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Sato et al.

(54) CELL STATION, RADIO COMMUNICATION SYSTEM, COMMUNICATION CONTROL METHOD OF CELL STATION, AND METHOD OF BUILDING RADIO COMMUNICATION NETWORK

(76) Inventors: **Hirofumi Sato**, Yokohama (JP); **Tsukasa Sasayama**, Yokohama (JP); **Takeshi Kawashima**, Yokohama (JP); **Koichi Aratani**, Yokohama (JP); **Kenji Yanagi**, Yokohama (JP)

Correspondence Address:
ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-9889 (US)

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(51) **Int. Cl.**[7] **H04J 3/00**

(52) **U.S. Cl.** **370/337**; 370/347

(57) **ABSTRACT**

Traffic that can be processed at a cell station is increased without reducing communication quality. When a channel is allocated to every time slot constituting a communication frame and radio control section receives a link channel establishment request from a personal station through a control channel allocated to any of the time slots, a control section notifies the personal station through the traffic channel of an allocation message indicating that the time slot allocated to the control channel will be allocated to a traffic channel. The transmission of the control channel is stopped when a predetermined time (a control channel transmission/reception duration) passes after the notification of the allocation message.

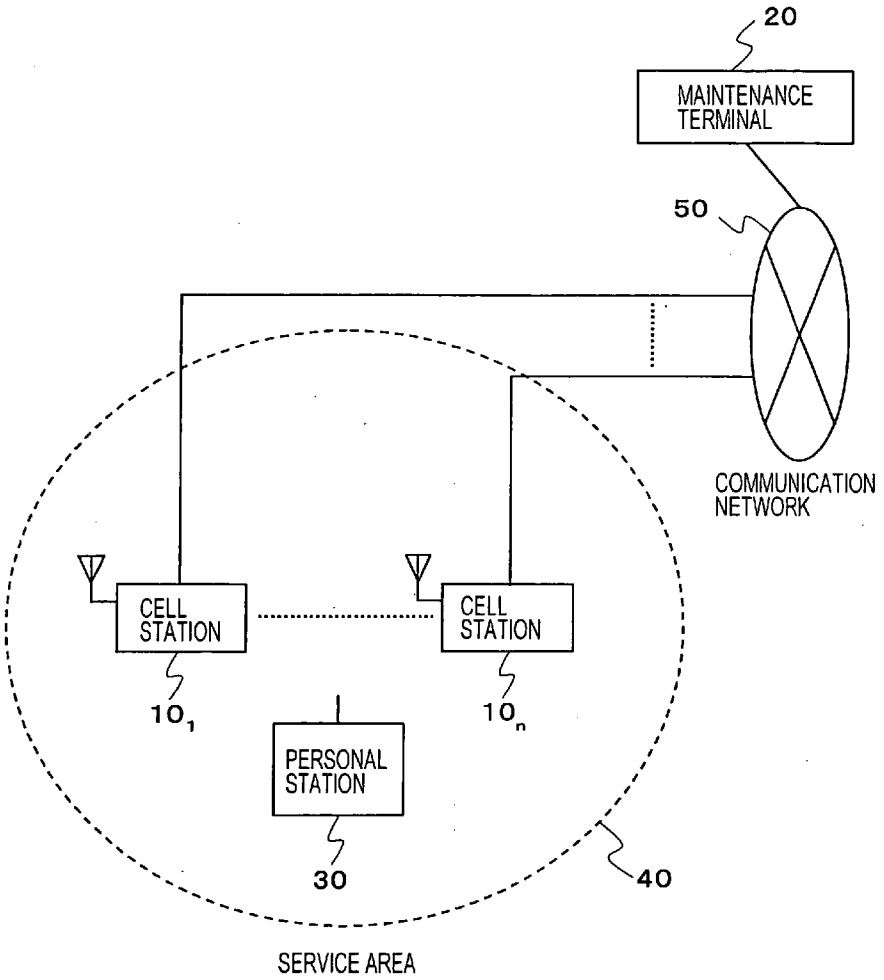


FIG.1

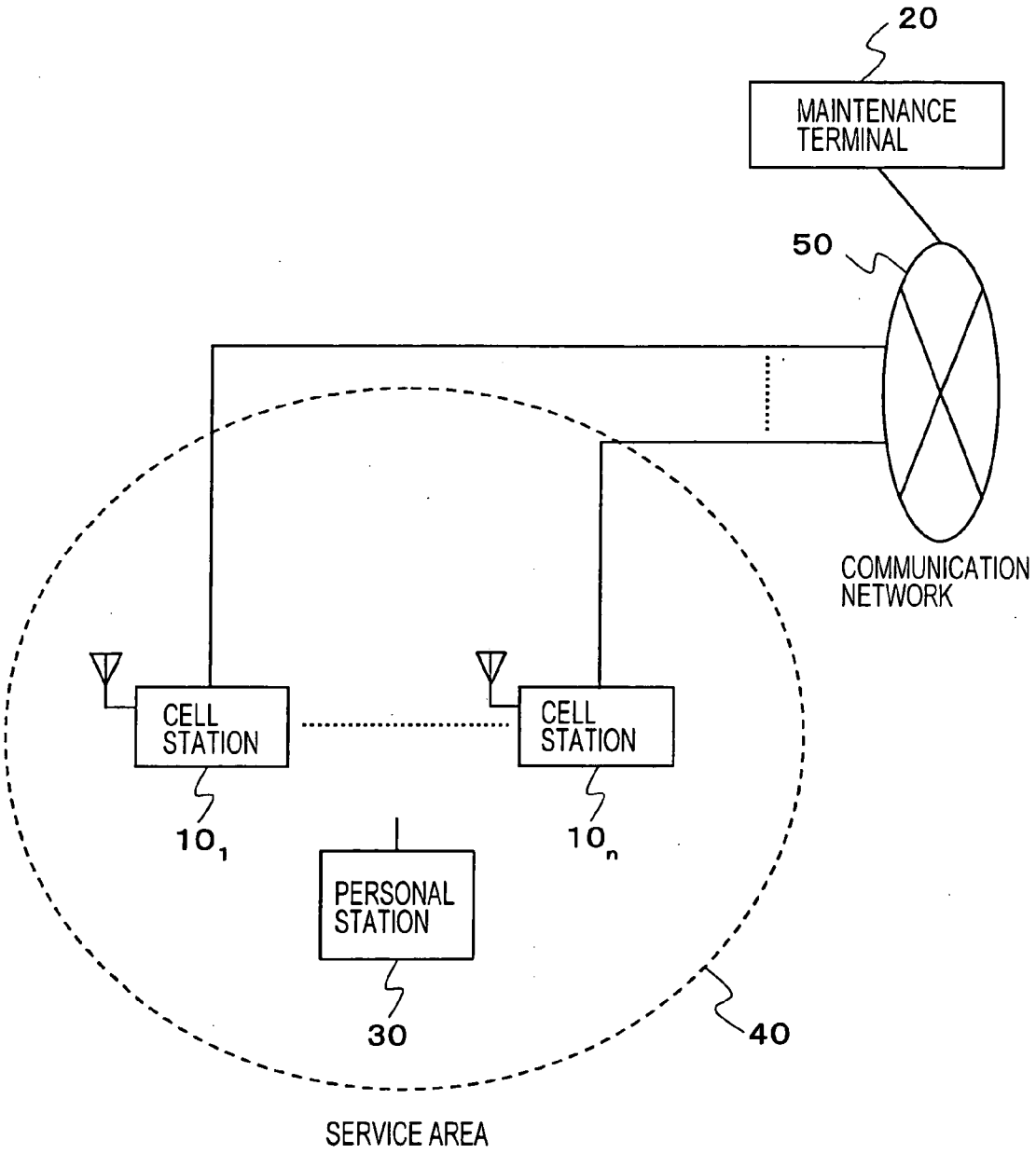

20
MAINTENANCE TERMINAL
50
COMMUNICATION NETWORK
CELL STATION
CELL STATION
10_1
10_n
PERSONAL STATION
30
40
SERVICE AREA

FIG.2

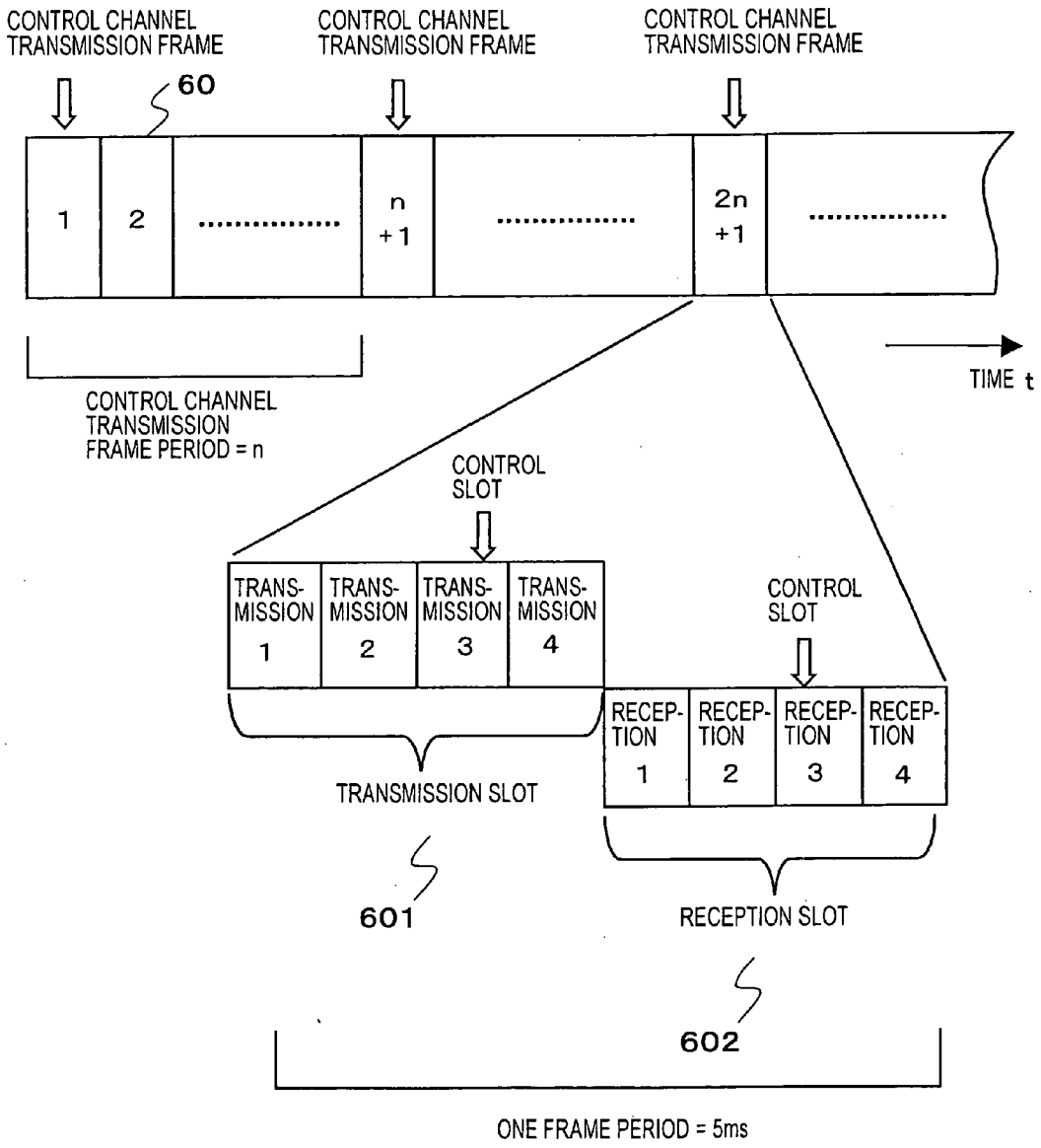

CONTROL CHANNEL TRANSMISSION FRAME
CONTROL CHANNEL TRANSMISSION FRAME
CONTROL CHANNEL TRANSMISSION FRAME
60
1
2
n +1
2n +1
TIME t
CONTROL CHANNEL TRANSMISSION FRAME PERIOD = n
CONTROL SLOT
TRANS-MISSION 1
TRANS-MISSION 2
TRANS-MISSION 3
TRANS-MISSION 4
CONTROL SLOT
RECEP-TION 1
RECEP-TION 2
RECEP-TION 3
RECEP-TION 4
TRANSMISSION SLOT
601
RECEPTION SLOT
602
ONE FRAME PERIOD = 5ms

