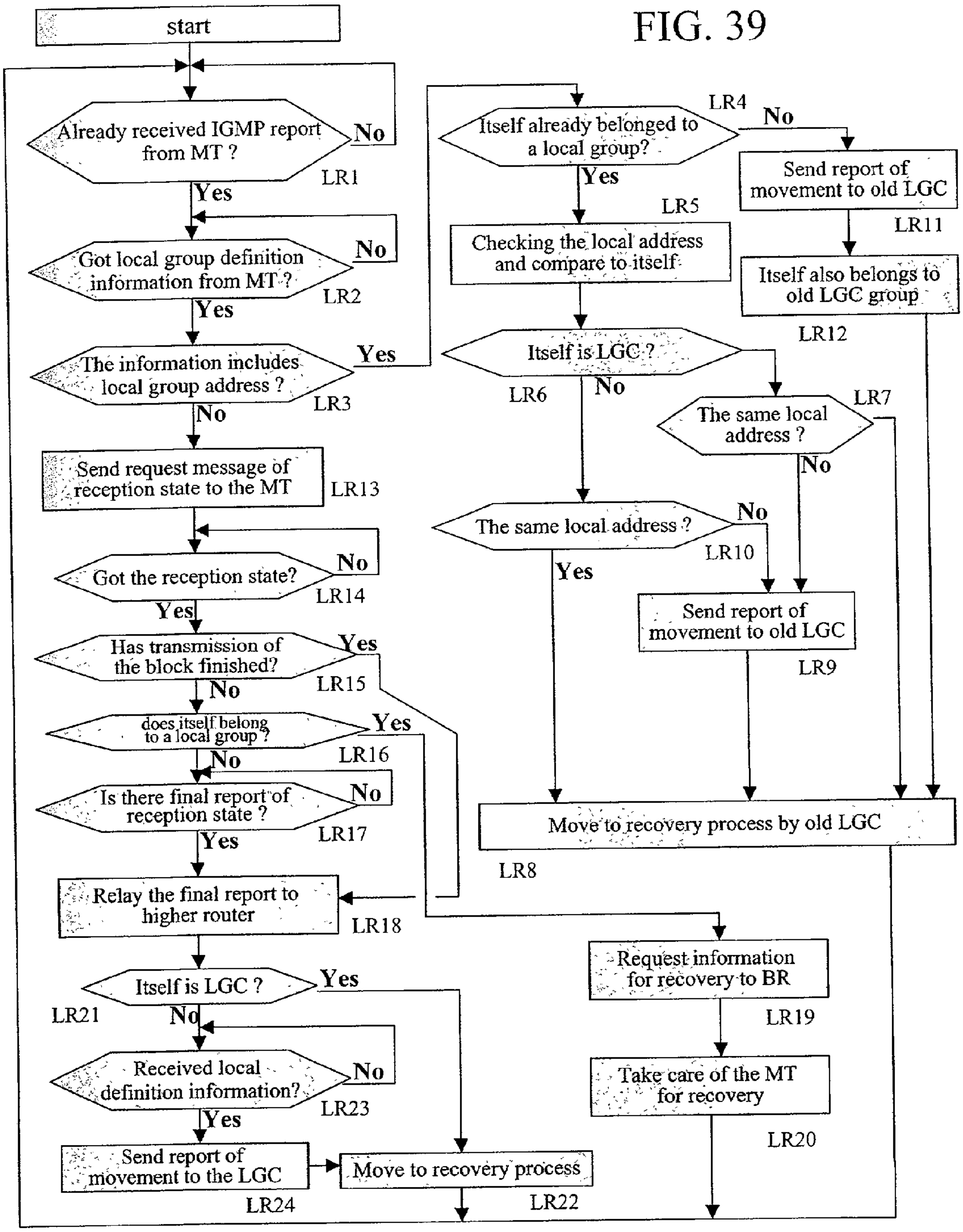

start
Already sent IGMP report to network ?
No
MM1
Yes
Does it have local group definition information from old LGC ?
Yes
MM2
Send the definition information to network
MM3
No
Send no definition information to network
MM6
Participation in local recovery carried out by old LGC router
MM4
Received request of reception state ?
No
MM7
Move to recovery process
MM5
Yes
Send the required reception state
MM8
Are there more frames to receive ?
No
MM9
Yes
Has transmission of the block finished ?
No
MM10
Yes
Send reception state
MM11
Received local group definition information ?
No
MM12
Yes
Move to recovery process
MM13

FIG. 39


start
Already received IGMP report from MT ?
No
Yes
LR1
Got local group definition information from MT ?
No
Yes
LR2
The information includes local group address ?
Yes
No
LR3
Send request message of reception state to the MT
LR13
Got the reception state?
No
Yes
LR14
Has transmission of the block finished?
Yes
No
LR15
does itself belong to a local group ?
Yes
No
LR16
Is there final report of reception state ?
No
Yes
LR17
Relay the final report to higher router
LR18
Itself is LGC ?
Yes
No
LR21
Received local definition information?
No
Yes
LR23
Send report of movement to the LGC
LR24
Move to recovery process
LR22
Itself already belonged to a local group?
LR4
No
Yes
Send report of movement to old LGC
LR5
LR11
Checking the local address and compare to itself
Itself also belongs to old LGC group
LR12
Itself is LGC ?
LR6
No
LR7
The same local address ?
No
The same local address ?
No
LR10
Yes
Send report of movement to old LGC
LR9
Move to recovery process by old LGC
LR8
Request information for recovery to BR
LR19
Take care of the MT for recovery
LR20

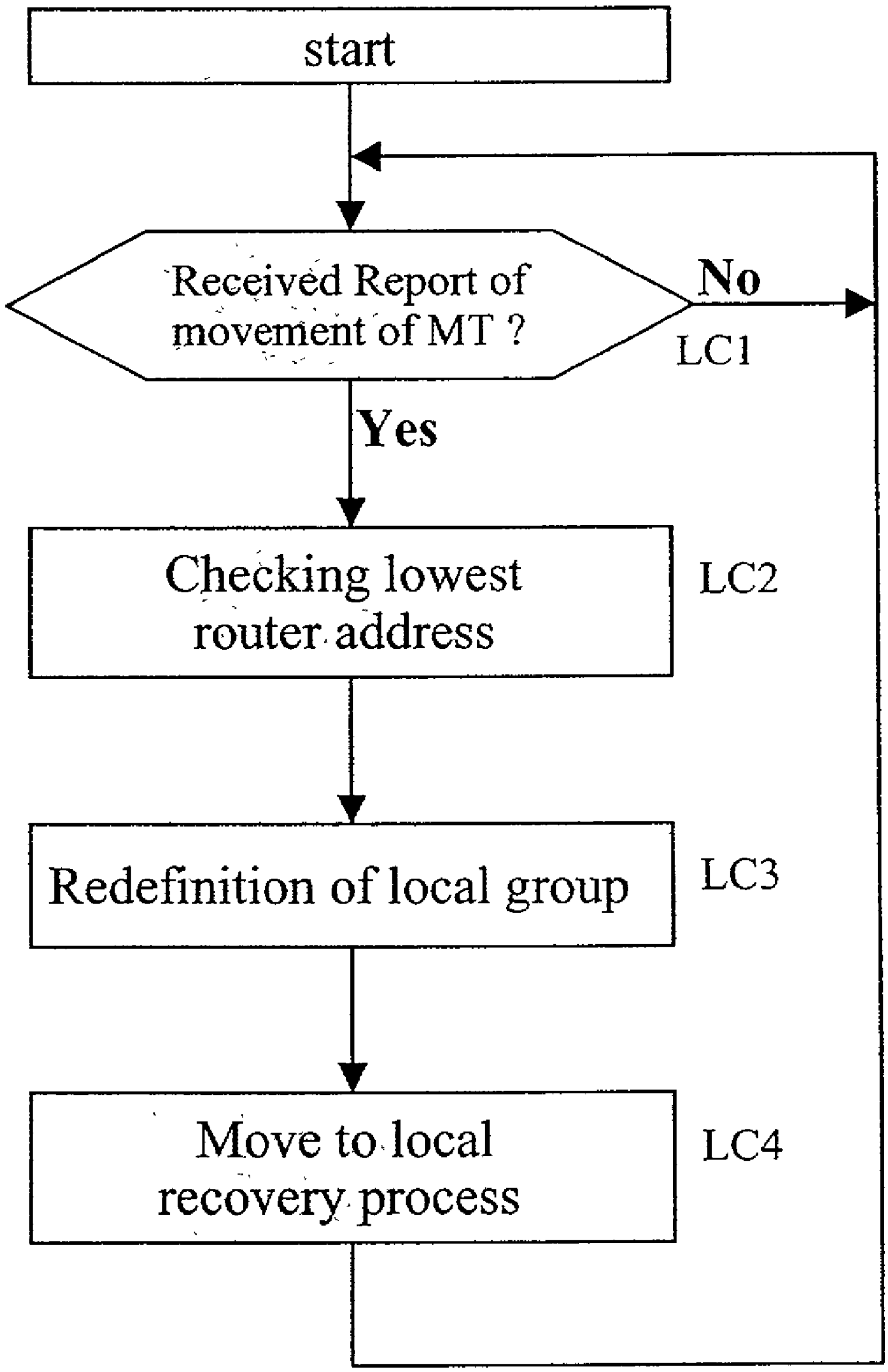

start
Received Report of movement of MT ?
No
LC1
Yes
Checking lowest router address
LC2
Redefinition of local group
LC3
Move to local recovery process
LC4

FIG. 40

METHOD OF MULTICASTING

FIELD OF THE INVENTION

[0001] The present invention relates to a method of multicasting data through a network, particularly but not exclusively, a mobile network.

BACKGROUND ART

[0002] The routing of data around diverse networks, which make up the Internet is based on a protocol known as the Internet Protocol (IP). Data is transferred in the form of data units known as IP datagrams between points in the Internet specified by IP addresses.

[0003] There are three ways in which data may be distributed between points. The first is unicast, in which data is transmitted from a single sender to a single recipient. The second is broadcast, in which data is transmitted throughout the network. The third is multicast, in which data is transmitted from a single sender to a group of recipients.

[0004] In general multicast transmission, a sender transmits data, via a network, to a plurality of hosts using a multicast group address. However, this method takes no account of whether data transmission was successful.

[0005] Reliable multicast transmission ensures successful transmission and generally comprises three stages. In the first stage, known as initial transmission, a sender transmits data, via a network, to a plurality of hosts using a multicast group address. In the second stage, known as acknowledgement, the hosts indicate success or failure of the initial transmission. In the third stage, known as recovery, any missing or corrupted data is retransmitted to the appropriate host. Overviews of multicasting are given in "Multicast Networking and Application" by C. Kenneth Miller, Addison-Wesley 1988 [ISBN 0-201-30979-3] and in "Deploying IP MULTICAST in the Enterprise" by T. Maufer, Prentice Hall PTR, 1998 [ISBN 0-13-897687-2].

[0006] For multicast transmission to work efficiently and to serve a large number of hosts, the network should preferably possess properties of high reliability of transmission and high scalability. Reliability of transmission is the likelihood of an intended recipient receiving data. Scalability reflects the number of hosts that the network can accommodate. Thus, a network with high scalability can accommodate almost any number of hosts.

[0007] High reliability is achieved by effective recovery. Two general recovery strategies are employed in multicasting. In the first, the sender is responsible for retransmission of data. In the second, one or more recipients co-ordinates retransmission for the rest of the multicast group.

[0008] In the sender-based strategy, the sender obtains responses, called reception states, from each receiver indicating whether the receiver correctly received the initial transmitted data and retransmits lost or corrupted data to receivers found wanting. However, this type of recovery has drawbacks in multicast communication. As the number of recipients increases, the sender is swamped with responses. This is known as the implosion problem. It results in overload of processing overhead at the sender, delay in data communication and loss of messages. Generally, traditional point-to-point data transfer protocols such as Transmission Control Protocol (TCP) RFC793 and High level Data Link Control (HDLC) and early multicast/broadcast protocols use this type of recovery.

[0009] In the receiver-based strategy, one or more control receivers are selected from, and are assigned to serve, a local group of receivers. The control receiver manages recovery instead of the sender. This type of recovery avoids the implosion problem, but has its own drawbacks, especially in networks where the receivers are connected to the network by low-capacity or unreliable links, such as radio links. The control receivers are forced to retransmit data over low-capacity links to the network and then from the network to other receivers. Thus, poor performance of the control receiver and low capacity links can cause low throughput, resulting in slow recovery.

[0010] Several protocols have been proposed to implement receiver-based recovery.