FIG.3

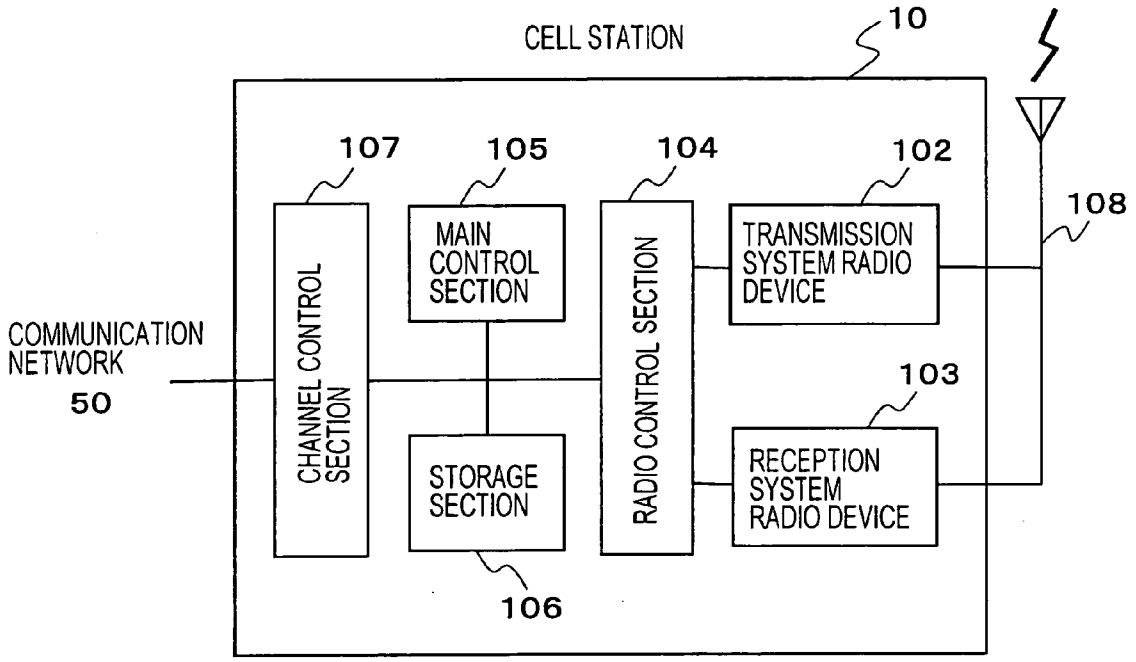

CELL STATION
10
107
105
104
102
108
MAIN CONTROL SECTION
TRANSMISSION SYSTEM RADIO DEVICE
COMMUNICATION NETWORK
50
CHANNEL CONTROL SECTION
RADIO CONTROL SECTION
103
STORAGE SECTION
RECEPTION SYSTEM RADIO DEVICE
106