[0011] "A Reliable Multicast Framework for Light-weight Sessions and Application Level Framing", by S. Floyd et al., ACM SIGCOMM 95 describes Scalable Reliable Multicast (SRM). SRM does not breakdown the multicast group in smaller local groups. Any receiver that received data correctly may be used as the retransmitter for the whole multicast group.

[0012] "Reliable IP Multicast-PGM Overview", A Stardust Forums Sate of the Art Report, Apr. 1998 and "PGM Reliable Transport Protocol Specification" by T. Speakman et al., which may be found at http://search.ietf.org/internet-drafts/draft-speakman-pgm-spec-03.txt describe Pretty Good Multicast (PGM) PGM routers co-ordinate distribution of failure messages. However, retransmission may be left to any receiver or even the sender.

[0013] "A Generic Concept for Large-Scale Multicast" by M. Hofmann, Proceedings of International Zurich Seminar on Digital Communications (IZS'96), Springer Verlag, February 1996 discloses Local Group Multicast Protocol (LGMP). This protocol defines local groups within the multicast group. The sender periodically polls a request to all receivers for reception states. A group controller takes charge of responding to these reception states for the local group under its control and retransmits data by unicast or multicast. Under this protocol, any receiver may serve as the group controller. However, there is no description of how the group controller is selected.

[0014] "MESH: Distributed Error Recovery for Multimedia Streams in Wide-Area Multicast Networks", by M. T. Lucus et al., Proceedings ICC'97 is concerned with time-constraint applications such as the transmission of voice and video signals. The network is arranged into local-area and wide-area networks. A local-area network may comprise several local groups and each local group has an active receiver in charge of local recovery. Active receivers exchange information about the network with each other. However, there is no disclosure of how local groups are formed and how an active receiver is selected.

[0015] "Reliable Multicast Transport Protocol (RMTP)" by S. Paul et al., IEEE Journal on Selected Areas in Communications, Vol. 15, No. 3, April 1997, U.S. Pat. No. 5,905,871 and EP 0698975 describe Reliable Multicast Transport Protocol (RMTP). RMTP uses local groups. A designated receiver takes charge of monitoring the network and local recovery. RMTP system has a hierarchical structure of regions in each of which a designated receiver is elected. Recovery by the designated receiver is carried out using unicasting or multicasting depending on the number of erroneous receivers. However, the process of choosing designated receivers and the organisation of local groups is done manually. Thus, this system does not optimise recovery traffic within the local-area network and each local group. This will delay recovery.

[0016] Multicast transmission may take place through a mobile network. A mobile network is a network that supports mobility, for example a cellular network. If a receiver terminal moves to another area or radio cell, there is a possibility that the multicast session may be cut off because the radio channel is interrupted for a short time during hand-over. This cut-off causes data losses and may lead to delays in communication. For receiver-based methods of recovery, this problem may also arise if the selected control receiver moves to another area or radio cell as this requires handing over of the role of local group controller to another receiver.

[0017] The present invention seeks to provide an improved method of multicasting.

SUMMARY OF THE INVENTION

[0018] According to the present invention there is provided a method of multicasting data from a sender to first, second and third receivers through a network including first and second routers, the method comprising transmitting a data packet from said sender to said first, second and third receivers, detecting at said first, second and third receivers whether said data packet is properly received, transmitting a first reception information signal from said first receiver to said first router by a first path, transmitting a second reception information signal from said second receiver to said first router by a second path, determining, at said first router, in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and, if so, transmitting information relating to said first and second detection information signals to said second router and determining, at said second router, whether said third receiver requires re-transmission of said data packet and, if not, instructing said first router to re-transmit said data packet to said first and second receivers.

[0019] This has the advantage that recovery is managed locally by a router within the network rather than by the sender or receiver, thus ameliorating the problem of implosion at the sender and reducing sensitivity to the quality of network links to the receiver.

[0020] According to the present invention there is also provided a method of multicasting data from a sender to first, second, third and fourth receivers through a network including first and second routers, the method comprising transmitting first and second data packet from said sender to said first, second, third and fourth receivers, detecting at said first, second, third and fourth receivers whether said first and second data packets are properly received, transmitting a first reception information signal from said first receiver to said first router by a first path, transmitting a second reception information signal from said second receiver to said first router by a second path, transmitting a third reception information signal from said third receiver to said first router by a third path, determining, at said first router, in dependence upon said first, second and third reception information signals, whether said first, second and third receivers require re-transmission of said first and second data packets and, if so, transmitting information relating to said first, second and third detection information signals to said second router, determining, at said second router, whether said fourth receiver requires re-transmission of said first and second data packets and, if not, instructing said first router to re-transmit appropriate data packets to said first, second and third receivers.

[0021] The method may further comprise transmitting a request for information relating to said data packet from said first router to an archive router and receiving at said first router information relating to said data packet.

[0022] The network may comprise a plurality of subnetworks.

[0023] According to the present invention there is also provided a method of operating a router, the method comprising receiving a first message comprising information relating to receipt of a data packet by a first receiver, receiving a second message comprising information relating to receipt of a data packet by a second receiver, determining in dependence upon said first and second messages whether said first and second receivers require re-transmission of said data packet and, if so, transmitting a third message relating to receipt of said data packet by said first and second receivers to another router and receiving an instruction from said other router to retransmit said data packet to said first and second receivers.

[0024] According to the present invention there is still further provided a method of operating a network element, the method comprising receiving a first message from a first network element comprising information relating to receipt of a data packet by a first receiver, determining whether a second message from a second network element comprising information relating to receipt of said data packet by a second receiver has been received and if not, instructing said first network element to re-transmit said data packet, if so, transmitting a third message relating to receipt of said data packet by said first and second receivers to third network element and receiving an instruction from said third network element to re-transmit said data packet to said first and second network elements.

[0025] According to the present invention there is still further provided a method of operating a network element, the method comprising receiving a first message from a first network element comprising a first set of information relating to a plurality of data packets, determining whether a second message from a second network element comprising a second set of information relating to said plurality of data packets has been received and if not, instructing said first network element to retransmit one or more of said plurality of data packets in dependence upon said first set of information, if so, in dependence upon said first and second sets of information, determining the number data packets common to both first and second sets that are required for re-transmission and determining whether this number exceeds a predetermined number and if the number does not exceed the predetermined number, instructing said first network element to re-transmit one or more of said plurality of data packets in dependence upon said first set of information and instructing said second network element to re-transmit one or more of said plurality of data packets in dependence upon said second set of information, if the number does exceed the predetermined number, transmitting a third message relating to said first and second sets of information to third network element and receiving an instruction from said third network element to re-transmit one or more of said plurality of data packets in dependence upon said first and second sets of information.

[0026] According to the present invention there is also provided a router comprising an input for receiving a first message comprising information relating to receipt of a data packet by a first receiver, an input for receiving a second message comprising information relating to receipt of a data packet by a second receiver, a processor for determining in dependence upon said first and second messages whether said first and second receivers require re-transmission of said data packet and an output for transmitting a third message relating to receipt of said data packet by said first and second receivers to another router if said first and second receivers require re-transmission of said data packet and an input for receiving an instruction from said other router to retransmit said data packet to said first and second receivers.

[0027] According to the present invention there is also provided a system for multicasting data from a sender to first, second and third receivers through a network including first and second routers, comprising a first router including an input to receive a first reception information signal relating to whether said data packet is properly received by said first receiver and a second reception information signal relating to whether said data packet is properly received by said second receiver, a processor to determine in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and an output to transmit information relating to said first and second detection information signals to said second router and a second router including an input to receive said information from the first router and a third reception information signal relating to whether said data packet is properly received by said third receiver, a processor to determine whether said third receiver requires re-transmission of said data packet and an output to transmit an instruction to said first router to re-transmit said data packet to said first and second receivers.

[0028] According to the present invention there is also provided a system for multicasting data from a sender to first, second and third receivers through a plurality of networks including first and second routers, comprising a first router including an input to receive a first reception information signal relating to whether said data packet is properly received by said first receiver and a second reception information signal relating to whether said data packet is properly received by said second receiver, a processor to determine in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and an output to transmit information relating to said first and second detection information signals to said second router and a second router including an input to receive said information from the first router and a third reception information signal relating to whether said data packet is properly received by said third receiver a processor to determine whether said third receiver requires re-transmission of said data packet and an output to transmit an instruction to said first router to re-transmit said data packet to said first and second receivers.

[0029] According to the present invention there is also provided a computer program comprising computer code to make data processing apparatus receive a first message comprising information relating to receipt of a data packet by a first receiver, to receive a second message comprising information relating to receipt of a data packet by a second receiver to determine in dependence upon said first and second messages whether said first and second receivers require retransmission of said data packet and to transmit a third message relating to receipt of said data packet by said first and second receivers to a router if said first and second receivers require re-transmission of said data packet and to receive an instruction from said router to retransmit said data packet to said first and second receivers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Embodiments of the present invention will now be provided, by way of example, with reference to the accompanying drawings in which:

[0031] **FIG. 1** is a schematic representation of a multicast system;

[0032] **FIG. 2** is a more detailed schematic representation of the system shown in **FIG. 1**;

[0033] **FIG. 3** is a general process flow diagram of a method of multicasting according to the present invention;

[0034] **FIG. 4** is a schematic representation of a first configuration of a sub-network;

[0035] **FIG. 5** is a schematic representation of a second configuration of a sub-network;

[0036] **FIG. 6** is a timing chart for signals transmitted according to the method of multicasting shown in **FIG. 3**;

[0037] **FIG. 7** is a sequence diagram showing steps involved in local recovery according to the method of multicasting shown in **FIG. 3**;

[0038] **FIG. 8** illustrates a first example of a process by which a router is chosen to become a local group controller;

[0039] **FIG. 9** illustrates a second example of a process by which a router is chosen to become a local group controller with a first set of reception states;

[0040] **FIG. 10** illustrates a second example of a process by which a router is chosen to become a local group controller with a second set of reception states;

[0041] **FIG. 11** illustrates an example of a process by which a router is chosen to become a local group controller for two local groups;

[0042] **FIG. 12** is a schematic diagram showing the transfer of data frames between routers each having a cache;

[0043] **FIG. 13** is a timing chart showing the duration for which a router may be chosen to be a local group controller in order to achieve system stability;

[0044] **FIG. 14** is an example of a local group definition;

[0045] **FIG. 15** shows how the local group shown in **FIG. 14** is addressed;

[0046] **FIG. 16** is a schematic diagram of a specific example of a mobile network and a moving terminal;

[0047] **FIG. 17** is a schematic diagram of a general example of a mobile network and a moving terminal;

[0048] **FIG. 18** is sequence diagram showing, for a first case, first circumstance, the transfer of signals between a mobile terminal and other network elements;

[0049] **FIG. 19** is sequence diagram showing, for a first case, second circumstance when a local group has been established, the transfer of signals between a mobile terminal and other network elements;

[0050] **FIG. 20** is sequence diagram showing, for a first case, second circumstance when no local group has been established, the signals between a mobile terminal and other network elements;

[0051] **FIG. 21** is sequence diagram showing, for a first case, third circumstance, the transfer of signals between a mobile terminal and other network elements;

[0052] **FIG. 22** is sequence diagram showing, for a first case, fourth circumstance when a mobile terminal moves within the same local group, the transfer of signals between the mobile terminal and other network elements;

[0053] **FIG. 23** is sequence diagram showing, for a first case, fourth circumstance when a mobile terminal moves to a different local group or to an area where there is no local group, the transfer of signals between the mobile terminal and other network elements;

[0054] **FIG. 24** is sequence diagram showing, for a second case the transfer of signals between a mobile terminal and other network elements;

[0055] **FIG. 25** is sequence diagram showing, for a second case the transfer of signals between a mobile terminal and other network elements;

[0056] **FIG. 26** is schematic representation of a layer model for the multicast system;

[0057] **FIG. 27*a*** is a schematic representation of a first frame structures used in multicasting;

[0058] **FIG. 27*b*** is a schematic representation of a second frame structures used in multicasting;

[0059] **FIG. 28** is a schematic representation of the structure of a multicast transport frame;

[0060] **FIG. 29** shows examples of the structure of a multicast transport data frame;

[0061] **FIG. 30** is a schematic representation of a router;

[0062] **FIG. 31** is a schematic representation of a border router;

[0063] **FIG. 32** is a schematic representation of a mobile terminal;

[0064] **FIG. 33** is a process flow diagram for choosing a local group controller as shown in **FIG. 8**;

[0065] **FIG. 34** is a process flow diagram for choosing a local group controller as shown in **FIGS. 9 and 10**;

[0066] **FIGS. 35*a*** and **34*b*** are a process flow diagrams of the operation of a router with caches shown in **FIG. 12**;

[0067] **FIG. 36** is a process flow diagram of the operation of a router to achieve system stability as shown in **FIG. 13**;

[0068] **FIG. 37** is a process flow diagram of the operation of a mobile terminal;

[0069] **FIG. 38** is a process flow diagram of the operation of a moving terminal;

[0070] **FIG. 39** is a process flow diagram of the operation of a new lowest level router and

[0071] **FIG. 40** is a process flow diagram of the operation of an old local group controller.

PREFERRED EMBODIMENTS OF THE INVENTION

[0072] Multicast System Structure

[0073] Network Structure

[0074] Referring to **FIG. 1, a** multicast system comprises a mobile network **1**, a sender **2** and a plurality of mobile terminals **3** which form a multicast receiver group **4**. In this example, the sender **2** may be a desktop personal computer and the mobile terminals **3** may be laptop computers. Reliable multicast transmission generally comprises three stages. In the first stage, known as initial transmission, the sender **2** transmits data **5**, via the mobile network **1**, to the mobile terminals **3** using a multicast group address. In the second stage, known as acknowledgement, the mobile terminals **3** return state of reception messages **6** to the mobile network **1** to indicate success or failure of the initial transmission. In this example, first and second mobile terminals 3_1, 3_2 do not successfully receive the data **5** and return "not acknowledged" messages (NACKs) to the mobile network **1**. In the last stage, known as recovery, the mobile network **1** retransmits the missing data **7** to the first and second terminals 3_1, 3_2. In this way, high reliability of transmission is achieved.

[0075] Referring to **FIG. 2**, the structure of the multicast system is described in greater detail. The mobile network **1** comprises a plurality of sub-networks (SN) **8** including leaf sub-networks **9**, to which mobile terminals **3** are connected, and transit sub-networks **10**, which connect the leaf sub-networks **9** to the sender **2**. Each sub-network **8** is connected to another sub-network **8** through a border router (BR) **11**. The border router **11** may be implemented in dedicated hardware or in a personal computer (PC). It may have a processor which is programmable and which implements certain functions. Each border router **11** serves as a multicast archiver (MA), which stores multicast data and addresses. The structure and function of border routers **11** will be described in more detail later.

[0076] The sender **2** transmits multicast data **5** to the mobile network **1** through an access network **12**, which may be a wire or wireless network. The multicast data **5** is transmitted to a plurality of mobile terminals **3** via border routers **11** on a multicast tree **13**. The multicast tree **13** is formed using multicast protocols including the Internet Engineering Task Force (IETF) standard protocol, Protocol Independent Multicast (PIM), Distance Vector Multicast Routing Protocol (DVMRP), Multicast Extensions to Open

Shortest Path First (MOSPF) and Multicast Border Gateway Protocol (MBGP). It will be appreciated that other protocols which set up or help set up the multicast tree **13** may also be used. The multicast data **5** reaches the mobile terminals **3** though radio channels provided through radio cells **14**.

[**0077**] If errors are detected in the data **5** at the mobile terminals **3**, recovery is carried out within the sub-networks **8**. Recovery reports **15** are generated and these are summarised at each border router **11** so that a single summary is returned to the sender **2**. Recovery, recovery reporting and report summarising are described in more detail later.

[**0078**] Referring to **FIG. 3, a** general process flow diagram shows an outline of a method of reliable multicasting data from the sender **2** to the mobile terminals **3**.

[**0079**] The sender **2** multicasts data **5** to a plurality of mobile terminals **3** (step S1). Mobile terminals **3** that receive packets of data with errors return a state of reception message **6**. Routers (not shown) within the sub-network **8** are chosen as controllers depending on the state of reception messages **6**. The controllers manage recovery for a group of mobile terminals **3** (step S2). The group of mobile terminals **3**, together with routers linking them to the controllers, is known as a local group and the controller in charge of recovery is known as the local group controller. Each controller carries out retransmission for its local group (step S3). This is known as local recovery. If there is more data to send, then steps S1 to S3 are repeated (step S4). Otherwise each controller reports the result **15** of local recovery to sender **2** (step S5).

[**0080**] Sub-Network **8** Structure

[**0081**] Referring to **FIG. 4, a** first example of a configuration of a sub-network **8**, in particular a leaf sub-network **9**, which receives multicast data **5** from the mobile network **1** is shown.

[**0082**] A plurality of mobile terminals **3** are located in radio cells **14** and are connected to the sub-network **8**. The sub-network **8** comprises a plurality of routers **16** arranged on a first multicast tree $\mathbf{13}_1$ and a plurality of base stations (BSs) **17** which transmit multicast data **5** to the mobile terminals **3** over a plurality of radio links **18**. The routers **16** may be implemented in dedicated hardware or in PCs.

[**0083**] Data **5** is multicast to the mobile terminals **3**, which form a multicast group $\mathbf{4}_1$. Each mobile terminal **3** responds with a signal indicating whether or not it correctly received the multicast data **5**. The signal may comprise an "acknowledge" message (ACK) (not shown) or a "not acknowledged" message (NACK) **19** and such a signal may be returned for every block or frame of data.

[**0084**] The NACK messages **19** are gathered by the lowest level routers **16**, in this example first, second and third routers $\mathbf{16}_1$, $\mathbf{16}_2$, $\mathbf{16}_3$. Each of the lowest level routers $\mathbf{16}_1$, $\mathbf{16}_2$, $\mathbf{16}_3$ decides whether it should become the local group controller based upon the number of NACK messages **19** received. If a lowest level router $\mathbf{16}_1$, $\mathbf{16}_2$, $\mathbf{16}_3$ decides that it should not be the local group controller, it generates a summary **20** of the NACK messages **19** and sends the summary **20** to a higher level router **16**. In this example, the second and third routers $\mathbf{16}_2$, $\mathbf{16}_3$ send first and second summaries $\mathbf{20}_1$, $\mathbf{20}_2$ to a higher level router **16**, in this example a fourth router $\mathbf{16}_4$. The higher level router $\mathbf{16}_4$ determines whether it should become the local group controller. If it decides that it should not be the local group controller, the higher level router $\mathbf{16}_4$ generates a new summary **20** and sends the new summary **20** to a still higher level router **16**. This process continues until a router **16** decides that it should become the local group controller. The decision process will be described in more detail later.

[**0085**] In this example, the first and fourth routers $\mathbf{16}_1$, $\mathbf{16}_4$ are selected as first and second local group controllers $\mathbf{21}_1$, $\mathbf{21}_2$ and they take control of local recovery for first and second local groups $\mathbf{22}_1$, $\mathbf{22}_2$ respectively.

[**0086**] The first local group controller $\mathbf{21}_1$ organises the first local group $\mathbf{22}_1$. To form the first local group $\mathbf{22}_1$, the first local group controller $\mathbf{21}_1$ receives a first bundle of data $\mathbf{23}_1$ which will be referred to hereinafter as first definition information $\mathbf{23}_1$ from a first border router $\mathbf{11}_1$ connecting the sub-network **8** with the rest of the mobile network **1**. The first bundle of data $\mathbf{23}_1$, comprises a local group address, recovery software and the data frames required for retransmission. The first local group controller $\mathbf{21}_1$ informs the mobile terminals **3** within the first local group $\mathbf{22}_1$, of their group identity. The first local group controller $\mathbf{21}_1$ then executes recovery. Finally, the first local group controller $\mathbf{21}_1$, sends a first recovery report $\mathbf{15}_1$, to the first border router $\mathbf{11}_1$. The second local group controller $\mathbf{21}_2$ performs a similar set of steps in respect of the second local group $\mathbf{22}_2$.

[**0087**] Referring to **FIG. 5, a** second example of a configuration of the sub-network **8** is shown. The second configuration differs from the first configuration in that the sender **2'** is mobile and is connected to the sub-network **8**. Thus, rather than receiving multicast data **5** from the mobile network **1**, the sub-network **8** transmits the multicast data **5** to the rest of the mobile network **1**.

[**0088**] The mobile sender **2'** is located in a first radio cell $\mathbf{14}_1$, and transmits multicast data **5** to a first base station $\mathbf{17}_1$, over a first radio link $\mathbf{18}_1$. A second multicast tree $\mathbf{13}_2$ is formed as shown in **FIG. 5**. Data **5** is multicast to a second multicast receiver group $\mathbf{4}_2$, which includes a second border router $\mathbf{11}_2$.

[**0089**] The process of acknowledgement and recovery is similar to that described in the first configuration, with two notable exceptions. Firstly, in this configuration, a fifth routers $\mathbf{16}_5$ and the second router $\mathbf{16}_2$ become third and fourth local group controllers $\mathbf{21}_3$, $\mathbf{21}_4$ respectively. Secondly, as stated earlier, the second border router $\mathbf{11}_2$ forms part of the second multicast receiver group $\mathbf{4}_2$. Despite this and despite the fact that the mobile sender **2'** is connected to the sub-network **8**, the second border router $\mathbf{11}_2$ still serves as the multicast archiver and provides the local group controllers **21** with the information **23** necessary for recovery. Neither the mobile sender **2'**, nor the closest router **16** to it, i.e. the third router $\mathbf{16}_3$, serve as the multicast archiver. However, it will be appreciated that the mobile sender **2'** or the third router $\mathbf{16}_3$ could serve as the multicast archiver.

[**0090**] In a preferred embodiment, if the local group controllers **21** do not recover errors within a predetermined period of time due to, for example, deterioration of radio channel quality or network congestion, then they may retransmit data **5** at a later time and return a report to higher level routers **16** that recovery was successful. This is known as delayed recovery strategy.

[0091] Referring to **FIG. 6, a** multicast timing chart is shown. The multicast data **5** is divided into blocks **24**, which are in turn divided into frames **25**. During initial transmission of a first block of data **24_1**, the sender **2** transmits a sequence of frames **25_1**, which are conveyed via routers **16** on the multicast tree **13** to mobile terminals **3** forming part of the multicast group **4** (step S**1**.**1**). The mobile terminals **3** return acknowledge messages **19**, which may be subsequently summarised (step S**1**.**2**). Steps S**1**.**1** and S**1**.**2** correspond to step S**1** in **FIG. 3**. The routers **16**, beginning with the lowest level routers, execute an algorithm to determine whether they should become a local group controller **21** (step S**2**). Once a local group controller **21** has been chosen, local recovery may proceed (step S**3**). This completes multicast transmission for the first block of data **24_1**, and transmission of second block begins **24_2**.

[0092] Recovery Process

[0093] Referring to **FIG. 7**, the recovery process is described in more detail. The recovery process comprises three stages, namely definition of the local group (step S**3**A), retransmission (step S**3**B) and reporting of recovery result process (step S**3**C).

[0094] In the first stage S**3**A, definition of the local group, the local group controller **21** requests and receives definition information **23** from the border router **11** (steps S**3**.**1** and S**3**.**2**). The local group controller **21** transmits the identity of the local group **22** to mobile receivers **3** within the local group **22** (step S**3**.**3**). The mobile receivers **3** confirm to the local group controller **21** that they have received the local group identity and that they are a member of the local group (step S**3**.**4**).

[0095] In the retransmission stage S**3**B, the local group controller **21** sequentially retransmits requested frames **25** (step S**3**.**5**) and the mobile terminals **3** send acknowledge messages **19** (step S**3**.**6**). The frames may be retransmitted by unicast, multicast or broadcast.

[0096] In the result reporting stage S**3**C, the local group controller **21** sends to the sender **2** a report **15** of the result of local recovery (step S**3**.**7**). As the report **15** is transmitted to the sender **2** through transit sub-networks **10**, the report is summarised.

Choosing a Router **16** to Become a Local Group Controller **21**

EXAMPLE 1

[0097] Referring to **FIG. 8, a** first example of a decision process by which a router **16** is chosen to become a local group controller **21** is shown with reference to part of the sub-network **8**.

[0098] Sixth and seventh routers **16_6**, **16_7** generate third and fourth summaries **20_3**, **20_4** of reception states and pass them to an eighth, higher level router **16_8**. The third and fourth summaries **20_3**, **20_4** of reception states are in the form of a sequence of numbers of error frames. In this example, the third summary **20_3** lists frames numbers **2**, **3**, **5**, **6**, **7** and **8**, hereinafter expressed in the form {**2**, **3**, **5**, **6**, **7**, **8**} and the fourth summary **20_4** lists {**1**, **3**, **5**, **6**}. The eighth router **16_8** compares the third and fourth summaries **20_3**, **20_4** for coincidences. In this example, both summaries **20_3**, **20_4** list {**3**, **5**, **6**}, thus there are three coincidental frame numbers. The eighth router **16_8**, checks whether the number of coincidental frames exceeds a predetermined threshold, in this example set at one. If the number of coincidental frames exceeds the threshold, then a fifth summary **20_5** is generated and passed on to a ninth, higher level router **16_9** In this example, the fifth summary **20_5** lists the sequence of error frames present in either the third and fourth and second summaries **20_3**, **20_4**, namely {**1**, **2**, **3**, **5**, **6**, **7**, **8**}.