FIG.4

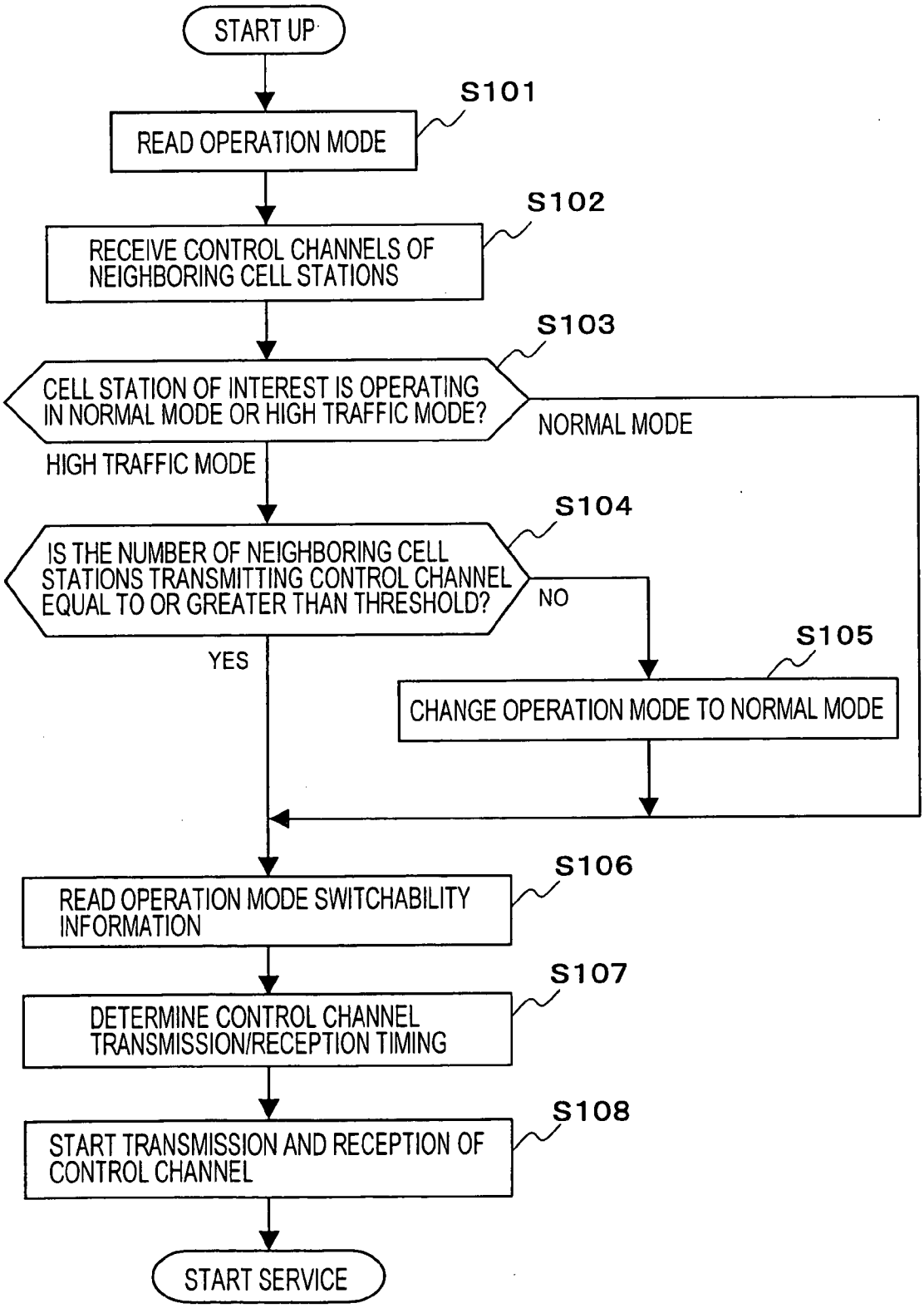

START UP
S101
READ OPERATION MODE
S102
RECEIVE CONTROL CHANNELS OF NEIGHBORING CELL STATIONS
S103
CELL STATION OF INTEREST IS OPERATING IN NORMAL MODE OR HIGH TRAFFIC MODE?
NORMAL MODE
HIGH TRAFFIC MODE
S104
IS THE NUMBER OF NEIGHBORING CELL STATIONS TRANSMITTING CONTROL CHANNEL EQUAL TO OR GREATER THAN THRESHOLD?
NO
YES
S105
CHANGE OPERATION MODE TO NORMAL MODE
S106
READ OPERATION MODE SWITCHABILITY INFORMATION
S107
DETERMINE CONTROL CHANNEL TRANSMISSION/RECEPTION TIMING
S108
START TRANSMISSION AND RECEPTION OF CONTROL CHANNEL
START SERVICE

FIG.5

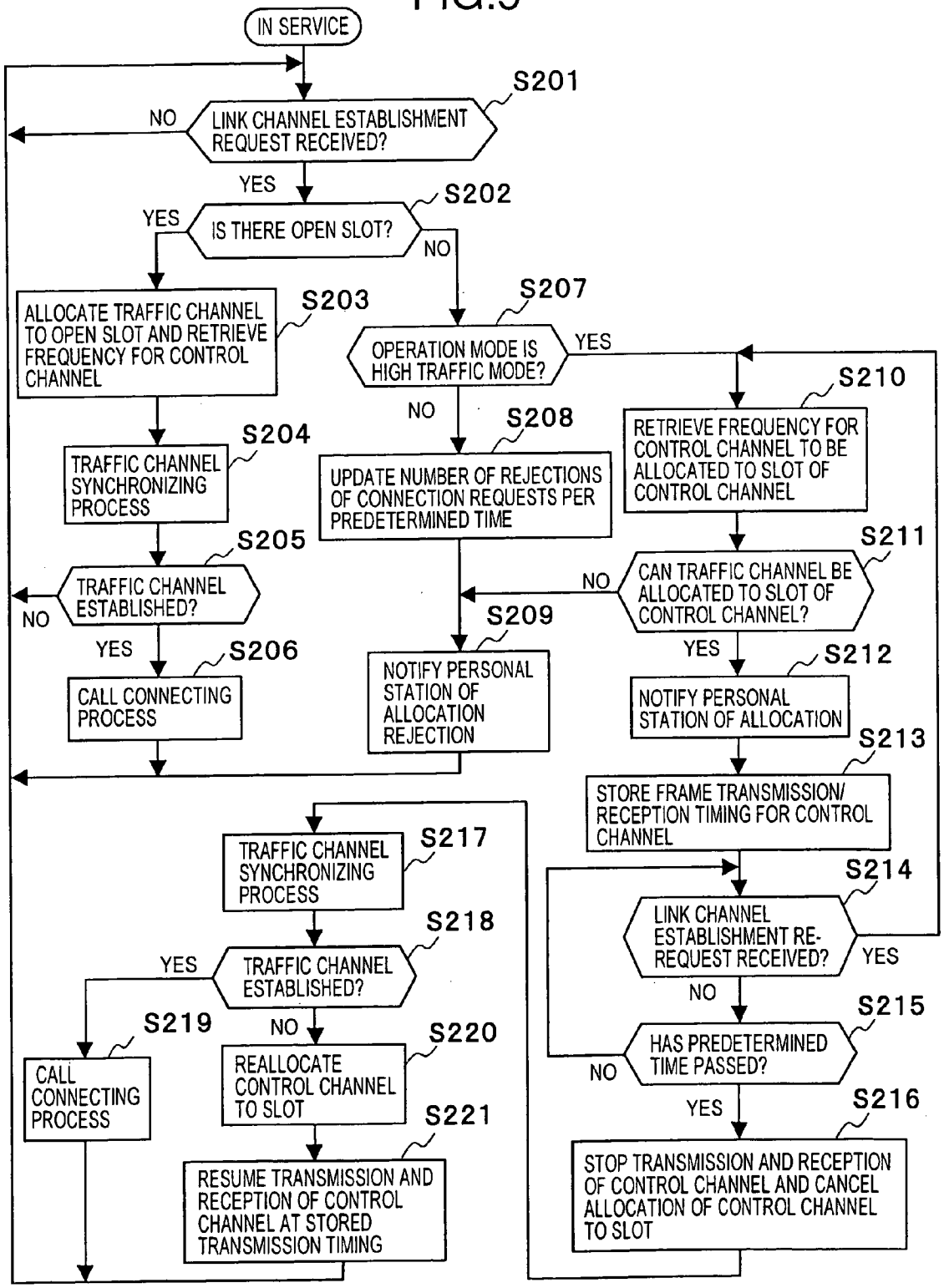

IN SERVICE
S201
LINK CHANNEL ESTABLISHMENT REQUEST RECEIVED?
NO
YES
S202
IS THERE OPEN SLOT?
YES
NO
S203
ALLOCATE TRAFFIC CHANNEL TO OPEN SLOT AND RETRIEVE FREQUENCY FOR CONTROL CHANNEL
S204
TRAFFIC CHANNEL SYNCHRONIZING PROCESS
S205
TRAFFIC CHANNEL ESTABLISHED?
NO
YES
S206
CALL CONNECTING PROCESS
S207
OPERATION MODE IS HIGH TRAFFIC MODE?
YES
NO
S208
UPDATE NUMBER OF REJECTIONS OF CONNECTION REQUESTS PER PREDETERMINED TIME
S209
NOTIFY PERSONAL STATION OF ALLOCATION REJECTION
S210
RETRIEVE FREQUENCY FOR CONTROL CHANNEL TO BE ALLOCATED TO SLOT OF CONTROL CHANNEL
S211
CAN TRAFFIC CHANNEL BE ALLOCATED TO SLOT OF CONTROL CHANNEL?
NO
YES
S212
NOTIFY PERSONAL STATION OF ALLOCATION
S213
STORE FRAME TRANSMISSION/ RECEPTION TIMING FOR CONTROL CHANNEL
S214
LINK CHANNEL ESTABLISHMENT RE-REQUEST RECEIVED?
YES
NO
S215
HAS PREDETERMINED TIME PASSED?
NO
YES
S216
STOP TRANSMISSION AND RECEPTION OF CONTROL CHANNEL AND CANCEL ALLOCATION OF CONTROL CHANNEL TO SLOT
S217
TRAFFIC CHANNEL SYNCHRONIZING PROCESS
S218
TRAFFIC CHANNEL ESTABLISHED?
YES
NO
S219
CALL CONNECTING PROCESS
S220
REALLOCATE CONTROL CHANNEL TO SLOT
S221
RESUME TRANSMISSION AND RECEPTION OF CONTROL CHANNEL AT STORED TRANSMISSION TIMING