[0099] In the same way, the ninth router **16_9** compares the fifth summary **20_5** with a sixth summary **20_6** received from a tenth, lower level router **20_{10}**. In this example, the fourth summary **20_4** contains no frame numbers, i.e. {nothing}. The ninth router **16_9** finds no coincidental frame numbers. Thus, the number of coincidental frames falls below the threshold of one. Therefore, the ninth router **16_9** designates the eighth router **16_8** as the local group controller **21** by transmitting an instruction of proxy **26**. The eighth router **16_8** becomes the fifth local group controller **21_5** and it manages local recovery. Local recovery includes requesting and receiving a bundle of information **23** from the border router **11** and defining the local group **22** which originally transmitted reception states **6** from which the third and fourth summaries **20_3**, **20_4** were produced. It will be appreciated that the sixth and seventh routers **16_6** **16_7** will have generated summaries third and fourth summaries **20_3**, **20_4** of reception states either from summaries they themselves received from lower level routers **16** or from reception states **6** received from base stations **17**.

Choosing a Router **16** to Become a Local Group Controller **21**

EXAMPLE 2

[0100] Referring to **FIGS. 9 and 10**, a second example of a process by which one or routers are chosen to become local group controllers **21** is shown with reference to the same part of the sub-network **8**. The second example is similar to the first except that more than one local group controllers **21** are chosen and more than one local groups **22** are established. This helps to reduce the retransmission traffic.

[0101] Referring to **FIG. 9**, the eighth router **16_8** receives the third and fourth summaries **20_3**, **20_4** from the sixth and seventh routers **16_6**, **16_7**. Instead of generating the fifth reception state summary **20_5** which includes error frames present in either the third and fourth summaries **20_3**, **20_4**, the eighth router **16_8** produces a seventh reception state summary **20_7** which lists only the coincidental frames, namely {**3**, **5**, **6**}. The eighth router **16_8** send the seventh reception state **20_7** summary to the ninth router **16_9**, which compares it with the sixth reception state summary **20_6**. The ninth router **16_9** does not find any coincidences and so instructs the eighth router **16_8** to become the third local group controller **20_3** in charge of retransmission of frames {**3**, **5**, **6**}. The eighth router **16_8** delegates responsibility for retransmission of the remaining frames to the routers **16** which returned summaries **20** with the error frames. Thus, eighth router **16_8** instructs sixth and seventh routers **16_6**, **16_7** to become sixth and seventh local group controllers **21_6**, **21_7** in charge of retransmission of frames {**2**, **7**, **8**} and {**1**, **9**} respectively.

[0102] In summary, the fifth, sixth and seventh local group controllers **21_5**, **21_6**, **21_7** are in charge of retransmission of frames {**3**, **5**, **6**}, {**2**, **7**, **8**} and {**1**, **9**} for fifth, sixth and seventh local groups **22_5**, **22_6**, **22_7**.

[0103] Referring to FIG. 10, the same procedure is applied to a different set of reception state summaries 20. The tenth router 16_{10}, returns an eighth reception state summary 20_8 of {2, 7}. Thus, the ninth router 16_9 compares the seventh and eighth reception state summaries 20_7, 20_8 and finds there is no coincidence between them. Therefore, the ninth router 16_9 instructs the eighth and tenth routers 16_8, 16_{10} to become fifth and eighth local group controllers 21_5, 21_8 respectively for recovery of frames {3, 5, 6} and {2, 7} for fifth and eighth local groups 22_5, 22_8. The sixth and seventh routers 16_6, 16_7 take charge of retransmission of frames, {2, 7, 8} and {1, 9}.

[0104] Choosing a Router 16 to Become Local Group Controller 21 for More Than One Local Group 22

[0105] Referring to FIG. 11, an example of a process by which a router 16 is chosen to become a local group controller 21 for more than one local group 22 is shown with reference to part of the sub-network 8. This example is similar to the first example, except for the addition of an eleventh router 16_{11} and a new set of reception state summaries 20.

[0106] The sixth, seventh and eleventh routers 16_6, 16_7, 16_{11} generate ninth, tenth and eleventh summaries 20_9, 20_{10}, 20_{11}, of reception states and passed them on to the eighth, higher level router 16_8. In this, example the ninth summary 20_9 lists {1, 3, 6, 7}, the tenth summary 20_{10} lists {1, 3, 8, 9} and the eleventh summary 20_{11} lists {2, 8, 9}. The eighth router 16_8 compares the ninth, tenth and eleventh summaries 20_9, 20_{10}, 20_{11} for coincidences. In this example, there are coincidences between the ninth and tenth summaries 20_9, 20_{10}, namely {1, 3}, while there are coincidences between tenth and eleventh summaries 20_{10}, 20_{11}, namely {8, 9}. The eighth router 16_8 checks whether the number of coincidental frames exceed the threshold of one coincidence and generates twelfth and thirteenth summaries 20_{12}, 20_{13}, one for each set of coincidences, which are passed on to the ninth, higher level router 16_9. In this example, the twelfth summary 20_{12}, lists {1, 3} and the thirteenth summary 20_{13} lists {8, 9}.

[0107] The ninth router 16_9 compares the twelfth summary 20_{12} with a fourteenth summary 20_{14} received from the tenth router 16_{10}. In this example the fourteenth summary 20_{14} lists no error frame numbers and so the ninth router 16_9 finds no coincidental frames. Therefore, the ninth router 16_9 designates the eighth router 16_8 as a ninth local group controller 21_9 in charge of recovery of {1, 3} for a ninth local group 22_9. In turn, the eighth router 16_8, instructs the sixth router 16_6 to become an tenth local group controller 21_{10} in charge of recovery of {6, 7} for an tenth local group

[0108] In the same way, the ninth router 16_9 compares the thirteenth summary 20_{13} with the fourteenth summary 20_{14} and finds no coincidental frames. Therefore, the ninth router 16_9 designates the eighth router 16_8 as a local group controller 21 in charge of recovery of {8, 9} for an eleventh local group 20_{11}. In turn, the eighth router 16_8, instructs the eleventh router 16_{11}, to become an eleventh local group controller 21_{11} in charge of recovery of {2} in a twelfth local group 22_{12}.

[0109] Thus, the eighth router 16_8 serves as local group controller for two different local groups, namely the ninth and eleventh local groups 22_9, 22_{11}.

[0110] Routers with Caches

[0111] Referring to FIG. 12, each router 16 has a cache for storing data and recovery software. Each router 16 stores a block of data 24 as it receives it and erases it when the data block 24 is correctly transmitted to lower routers 16. If the lowest level routers 16 receive the data blocks correctly, then they take care of local recovery for mobile terminals 3. However, if any frame errors are introduced as the data propagates through levels of router, the highest router 16 which is not in error carries out local recovery for routers 16 below it.

[0112] In this example, a single block of data 24 comprises five frames 25_4. Errors occur in frames 2, 3 and 5 as shown in FIG. 11. Therefore, an twelfth router 16_{12} receives an erroneous frame 2 and requests retransmission of frame 2 to a higher level router (not shown). As frames 25_4 are correctly received, the twelfth router 16_{12} relays them to lower level routers 16. Thirteenth and fourteenth routers 16_{13}, 16_{14} receive erroneous frames 2 and 3 and request their retransmission. A fifteenth router 16_{15} receives erroneous frames 2 and 5 and requests retransmission of these frames.

[0113] The twelfth router 16_{12} multicasts frame 2 to all of lower routers once it receives frame 2 from a higher router (not shown). The twelfth router 16_{12} defines a new local multicast group 22 for recovery of frame 3. However, the twelfth router 16_{12} sends frame 5 by unicast, instead of multicast, because only one router, namely the fifteenth router 16_{15} requests retransmission.

[0114] Every router 16 acknowledges the state of reception 6 to a higher level router as soon as it receives frames correctly. Every router 16 removes the frames which are sent correctly to all of lower routers 16 from its cache, while keeping the frames that are incorrectly transmitted. The advantage of this arrangement is that there is no need to obtain retransmission of already correctly transmitted frames from the border router 11, thus reducing the amount of network traffic.

[0115] System Stability

[0116] The process of determining which routers 16 become local group controllers 21 occurs after transmission of every block 24. However, this may lead to instability in the system if routers 16 switch this often. To overcome this problem, routers 16 may be configured such that once one becomes a local group controller 21, it continues to do so for a given period. Thus, the local group controller 21 holds the recovery module, which is the software necessary for recovery, together with information for local group definition, information for local group management and retransmission frames for a period of several blocks. This has the advantages of reducing traffic between the local group controller 21 and the border router 11 and of reducing the frequency with which the local group controller 21 changes.

[0117] Referring to FIG. 13, once a router 16 is selected as a local group controller 21 it continues to be selected for a given period, for example a period equivalent to four blocks of data. Once the router 16 becomes a local group controller 21 after block 1 at a time T1, it organises a new local group 22 and keeps the information for the local group and recovery module at least until a time T5. This period of time is called a local group controller continuation period 27. If in the meantime, for example at time T3, the router 16 is again chosen as a local group controller is the same as that of time T1, then the continuation period **27** is refreshed by another 4 blocks, i.e. until time T7. Until the time T3, continuation period **27** shrinks to 2 blocks because the right edge **28**, the end of the continuation period **27**, does not shift. However, at time T3 the continuation period **27** is restored to 4 blocks and the right edge **28** moves from time T5 to time T7. Once the left edge **29** of the continuation period **27** reaches the right edge **27**, then the router **16** is no longer the local group controller **21**.

[**0118**] Definition of Local Group

[**0119**] The method of multicasting according to the present invention uses two kinds of groups. The first is a multicast group for initial transmission and second is a local group for recovery.

[**0120**] The multicast group **4** and multicast tree **13** are organised by routers **16** according to Internet Group Management Protocol (IGMP). Mobile terminals **3** may become a member or leave the multicast group **4** by transmitting join and leave messages respectively. The lowest level router **16** periodically sends a multicast group message comprising multicast group information. If a mobile terminal **3** receives this message and wants to join the multicast group, it responds with a JOIN message. If the mobile terminal **3** wants to leave the multicast group, it sends a LEAVE message to the lowest level router.

[**0121**] The local group is defined according to a block number B and session number S.

[**0122**] Referring to **FIG. 14**, an example of a local group definition is shown. In this example, a twelfth local group controller LGC defines thirteenth and fourteenth local groups LG1, LG2. A sixteenth router R1 belongs to the thirteenth local group LG1, a seventeenth router R2 belongs to both local groups LG1, LG2, while eighteenth and nineteenth routers R3, R4 belong to the fourteenth local group LG2. Errors occur at routers R5-R9, R11-R13, but not at Rio. The thirteenth and fourteenth local groups LG1, LG2 are defined at the twelfth local group controller LGC as follows:

[**0123**] LG1: {LG1 address, (B1,S1) |(R1,R2)}

[**0124**] LG2: {LG2 address, (B1,S1) |(R2,R3,R4)}

[**0125**] Each router defines, for example, as follows,

[**0126**] LG1 : {LG1 address, (B1,S1) |(R5 , R6)} at the sixteenth router R1

[**0127**] LG1 : {LG1 address, (B1,S1) |(R7, R8)} at the seventeenth router R2

[**0128**] LG2 : {LG2 address, (B1,S1) |(R7, R8)} at the seventeenth router R2

[**0129**] LG2 : {LG2 address, (B1,S1) |(R9, R11)} at the eighteenth router R3

[**0130**] LG2 : {LG2 address, (B1,S1) |(R12, R13)} at the nineteenth router R4

[**0131**] Referring to **FIG. 15**, the process of organising the local groups for recovery is shown. The twelfth local group controller LGC multicasts a query message M for local group definition information to each local group, comprising a local group address LG_address, block number B, session number S and local group controller router address LGC_router_address, i.e. {LG_address, {B, S}, LGC_router_address}. The local group controller LGC sends a first message **M1** to the sixteenth and seventeenth routers **R1**, **R2**, which in turn relay the first message **M1** to lower level routers **R5**, **R6**, **R7**, **R8**. The local group controller LGC sends a second message **M2** to the seventeenth, eighteenth and nineteenth routers **R2**, **R3**, **R4** which in turn relay the second message **M2** to lower level routers **R7**, **R8**, **R9**, **R11**, **R12**, **R13** which returned error frame. The lowest routers in each local group relay the messages **M1, M2** to the mobile terminals **3**. Local group definition is completed by the mobile terminals **3** returning confirmation C of local group definition to the local group controller LGC. Thus, local multicast group trees for the thirteenth and fourteenth local groups **LG1**, **LG2** are defined.

[**0132**] After local group definition, the local group controller LGC can carry out recovery with the new local group addresses.

[**0133**] If a mobile terminal **3** moves and attaches itself to a new local group **22**, the local group controller address is required to tell a new lowest router **16** that the mobile terminal **3** was originally a member of another local group **22**. This information is used to assist mobility.

[**0134**] Mobility

[**0135**] Network Structure

[**0136**] Referring to **FIG. 16, a** moving mobile terminal $\mathbf{3}_M$ moves to another radio cell **14** during multicasting. Twentieth and twenty-first routers $\mathbf{16}_{20}$, $\mathbf{16}_{21}$ maintain continuation of the multicast session. The sub-network **8** redefines the multicast tree **13** for the moving terminal $\mathbf{3}_M$ so that the twentieth and twenty-first routers $\mathbf{16}_{20}$, $\mathbf{16}_{21}$ form part of the tree **13**. The twentieth router $\mathbf{16}_{20}$ becomes a local group controller **21** and carries out recovery for the moving terminal $\mathbf{3}_M$.

[**0137**] Referring to **FIG. 17, a** method by which continuity of the multicast session is maintained will now be described.

[**0138**] In general terms, the network **1** comprises an original area $\mathbf{8}_{OLD}$ in which the moving terminal $\mathbf{3}_M$ is initially located and a destination area $\mathbf{8}_{NEW}$ to which it moves. In the original area $\mathbf{8}_{OLD}$, the moving terminal $\mathbf{3}_M$ is located in an old radio cell $\mathbf{14}_{OLD}$ and is connected to the network **1**, through an old lowest level router $\mathbf{16}_{OLD}$. An old local group controller $\mathbf{21}_{OLD}$ takes charge of recovery for the moving terminal $\mathbf{3}_M$. In the destination area $\mathbf{8}_{NEW}$, the moving terminal $\mathbf{3}_M$ is located in a new radio cell $\mathbf{14}_{NEW}$ and is connected to the network **1**, through an old lowest level router $\mathbf{16}_{NEW}$. A new local group controller $\mathbf{21}_{NEW}$ takes charge of recovery for the moving terminal $\mathbf{3}_M$.

[**0139**] As soon as the moving terminal $\mathbf{3}_M$ realises that it has moved from an old cell $\mathbf{14}_{OLD}$ to new cell $\mathbf{14}_{NEW}$, it transmits a join message JOIN according to Internet Group Management Protocol (IGMP) RFC 1112 IETF Internet standard.

[**0140**] The manner in which the network **1** responds depends upon the final destination of the moving terminal $\mathbf{3}_M$ and the timing of its move. There are two general cases. The moving terminal $\mathbf{3}_M$ may move to a cell **14** connected to a new part of the network where the multicast tree **13** has already been established. Alternatively, the multicast tree **13** may not have been organised.

[**0141**] The response of the network **1** in each case will now be described.

[**0142**] Multicast Tree **13** Already Established in Destination Area $\mathbf{8}_{NEW}$

[**0143**] In the first case, when the multicast tree **13** has already been established in the destination area $\mathbf{8}_{NEW}$, the response of the network **1** further depends on whether routers **16** in the original and destination parts of the network $\mathbf{8}_{NEW}$, $\mathbf{8}_{OLD}$ have executed the algorithm for determining whether they should become a local group controller **21**.

[**0144**] Table 1 below, shows first, second, third and fourth circumstances A, B, C, D under which the moving terminal $\mathbf{3}_M$ may move:

TABLE 1

State of original area 8_{OLD}	State of destination area 8_{NEW} Before decision	After decision
Before decision	A	B
After decision	C	D

[**0145**] The network **1** response is governed by two rules. The first rule is that if the algorithm has not been executed in the original area $\mathbf{8}_{OLD}$, then the new lowest level router $\mathbf{16}_{NEW}$ or the new local group controller $\mathbf{21}_{NEW}$ in the destination area $\mathbf{8}_{NEW}$ takes care of recovery for the moving terminal $\mathbf{3}_M$. The second rule is that if the algorithm has been executed in the original area $\mathbf{8}_{OLD}$, then an old local group controller $\mathbf{21}_{OLD}$ in the original area $\mathbf{8}_{OLD}$ takes care of recovery for the moving terminal $\mathbf{3}_M$.

[**0146**] First Circumstance A

[**0147**] Referring to **FIG. 18, a** multicasting sequence diagram for the first circumstance A is shown. In this case, the local group controller decision algorithm has not been executed in either the original or the destination parts of the network $\mathbf{8}_{OLD}$, $\mathbf{8}_{NEW}$.

[**0148**] The sender **2** multicasts a block of data **24** via an old lowest level router $\mathbf{16}_{OLD}$ to the moving terminal $\mathbf{3}_M$ located in the original area $\mathbf{8}_{OLD}$ (step A**1**). The moving terminal $\mathbf{3}_M$ moves to the new area $\mathbf{8}_{NEW}$ while it receives multicast frames **25** of the data block **24** (step A**2**). When the moving terminal $\mathbf{3}_M$ detects that it is in a new cell $\mathbf{14}_{NEW}$, it sends a join message JOIN, which includes a corresponding multicast group address but not a local group address (step A**3**). The new lowest level router $\mathbf{16}_{NEW}$ of the destination area $\mathbf{8}_{NEW}$ receives the message (step A**4**). The new lowest level router $\mathbf{16}_{NEW}$ requests and receives the reception state **6** from the moving terminal $\mathbf{3}_M$ (steps A**5** & A**6**). The moving terminal $\mathbf{3}_M$ receives the remaining frames of the data block **24** (step A**7**) and returns a reception state **6** (step A**8**). The reception state **6** is transmitted to the new lowest level router $\mathbf{16}_{NEW}$, which executes an algorithm to determine whether it should become a local group controller **21**. The reception state **6** is transmitted to a higher level router **16** until a router **16** determines that the router **16** below it should becomes the new local group controller $\mathbf{21}_{NEW}$ (step A**9**). Once the new local group controller $\mathbf{21}_{NEW}$ has been selected, a new local group $\mathbf{22}_{NEW}$ is defined and local recovery is carried out in the new area $\mathbf{8}_{NEW}$ (step **A10** & **A11**). A first timeout $\mathbf{30}_1$, is set for recovery and begins when the local group definition is transmitted. Multicast transmission of the next block of data **24** takes place via the new lowest level router $\mathbf{16}_{NEW}$ (step **A12**).

[**0149**] Second Circumstance B

[**0150**] In the second circumstance B, when the moving terminal $\mathbf{3}_M$ moves from the original area $\mathbf{8}_{OLD}$ where the algorithm has not been executed to the destination area $\mathbf{8}_{NEW}$ where the algorithm has been carried out, two situations B(**1**), B(**2**) can arise. In the first situation, a new local group $\mathbf{22}_{NEW}$ is established in the destination area $\mathbf{8}_{NEW}$. In the second situation, no local group **22** is established in the destination area $\mathbf{8}_{NEW}$, even though the algorithm has been executed, because there are no errors have been returned and no local recovery is required.

[**0151**] Referring to **FIG. 19, a** sequence diagram is shown for the first situation B(**1**). In this case, the moving terminal $\mathbf{3}_M$ moves from the original area $\mathbf{8}_{OLD}$ where the algorithm has not been executed to the destination area $\mathbf{8}_{NEW}$ where the algorithm has been carried out and where a new local group $\mathbf{22}_{NEW}$ has been established.

[**0152**] The sender **2** multicasts a block of data **24** via the old lowest level router $\mathbf{16}_{OLD}$ to the moving terminal $\mathbf{3}_M$ located in the original area $\mathbf{8}_{OLD}$ (step B**1**). The moving terminal $\mathbf{3}_M$ moves to the new area $\mathbf{8}_{NEW}$ while it receives multicast frames of the data block (step B**2**). In the destination area $\mathbf{8}_{NEW}$, the local group controller decision algorithm has been already executed (step B**3**). A second timeout $\mathbf{30}_2$ is set for recovery and begins when algorithm is executed. When the moving terminal $\mathbf{3}_M$ detects that it is in a new cell $\mathbf{14}_{NEW}$, it sends the join message JOIN, which includes a corresponding multicast group address but not a local group address (step B**4**). The new lowest level router $\mathbf{16}_{NEW}$ of the destination area receives the message. The new lowest level router $\mathbf{16}_{NEW}$ requests and receives a reception state **6** from the moving terminal $\mathbf{3}_M$ (steps B**5** & B**6**). The new lowest router $\mathbf{16}_{NEW}$ takes care of recovery for moving terminal $\mathbf{3}_M$ because local groups **22** are already established. The new lowest router $\mathbf{16}_{NEW}$ requests and receives frames needed for retransmission to the moving terminal $\mathbf{3}_M$ from the border router **11** (step B**7** & B**8**). The new lowest router $\mathbf{16}_{NEW}$ executes recovery for the moving terminal $\mathbf{3}_M$ (step B**9**). Multicast transmission of the next block of data **24** takes place via the new lowest level router $\mathbf{16}_{NEW}$ (step B**10**).

[**0153**] Referring to **FIG. 20, a** sequence diagram is shown for the second situation. In this case, the moving terminal $\mathbf{3}_M$ moves from the original area $\mathbf{8}_{OLD}$ where the algorithm has not been executed to the destination area $\mathbf{8}_{NEW}$ where the algorithm has been carried out, but no local group has been established.

[**0154**] The sender **2** multicasts a block of data **24** via the old lowest level router $\mathbf{16}_{OLD}$ to the moving terminal $\mathbf{3}_M$ located in the original area $\mathbf{8}_{OLD}$ (step B**11**). The moving terminal $\mathbf{3}_M$ moves to the new area $\mathbf{8}_{NEW}$ while it receives multicast frames of the data block (step B**12**). When the moving terminal $\mathbf{3}_M$ detects that it is in a new cell $\mathbf{14}_{NEW}$, it sends a join message JOIN, which includes a corresponding multicast group address but not a local group address (step B13). The new lowest level router 16_{NEW} of the destination area 8_{NEW} receives the message JOIN. The new lowest level router 16_{NEW} requests and receives a reception state 6 from the moving terminal 3_M (steps B14 & B15). The new lowest level router 16_{NW} takes care of recovery for moving terminal 3_M because no local groups have been established. The new lowest level router 16_{NEW} requests and receives frames needed for retransmission to the moving terminal 3_M from the border router 11 (steps B16 & B17).). A third timeout 30_3 is set for recovery and begins when the new lowest level router 16_{NEW} receives the frames for retransmission. The new lowest level router 16_{NEW} executes recovery for the moving terminal 3_M (step B18). Multicast transmission of the next block 24 of data takes place via the new lowest level router 16_{NEW} (step B19).

[0155] Third Circumstance C

[0156] Referring to FIG. 21, a multicasting sequence diagram for the third circumstance C is shown. In this case, the local group controller decision algorithm has been executed in the original part of the network 8_{OLD}, but not at the destination 8_{NEW}.

[0157] The sender 2 multicasts a block of data 24via the lowest level router 16_{NEW} to the moving terminal 3_M located in the original area 8_{OLD} (step C1). In the original area 8_{OLD}, the local group controller decision algorithm is executed and an old local group controller 21_{OLD} is selected (step C2). The old local group controller 21_{OLD} sends a local group definition to the moving terminal 3_M (step C3). A fourth timeout 30_4 is set for recovery and begins the local group definition is transmitted. The moving terminal 3_M moves to the new area 8_{NEW} and when it detects that it is in the new cell 14_{NEW}, it sends a join message JOIN, which includes a corresponding multicast group address and a local group address (steps C4 & C5). The new lowest level router 16_{NEW} of the destination area 8_{NEW} receives the message, checks the local group address and learns that the moving terminal 3_M previously belonged to the old local group controller 21_{OLD} in the original area 8_{OLD} (step C6). The new lowest level router 16_{NEW} reports to the old local group controller 21_{OLD}, informing it that the moving terminal 3_M is in the destination area 8_{NEW} (step C7). The old local group controller 21_{OLD} in the original area 8_{OLD} takes care of recovery for the moving terminal ^{3}M located in the destination area ^{8}NEW and retransmits the required frames via the new lowest level router 16_{NEW} (step C8). Multicast transmission of the next block of data takes place via the new lowest level router 16_{NEW} (step C9).