FIG.6

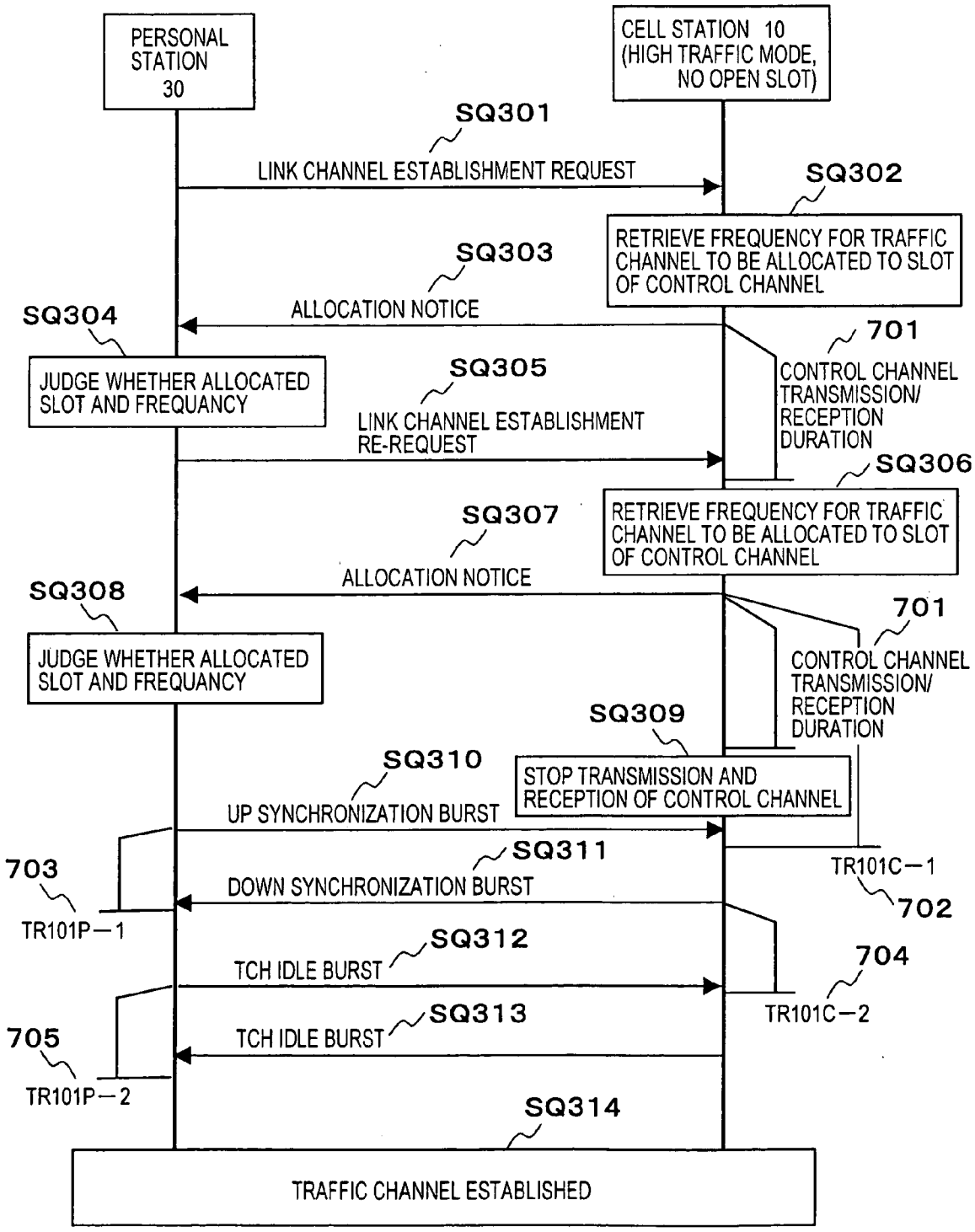

PERSONAL STATION 30
CELL STATION 10 (HIGH TRAFFIC MODE, NO OPEN SLOT)
SQ301
LINK CHANNEL ESTABLISHMENT REQUEST
SQ302
RETRIEVE FREQUENCY FOR TRAFFIC CHANNEL TO BE ALLOCATED TO SLOT OF CONTROL CHANNEL
SQ303
ALLOCATION NOTICE
SQ304
JUDGE WHETHER ALLOCATED SLOT AND FREQUANCY
701
CONTROL CHANNEL TRANSMISSION/ RECEPTION DURATION
SQ305
LINK CHANNEL ESTABLISHMENT RE-REQUEST
SQ306
RETRIEVE FREQUENCY FOR TRAFFIC CHANNEL TO BE ALLOCATED TO SLOT OF CONTROL CHANNEL
SQ307
ALLOCATION NOTICE
SQ308
JUDGE WHETHER ALLOCATED SLOT AND FREQUANCY
701
CONTROL CHANNEL TRANSMISSION/ RECEPTION DURATION
SQ309
STOP TRANSMISSION AND RECEPTION OF CONTROL CHANNEL
SQ310
UP SYNCHRONIZATION BURST
SQ311
DOWN SYNCHRONIZATION BURST
703
TR101P−1
TR101C−1
702
SQ312
TCH IDLE BURST
704
TR101C−2
SQ313
TCH IDLE BURST
705
TR101P−2
SQ314
TRAFFIC CHANNEL ESTABLISHED