Fourth Circumstance D

[0158] In the fourth circumstance D, when the moving terminal 3_M moves from the original area 8_{OLD} where the algorithm has already been executed to the destination area 8_{NEW} where the algorithm has also been carried out, three situations D(1), D(2), D(3) can arise. In the first situation, the moving terminal 3_M moves from an original area 8_{OLD} that is part of an old local group 22_{OLD} to a destination area 8_{NEW} that is part of the same old local group 22_{OLD}. In the second situation, the moving terminal 3_M moves from an original area 8_{OLD} that is part of an old local group 22_{OLD} to a destination area 8_{NEW} that is part of a new local group 22_{NEW}. In the third situation, the moving terminal 3_M moves from an original area 8_{OLD} that is part of an old local group 22_{OLD} to a destination area 8_{NEW} in which no local group is defined.

[0159] Referring to FIG. 22, a multicast sequence diagram is shown for the first situation D(1), in which the moving terminal 3_M moves from an original area 8_{OLD} that is part of an old local group 22_{OLD} to a destination area 8_{NEW} that is part of the same, old local group 22_{OLD}.

[0160] The sender 2 multicasts a block of data via the old lowest level router 16_{OLD} to the moving terminal 3_M located in the original area 8_{OLD} (step D1). In the original area 8_{OLD}, the local group controller decision algorithm is executed in respect of the block of data and an old local group controller 21_{OLD} is selected (step D2). The old local group controller 21_{OLD} sends a local group definition to the moving terminal 3_M (step D3). A fifth timeout limit 30_5 is set and begins when the local group definition is transmitted. The moving terminal 3_M moves to a new area 8_{NEW}, which happens to be part of the same, old local group 22_{OLD}, and when it detects that it is in the new cell 14_{NEW}, it sends a join message, which includes a corresponding multicast group address and a local group address (steps D4 & D5). The new lowest level router 16_{NEW} of the destination area 8_{NEW} receives the message, checks the local group address and learns that the moving terminal 3_M is part of the same, old local group 22_{OLD} (step D6). The new lowest level router 16_{NEW} reports to the old local group controller 21_{OLD}, informing it that the moving terminal 3_M has moved (step D7). No other action is required because the moving terminal 3_M is part of the same, old local group 22_{OLD}. Local recovery and multicasting of the next block of data continues as usual (steps D8 & D9).

[0161] Referring to FIG. 23, a multicast sequence diagram is shown for the second and third situations D(2), D(3) in which the moving terminal 3_M moves from the original area 8_{OLD} that is part of an old local group 22_{OLD} to a destination area 8_{NEW} that is part of a new, different local group 22_{NEW} or that does not have a local group. These two situations are treated in the same way.

[0162] The sender 2 multicasts a block of data 24 via the old lowest level router 16_{OLD} to the moving terminal 3_M located in the original area 8_{OLD} (step D10). In the original area 8_{OLD}, the local group controller decision algorithm is executed in respect of the block of data and an old local group controller 21_{OLD} is selected (step D11). The local group controller 21 sends a local group definition to the moving terminal 3_M (step D12). A sixth timeout limit 30_6 is set and begins when the local group definition is transmitted. The moving terminal 3_M moves to a new area 8_{NEW} and when it detects that it is in the new cell 14_{NEW}, it sends a join message JOIN, which includes a corresponding multicast group address and a local group address (steps D13 & D14). The new lowest level router 16_{NEW} receives the message JOIN, checks the local group address and learns that the moving terminal 3_M previously belonged to the old local group controller 21_{OLD} in the original area 8_{OLD} (step D15). The new lowest level router 16_{NEW} reports to the old local group controller 21_{OLD}, informing it that the moving terminal 3_M is in the destination area 8_{NEW} (step D16). The old local group controller 21_{OLD} takes care of recovery for the moving terminal 3_M located in the destination area 8_{NEW} and retransmits the required frames via the new lowest level router 16_{NEW} (step D17). Multicast transmission of the next block of data takes place via the new lowest level router 16_{NEW} (step D18).

[0163] No multicast tree **13** established in destination area $\mathbf{8}_{NEW}$

[0164] In the second case, where no multicast tree has been established in the destination area $\mathbf{8}_{NEW}$, the response of the network **1** depends on whether routers **16** in the original part of the network $\mathbf{8}_{OLD}$ have executed the algorithm for determining whether they should become local group controllers **21**.

[0165] There are fifth and sixth circumstances E, F under which the moving terminal $\mathbf{3}_M$ may move. In the fifth circumstance E, the local group controller decision algorithm has not been executed in the original part of the network $\mathbf{8}_{OLD}$. In the sixth circumstance F, the local group controller decision algorithm has been executed.

[0166] As in the first case, the network **1** response is governed by two rules as hereinbefore described.

[0167] Fifth Circumstance E

[0168] Referring to **FIG. 24, a** multicasting sequence diagram for the fifth circumstance E is shown. In this case, the local group controller decision algorithm has not been executed in the original part of the network $\mathbf{8}_{OLD}$.

[0169] The sender **2** multicasts a block of data via an old lowest level router $\mathbf{16}_{OLD}$ to the moving terminal $\mathbf{3}_M$ located in the original area $\mathbf{8}_{OLD}$ (step E1). The moving terminal $\mathbf{3}_M$ moves to a new area $\mathbf{8}_{NEW}$ while it receives multicast frames of the data block **24** (step E2). When the moving terminal $\mathbf{3}_M$ detects that it is in a new cell $\mathbf{14}_{NEW}$, it sends a join message JOIN, which includes a corresponding multicast group address but not a local group address (step E3). A new lowest level router $\mathbf{16}_{NEW}$ of the destination area receives the message and exchanges multicast routing information with higher routers **16** so as to form a new multicast tree **13** using protocols hereinbefore described (Step E4). The new lowest level router $\mathbf{16}_{NEW}$ requests and receives the reception state **6** from the moving terminal $\mathbf{3}_M$ (steps E5 & E6). The moving terminal $\mathbf{3}_M$ receives the remaining frames of the data block (step E7) and returns a reception state **6** (step E8). The reception state **6** is transmitted to the new lowest level router $\mathbf{16}_{NEW}$, which executes an algorithm to determine whether it should become a new local group controller $\mathbf{21}_{NEW}$. The reception state **6** is transmitted to a higher level router **16** in the destination area $\mathbf{8}_{NEW}$ until a router **16** determines that the router **16** below it should becomes the new local group controller $\mathbf{21}_{NEW}$ (step E9). Once the new local group controller $\mathbf{21}_{NEW}$ has been selected, a new local group $\mathbf{22}_{NEW}$ is defined and local recovery is carried out in the new area $\mathbf{8}_{NEW}$ (step E**10** & E**11**). A seventh timeout limit $\mathbf{30}_7$ is set and begins when the local group definition is transmitted. Multicast transmission of the next block of data takes place via the new lowest level router $\mathbf{16}_{NEW}$ (step E12).

[0170] Sixth Circumstance F

[0171] Referring to **FIG. 25, a** multicasting sequence diagram for the sixth circumstance F is shown. In this case, the local group controller decision algorithm has been executed in the original part of the network $\mathbf{8}_{NEW}$.

[0172] The sender **2** multicasts a block of data via an old lowest level router $\mathbf{16}_{OLD}$ to the moving terminal $\mathbf{3}_M$ located in the original area $\mathbf{8}_{OLD}$ (step F1). In the original area $\mathbf{8}_{OLD}$, the local group controller decision algorithm is executed and an old local group controller $\mathbf{21}_{OLD}$ is selected (step F2). The old local group controller $\mathbf{21}_{OLD}$ sends a local group definition in respect of the block of data to the moving terminal $\mathbf{3}_M$ (step F3). The moving terminal $\mathbf{3}_M$ moves to a new area $\mathbf{8}_{NEW}$ and when it detects that it is in the new cell $\mathbf{14}_{NEW}$, it sends a join message JOIN, which includes a corresponding multicast group address and a local group address (step F4). The new lowest level router $\mathbf{16}_{NEW}$ of the destination area receives the message JOIN and exchanges multicast routing information with higher routers **16** so as to form a new multicast tree $\mathbf{13}_{NEW}$ (Step F**5**). Once the new multicast tree $\mathbf{13}_{NEW}$ is established, the new lowest level router $\mathbf{16}_{NEW}$ checks the local group address and learns that the moving terminal $\mathbf{3}_M$ previously belonged to the old local group controller $\mathbf{21}_{OLD}$ in the original area $\mathbf{8}_{OLD}$ (step F**6**). The new lowest level router $\mathbf{16}_{OLD}$ reports to the old local group controller $\mathbf{21}_{OLD}$, informing it that the moving terminal $\mathbf{3}_M$ is in the destination area $\mathbf{8}_{NEW}$ (step F**7**). A eighth timeout limit $\mathbf{30}_8$ is set and begins when the local group controller receives the report of movement of the terminal. The old local group controller $\mathbf{21}_{OLD}$ in the original area $\mathbf{8}_{OLD}$ takes care of recovery for the moving terminal $\mathbf{3}_M$ located in the destination area $\mathbf{8}_{NEW}$ and retransmits the required frames via the new lowest level router $\mathbf{16}_{NEW}$ (step F**8**). Multicast transmission of the next block of data takes place via the new lowest level router $\mathbf{16}_{NEW}$ (step F**9**).

[0173] Layer Model

[0174] Referring to **FIG. 26, a** layer model for the multicast system is shown according to the International Standards Organisation (ISO) Reference Model for Open Systems Interconnections (OSI). The network dependent layers of the layer model, i.e. the three lowest layers, comprise a physical layer **31**, a data link layer **32** and an IP layer **33**. The physical layer **31** takes charge of communication at the physical level. The data link layer **32** manages the communication of data between nodes. The IP layer **33** manages end-to-end communication of IP packets from sender to receiver.

[0175] The transport layer is split. On the one hand, transmission control protocol (TCP) layer **34** serves a TCP application **35**. On the other, either a combination of a user datagram protocol (UDP) layer **36** and an overlying first multicast layer **37** or a second multicast layer **38** alone may serve a multicast application **39**. Between them, the TCP and UDP layers **34, 36** provide for connection- and connectionless-types of communication using IP packets. TCP is more reliable than UDP because it performs such functions as error recovery and flow control. However, TCP/UDP is dedicated to one-to-one communication. In this example, the multicast layers **37, 38** are responsible for carrying out the method of multicasting according to the present invention.

[0176] In this example, session and presentation layers are included in the application layer. Respective first and second interfaces **40, 41** between the multicast application **39** and the first and second multicast layers **37, 38** are the same. On the other hand, respective third and fourth interfaces **42, 43** between the IP layer **33** are different. The UDP layer **36** provides efficient communication between a connectionless-type application and the IP layer **33** by, for example, managing the session of the application. In the case of the second multicast layer **38**, there is no UDP layer. Therefore, the second multicast layer **38** undertakes UDP functions and this is reflected in the fourth interface **43**.

[0177] Frame Structure

[0178] Referring to **FIG. 27***a*, a first example of a frame structure **44** at the third interface **42** is shown. The first frame structure **44** comprises an IP header **45** and IP data payload **46**. The IP data **46** comprises a UDP header **47** and UDP data **48**. The UDP data **48** comprises multicast transport (MCT) header **49** and MCT data **50**.

[0179] Referring to **FIG. 27***b*, a second example of a frame structure **51** at the fourth interface **43** is shown. The second frame structure **51** comprises an IP header **52** and IP data payload **53**. The IP data **53** comprises a MCT header **54** and MCT data **55**. In case of the second frame structure **51**, a new protocol number in the IP header **52** is defined.

[0180] Referring to **FIG. 28**, the general structure of an MCT frame **56** comprising the MCT header **49**, **54** and the MCT data **50**, **55** is shown. The MCT header **49**, **54** comprises a source port number **57**, destination port number **58**, indicator of MCT frame type **59**, a sequence number **60** and other control data **61**. The source and destination port numbers **57**, **58** identify the application process at the source host and destination host, respectively. The sequence number **60** is used at the receiver to reorder application data sent in the MCT frame **56** by the sender. When control data is sent, the control data frame does not use the sequence number **60**.

[0181] In this example, the indicator **59** comprises a three-bit number, defining seven types of MCT frame **56**. Table **2** below lists the different indicators against message type:

TABLE 2

Indicator	Message Type
001	Application data
010	Reception State
011	Definition information report
100	Request for reception state
101	Request for information of local recovery
110	Information of local recovery
111	Report of moving terminal movement

[0182] It will be appreciated that different combinations of indicator number and message may be used. When sending multicast data, the indicator **59** is set to "001", thus Application data. The MCT frame **56** is handled by the multicast layer **37**, **38**.

[0183] Referring to **FIG. 29**, first, second, third, fourth, fifth and sixth examples $\mathbf{56_1}$, $\mathbf{56_2}$, $\mathbf{56_3}$, $\mathbf{56_4}$, $\mathbf{56_5}$, $\mathbf{56_6}$ of the structures of the MCT frame **56** are shown.

[0184] The MCT frame $\mathbf{56_1}$ is a reception state **6** generated by the mobile terminal **3** or the router **16**. It comprises a mobile terminal/router address **62** and a bit area **63**. The address **62** is the IP address for the mobile terminal or router that sent the reception state. Each bit **64** in the bit area **63** represents a frame in a block. A bit **64** set to "1" indicates a correctly received frame, while a bit **64** set to "0" represents an incorrectly received.

[0185] The second MCT frame $\mathbf{56_2}$ is a definition information report M (**FIG. 15**) generated by the local group controller **21**. It comprises a local group address **65**, a local group controller address **66**, a block number **67** and a session number **68**.

[0186] The third MCT frame $\mathbf{56_3}$ is a request for information of local recovery generated by the local group controller **21** and the lowest level router **16**. It comprises a local group address **69**, a frame sequence number for retransmission **70** and session number **71**, which identifies multicast application.

[0187] The fourth MCT frame $\mathbf{56_4}$ is information of local recovery **23** generated by the border router **11**. It comprises a local group address **72** and a requested module software for recovery **73**.

[0188] The fifth MCT frame $\mathbf{56_5}$ is a report of mobile terminal movement generated by the lowest level router **16**. It comprises a local group address **74**, a local group controller address **75**, a block number **76**, a session number **77** and a lowest level router address **78**.

[0189] The sixth MCT frame $\mathbf{56_6}$ is a request for reception state. It comprises a session number S and a block number B. There is no MCT data.

[0190] The MCT data frame **50**, **55** is used for the initial transmission and retransmission of data.

[0191] Structure of Network Elements

[0192] Router **16**

[0193] Referring to **FIG. 30, a** schematic diagram of the processes implemented by each router **16** is shown. A plurality of processes are executed by a microprocessor (not shown) as will now be described.

[0194] A management of summary of reception state process **79** analyses reports of reception state **6** from received from a lower level router **16** or mobile terminal **3** and, if one is needed, generates a new summary **20** report of reception state to send to a higher level router **16**. A local group controller decision process **80** judges whether the router **16** should become the local group controller **21** according to the local group controller decision algorithm. The exchange of information with the border router process **81** is used for requesting information from the border router **11** to organise a new local group. A local group control process **82** manages local group definition, handles reports of local recovery and execution of local recovery. A management of local group controller continuation process **83** judges whether the router **16**, once selected as a local group controller **21**, should continue to be selected and whether it should keep or remove local group controller information **23**. A management of delayed recovery process **84** is used for the management of delayed recovery. A mobility management process **85** manages continuation of the multicast session for the moving terminal after organisation of the local group **22**. A data management process **86** manages the renewal, removal and addition of local group definition information and retransmission frames sent from the border router **11**. It also manages the renewal, removal and addition of summaries of reception states from lower level routers **16**. A network system management process **87** manages network control information. A data disassemble/assemble process **88** divides blocks into frames and assembles multicast data. A communication control process **89** and Interface (I/O) **90** are based on standard protocols.

[0195] Border Router **11**

[0196] Referring to **FIG. 31, a** schematic diagram of the processes implemented by each border router **11** is shown.

The border router **11** implements the processes described above in relation to a router **16** minus the exchange of information with the border router process **81** plus some additional described below.

[**0197**] A management of recovery module process **91** stores recovery modules suitable for multicast applications. In response to a request from a local group controller **21**, the border router **11** returns a corresponding recovery module. An exchange of information with a proxy router process **92** manages the local group address and error frame sequence number within the sub-network **8** connected to the border router **11**. In response to a request from the local group controller **21**, the border router **11** returns information relating to a new local group **22** and retransmission frames. A data management process **93** assigns a local group address to a local group controller **21**. It copies and stores multicast data, while relaying it to lower level routers **16** on the multicast tree **13**.

[**0198**] Mobile Terminal **3**

[**0199**] Referring to **FIG. 32, a** schematic diagram of the processes implemented by each mobile terminal **3** is shown. A plurality of processes are executed by a microprocessor (not shown) as described below.

[**0200**] A mobility management process **94** controls message sequences with the network **1** after the mobile terminal **3** sends a join message. A multicast transmission management process **95** controls operation of the multicast layer **37**, **38** when it receives multicast application data from the application layer **39**. A normal transmission management process **96** controls the transport layer other than the multicast layer **37**, **38**, i.e. TCP and UDP layers **34**, **36**. A data management process **97** keeps local group definition information after having participated in local group for recovery and also a block of data.

[**0201**] The mobile terminal **3** also implements the management of delayed recovery process **84**, the network system management process **87**, the data disassemble/assemble process **88**, communication control **89** and interface process **90** as described hereinbefore.

[**0202**] Process Flows

At the Router **16**, Process for Choosing to Become the Local Group Controller **11**

EXAMPLE 1

[**0203**] Referring to **FIG. 33, a** process flow diagram for deciding the local group controller **21** according to the first example referred to in **FIG. 8** is shown.

[**0204**] A router **16** waits until it receives at least one summary of reception states **20** from lower level routers **16** or mobile terminals **3** (step R1). When it receives at least one summary of reception states **20**, the router **16** checks whether it has received summaries **20** from more than one router **16** (step R2). If it has received summaries **20** from more than one router **16**, the router **16** checks the summaries for coincident error frames (step R3). If there are coincidences and if the number of coincidences exceeds a threshold (step R4), then the router **16** makes a new summary of the reception states (step R5) and sends it to higher level router **16** (step R6). If there are no coincidences or the number of coincidences does not exceed the threshold, then the router **16** instructs the lower level routers **16** to become the local group controller **21** (step R7). Similarly, in step R2, if the router **16** does not receive a plurality of summaries from routers **16**, the router **16** instructs the lower level router **16** to become the local group controller **21**.

[**0205**] If the router **16** sends a summary **20** to a higher level router in step R6, it waits for instructions from the higher level router. If the router receives instructions from the higher level router **16** to become the local group controller **21** (step R8), it becomes the local group controller **21** and executes local recovery (step R9). In the absence of such an instruction, the decision process returns to the beginning ready for the next block.

At the Router **16**, Process for Choosing to Become the Local Group Controller **11**

EXAMPLE 2

[**0206**] Referring to **FIG. 34, a** process flow diagram for deciding the local group controller **21** according to the second example referred to in **FIGS. 9 and 10** is shown.

[**0207**] A router **16** waits until it receives at least one summary of reception states **20** from lower level routers **16** or mobile terminals **3** (step R10). When it receives at least one summary of reception states **20**, the router **16** checks whether it has received summaries **20** from more than one router **16** (step R11). If it has received summaries **20** from more than one router **16**, the router **16** checks the summaries for coincident error frames (step R12). If there are coincidences and if the number of coincidences exceeds a threshold (step R13), then the router **16** makes a new summary of the reception states listing the coincidental frame numbers (step R14) and sends it to higher level router **16** (step R15). If there are no coincidences or the number of coincidences does not exceed the threshold, then the router **16** instructs the lower level routers **16** to become the local group controller **21** (step R16). Similarly, in step R11, if the router **16** does not receive a plurality of summaries from routers **16**, the router **16** instructs the lower level router **16** to become the local group controller **21**.

[**0208**] If the router **16** sends a summary **20** to a higher level router in step R15, it waits for instructions from the higher level router. If the router receives instructions from the higher level router **16** to become the local group controller **21** (step R17), it becomes the local group controller **21** for the recovery of retransmission of error frames except the coincidental frames (step R18) and executes local recovery (step R19). In the absence of such an instruction, the decision process returns to the beginning ready for the next block.

At the Router **16** with Cache, Processes for Detecting Errors and Choosing to Become the Local Group Controller **11**

[**0209**] Referring to **FIGS. 35***a* and **35***b*, process flow diagrams for detecting error and deciding the local group controller **21** according to the example referred to in **FIG. 11** are shown.

[**0210**] In **FIG. 35***a*, the router **16** receives data and checks whether it constitutes a block (step RC1). The router **16** waits until it receives a block of data before proceeding further. Once the router receives a block of data, it checks whether there are any error frames (step RC**2**). If there are any erroneous frames, the router **16** sends a request to the border router **11** for retransmission of the erroneous frames (step RC**3**), otherwise it waits until it receives the next block.

[**0211**] In **FIG. 35***b*, the router **16** waits until it receives summaries **20** of reception states from lower level routers **16** (step RC **4**). Once it has received the summaries **20**, the router **16** checks them (step RC**5**) and detects whether there are any errors in the block of data (step RC**6**). The router **16** checks the number of coincidental error frames (step RC**7**). Local groups **22** are arranged according to the number of coincidental error frames. If the number of coincidental error frames exceeds a threshold, then the router **16** defines a local group for multicast retransmission of all except the coincidental error frames (step RC**8**). If the number of coincidental error frames falls below the threshold, then the router **16** defines a local group for unicast retransmission of the non-coincidental erroneous frames (step RC**8**).

At the Router **16**, Process for Achieving System Stability

[**0212**] Referring to **FIG. 36, a** process flow diagram for achieving system stability according to the example referred to in **FIG. 13** is shown.

[**0213**] A router **16** decides whether it should become the local group controller **21** according to one of the examples described hereinbefore (step SS**1**, SS**2**). If the router **16** decides that it should become the local group controller **21**, it checks whether it has been the local group controller **21** for any of the previous four blocks of data (step SS**3**). If it has, then the local group controller **21** then local group controller continuation period **27** (**FIG. 13**) is extended (step SS**4**). If not, a local group controller continuation period is set and the local group controller **21** executes local recovery (step SS**5**).

[**0214**] If at step SS**2**, the router **16** decides that it should not become the local group controller **21**, it checks whether it has been the local group controller **21** for any of the previous four blocks (step SS**6**). If it has, then the router **16** checks to see if the local group controller continuation period **27** (**FIG. 13**) has expired (step SS**7**). If the period **27** has expired, then the router **16** deletes information regarding local group address and the recovery module (step SS**8**). If the period **27** has not expired, then the router **16** keeps the recovery information and stores frames while relaying them to lower routers (step SS**9**).

[**0215**] The process then returns to the beginning to determine the local group controller **21** for the next block.

At the Mobile Terminal **3**, Process for Participating in Defining the Local Group

[**0216**] Referring to **FIG. 37, a** process flow diagram for participating in defining the local group according to the examples shown in **FIGS. 14 and 15** is shown.

[**0217**] The mobile terminal **3** waits until it receives local group definition information comprising local address, block number and session number (step M**1**). This is carried out by the multicast transmission management process **95** (**FIG. 32**). The mobile terminal **3** checks the block number B and session number S (step M**2**) and determines whether the received definition information is for the recovery of the frames requested by the mobile terminal **3** (step M**3**). If they are, the router **16** becomes a member of the local group (step M**4**) and participates in local recovery for the local group defined by the local group address (step M**5**). Otherwise, the router **16** does not become a member of the local group and waits until it receives further local group definition information.

At the Mobile Terminal **3**, Process for Maintaining Session Continuity

[**0218**] Referring to **FIG. 38, a** process flow diagram for maintaining session continuity at the moving terminal $\mathbf{3}_M$, as it moves from an original area $\mathbf{8}_{OLD}$ to a destination area $\mathbf{8}_{NEW}$, according to the examples shown in FIGS. **16** to **25** is shown.

[**0219**] If the moving terminal $\mathbf{3}_M$ moves to a new cell $\mathbf{14}_{NEW}$, once it completes the handover process, it sends a join message (step MM**1**). The moving terminal $\mathbf{3}_M$ checks whether it holds the local group definition from the old local group controller $\mathbf{21}_{OLD}$ in the original area $\mathbf{8}_{OLD}$ (step MM**2**). The circumstances under which the mobile terminal $\mathbf{3}_M$ would hold the local group definition are if the local group controller decision algorithm has been executed in the original area $\mathbf{8}_{OLD}$ and the old local group $\mathbf{22}_{OLD}$ has been organised, as shown in **FIGS. 21 and 22**.

[**0220**] If the moving terminal $\mathbf{3}_M$ does hold the local group definition, then it sends the local group definition information to the destination area $\mathbf{8}_{NEW}$ (step MM**3**). The old local group controller $\mathbf{21}_{OLD}$ in the original area $\mathbf{8}_{OLD}$ takes care of recovery for the moving terminal $\mathbf{3}_M$ after the move (steps MM**4**, MM**5**).

[**0221**] If the moving terminal $\mathbf{3}_M$ does not hold a local group definition, then no local group definition information is sent to the destination area $\mathbf{8}_{NEW}$ (step MM**6**). The moving terminal $\mathbf{3}_M$ exchanges requests and replies with the new lowest level router $\mathbf{16}_{NEW}$ in the destination area $\mathbf{8}_{NEW}$. The moving terminal $\mathbf{3}_M$ waits until it receives a request for its reception state (step MM**7**). Once, it receives the request, the moving terminal $\mathbf{3}_M$ returns the reception state (step MM**8**). The moving terminal $\mathbf{3}_M$ checks whether there are any further frames to be received (step MM**9**). The moving terminal $\mathbf{3}_M$ continues to receive frames until the block is completed (step MM**10**), at which point it sends a reception state (step MM**11**). Once a reception state has been sent at step MM**11** or if there are no more frames to be received at step MM **9**, the moving terminal $\mathbf{3}_M$ waits until it receives the local group definition information (step MM**12**) and on receiving the information local recovery takes place (step MM**13**).

At the New Lowest Level Router $\mathbf{16}_{NEW}$, Process for Maintaining Session Continuity

[**0222**] Referring to **FIG. 39, a** process flow diagram for maintaining session continuity at the new lowest level router $\mathbf{16}_{NEW}$ in the destination area $\mathbf{8}_{NEW}$ according to the examples shown in FIGS. **16** to **25** is shown.

[**0223**] The new lowest level router $\mathbf{16}_{NEW}$ in the destination area $\mathbf{8}_{NEW}$ waits until it receives a join message from the moving terminal $\mathbf{3}_M$ (step LR**1**) and then waits to receive local group definition information (step LR2). The new lowest router 16_{NEW} checks whether the local group definition information includes a local group address (step LR3). The circumstances under which the mobile terminal 3_M would send the local group address are if the local group controller decision algorithm has been executed in the original area 8_{OLD} and a local group 22 has been organised, as shown in **FIGS. 20 and 21**.

[**0224**] If, at step LR3, the information includes a local group address, the new lowest level router 16_{NEW} checks whether the router 16_{NEW} itself belongs to a local group 22 (step LR4). If it did belong to a local group 22, the new lowest level router 16_{NEW} would compare the local group address with that received from the moving terminal 3_M to check whether the moving terminal 3_M moved within the same local group (step LR5). The new lowest level router 16_{NEW} determines whether it is a local group controller 21 (step LR6). If it is a local group controller 21, the new lowest level router 16_{NEW} checks whether it has the same local address as that received from the moving terminal 3_M (step LR7). If the two local addresses match, then the recovery process is managed by the old local group controller 21_{OLD} in the original area 8_{OLD} (step LR8). If not, the new lowest level router 16_{NEW} sends a report to the old local group controller 21_{OLD} in the original area 8_{OLD} that the moving terminal 3_M has moved (step LR9) and the recovery process is managed by the old local group controller 21_{OLD} (step LR8). If, at step LR6, the new lowest level router 16_{NEW} determines that it is not a local group controller 21, it checks whether it has the same local address as the moving terminal 3_M (step LR10). If the two local addresses match, then the recovery process is managed by the old local group controller 21_{OLD} (step LR8). If not, the new lowest level router 16_{NEW} sends a report to the old local group controller 21_{OLD} in the original area 8_{OLD} that the moving terminal 3_M has moved (step LR9) and the recovery process is managed by the old local group controller 21_{OLD} (step LR8).

[**0225**] If, at step LR4, the new lowest level router 16_{NEW} does not belong to a local group 22, it sends a report to the old local group controller 21_{OLD} in the original area 8_{OLD} that the moving terminal 3_M has moved (step LR11), the router 16_{NEW} itself being part of the original local group 22_{OLD} (step LR12) and the recovery process is managed by the old local group controller 21_{OLD} (step LR8).

[**0226**] If, at step LR 3, the information does not include a local group address, the new lowest level router 16_{NEW} sends a request for reception state to the moving terminal 3_M (step LR13) and waits for a reply (step LR14). Once it receives a reception state, the new lowest level router 16_{NEW} checks whether transmission of the data block has finished (step LR15). If it has not, the new lowest level router 16_{NEW} checks whether the router 16_{NEW} itself belongs to a local group 22 (step LR16). If it does not, it checks whether there is a final report of reception state (step LR17). If there is, the new lowest level router 16_{NEW} relays the final report to a higher router 16 (step LR18). If, at step LR15, transmission of the block has finished, then the reception state received at step LR 15 is the final report and this is relayed to the higher level router 16 (step LR18).

[**0227**] If, at step LR16, the new lowest level router 16_{NEW} belongs to a local group 22, it sends a request for information for recovery to the border router 11 (step LR19) and executes recovery for the moving terminal 3_M (step LR20).

[**0228**] After step LR18, the new lowest level router 16_{NEW} checks whether the router 16_{NEW} itself is a local group controller 21 (step LR21). If it is, the new lowest level router 16_{NEW} executes recovery (step LR22). If it is not, it waits to receive local definition information from the old local group controller 21_{OLD} (step LR23). Once it receives the local group definition, the new lowest level router 16_{NEW} sends a report of the movement of the moving terminal 3_M to the old local group controller 21_{OLD} (step LR24), which executes local recovery (step LR22).

At the Old Local Group Controller 21_{OLD}, Process for Maintaining Session Continuity

[**0229**] Referring to **FIG. 40, a** process flow diagram for maintaining session continuity at the old local group controller 21_{OLD} in the original area 8_{OLD} according to the examples shown in FIGS. **16** to **25** is shown.

[**0230**] The old local group controller 21_{OLD} for the original area 8_{OLD} waits until it receives a report of movement of the moving terminal 3_M from the new lowest level router 16_{NEW} (step LC1). The report includes local group information comprises local group address, session number and block number, which the old local group controller 21_{OLD} arranged. The old local group controller 21_{OLD} checks the address of the new lowest level router 16_{NEW} (step LC2) and redefines the local group tree to include the new lowest router 16_{NEW} (step LC3). The old local group controller 21_{OLD} executes local recovery for the moving terminal 3_M (step LC4).

[**0231**] It will be appreciated that many modifications may be made to the embodiment described.

1. A method of multicasting data from a sender to first, second and third receivers through a network including first and second routers, the method comprising:

transmitting a data packet from said sender to said first, second and third receivers;

detecting at said first, second and third receivers whether said data packet is properly received;

transmitting a first reception information signal from said first receiver to said first router by a first path;

transmitting a second reception information signal from said second receiver to said first router by a second path;

determining, at said first router, in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and, if so, transmitting information relating to said first and second reception information signals to said second router;

determining, at said second router, whether said third receiver requires re-transmission of said data packet and, if not, instructing said first router to re-transmit said data packet to said first and second receivers.

2. A method according to claim 1, further comprising transmitting a request for information relating to said data packet from said first router to an archive router.

3. A method according to claim 1, further comprising receiving at said first router information relating to said data packet.

4. A method according to claim 1, wherein the network comprises a plurality of sub-networks.

5. A method of multicasting data from a sender to first, second, third and fourth receivers through a network including first and second routers, the method comprising:

transmitting first and second data packet from said sender to said first, second, third and fourth receivers;

detecting at said first, second, third and fourth receivers whether said first and second data packets are properly received;

transmitting a first reception information signal from said first receiver to said first router by a first path;

transmitting a second reception information signal from said second receiver to said first router by a second path;

transmitting a third reception information signal from said third receiver to said first router by a third path;

determining, at said first router, in dependence upon said first, second and third reception information signals, whether said first, second and third receivers require re-transmission of said first and second data packets and, if so, transmitting information relating to said first, second and third reception information signals to said second router;

determining, at said second router, whether said fourth receiver requires re-transmission of said first and second data packets and, if not, instructing said first router to re-transmit appropriate data packets to said first, second and third receivers.

6. A method according to claim 5, further comprising transmitting a request for information relating to said data packet from said first router to an archive router.

7. A method according to claim 5, further comprising receiving at said first router information relating to said data packet.

8. A method according to claim 5, wherein the network comprises a plurality of sub-networks.

9. A method of operating a router, the method comprising:

receiving a first message comprising information relating to receipt of a data packet by a first receiver,

receiving a second message comprising information relating to receipt of a data packet by a second receiver,

determining in dependence upon said first and second messages whether said first and second receivers require re-transmission of said data packet and, if so, transmitting a third message relating to receipt of said data packet by said first and second receivers to another router and

receiving an instruction from said other router to retransmit said data packet to said first and second routers.

10. A method of operating a network element, the method comprising:

receiving a first message from a first network element comprising information relating to receipt of a data packet by a first receiver,

determining whether a second message from a second network element comprising information relating to receipt of said data packet by a second receiver has been received and

if not, instructing said first network element to re-transmit said data packet, or

if so, transmitting a third message relating to receipt of said data packet by said first and second receivers to third network element and receiving an instruction from said third network element to re-transmit said data packet to said first and second network elements.

11. A method of operating a network element, the method comprising:

receiving a first message from a first network element comprising a first set of information relating to a plurality of data packets,

determining whether a second message from a second network element comprising a second set of information relating to said plurality of data packets has been received and

if not, instructing said first network element to re-transmit one or more of said plurality of data packets in dependence upon said first set of information,

if so, in dependence upon said first and second sets of information, determining the number data packets common to both first and second sets that are required for re-transmission and determining whether this number exceeds a predetermined number and

if the number does not exceed the predetermined number, instructing said first network element to re-transmit one or more of said plurality of data packets in dependence upon said first set of information and instructing said second network element to re-transmit one or more of said plurality of data packets in dependence upon said second set of information,

if the number does exceed the predetermined number, transmitting a third message relating to said first and second sets of information to third network element and receiving an instruction from said third network element to re-transmit one or more of said plurality of data packets in dependence upon said first and second sets of information.

12. A method of recovery of a data packet in a network including first and second routers, the method comprising:

receiving at the first router, via a first path, first reception information relating to said data packet including information relating to the identity of the source of said first reception information;

receiving at the first router, via a second path, second reception information relating to said data packet including information relating to the identity of the source of said second reception information;

determining, at said first router, in dependence upon said first and second reception information signals, whether recovery of said data packet is required and, if so, transmitting information relating to said first and second reception information signals to said second router; and

determining at said second router, whether further reception state information relating to said data packet identifying a further source is received and whether recovery of said data packet in respect of said further source is required and, if not, instructing said first router to transmit said data packet for intended receipt by said sources of said first and second reception information.

13. A method according claim 12, wherein the network comprises a plurality of sub-networks.

14. A system for multicasting data from a sender to first, second and third receivers through a network including first and second routers, comprising:

a first router including:

an input to receive a first reception information signal relating to whether said data packet is properly received by said first receiver and a second reception information signal relating to whether said data packet is properly received by said second receiver;

a processor to determine in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and

an output to transmit information relating to said first and second detection information signals to said second router;

a second router including:

an input to receive said information from the first router and a third reception information signal relating to whether said data packet is properly received by said third receiver

a processor to determine whether said third receiver requires re-transmission of said data packet and

an output to transmit an instruction to said first router to re-transmit said data packet to said first and second receivers.

15. A system for multicasting data from a sender to first, second and third receivers through a plurality of networks including first and second routers, comprising:

a first router including:

an input to receive a first reception information signal relating to whether said data packet is properly received by said first receiver and a second reception information signal relating to whether said data packet is properly received by said second receiver;

a processor to determine in dependence upon said first and second reception information signals, whether said first and second receivers require re-transmission of said data packet and

an output to transmit information relating to said first and second detection information signals to said second router;

a second router including:

an input to receive said information from the first router and a third reception information signal relating to whether said data packet is properly received by said third receiver

a processor to determine whether said third receiver requires re-transmission of said data packet and

an output to transmit an instruction to said first router to re-transmit said data packet to said first and second receivers.

16. A router comprising:

an input for receiving a first message comprising information relating to receipt of a data packet by a first receiver;

an input for receiving a second message comprising information relating to receipt of a data packet by a second receiver,

a processor for determining in dependence upon said first and second messages whether said first and second receivers require re-transmission of said data packet and

an output for transmitting a third message relating to receipt of said data packet by said first and second receivers to another router if said first and second receivers require re-transmission of said data packet and

an input for receiving an instruction from said other router to retransmit said data packet to said first and second receivers.

17. A computer program comprising computer code operable to make data processing apparatus:

receive a first message comprising information relating to receipt of a data packet by a first receiver;

receive a second message comprising information relating to receipt of a data packet by a second receiver,

determine in dependence upon said first and second messages whether said first and second receivers require retransmission of said data packet and

transmit a third message relating to receipt of said data packet by said first and second receivers to a router if said first and second receivers require re-transmission of said data packet and

receive an instruction from said router to retransmit said data packet to said first and second receivers.

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