FIG.7

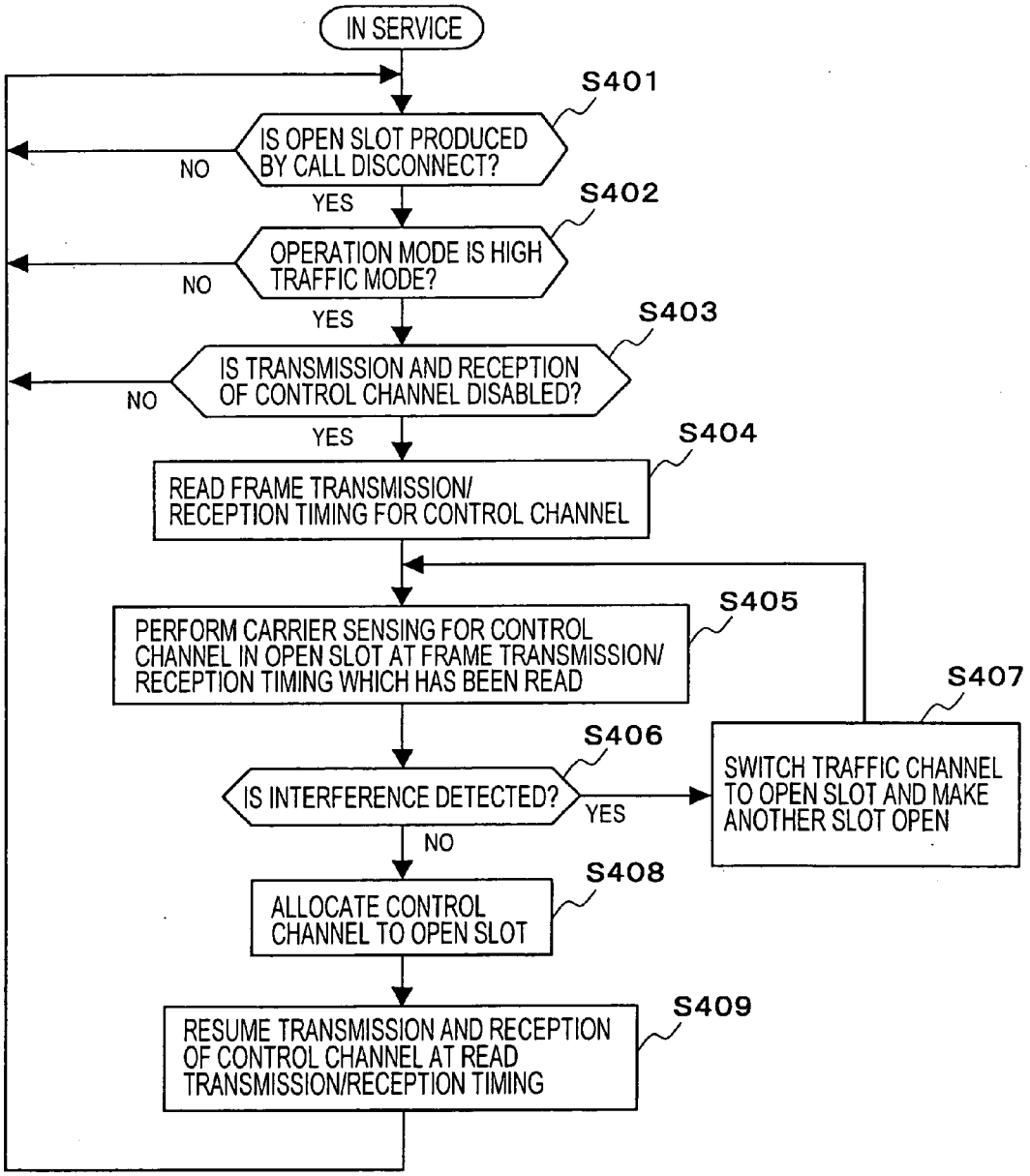

IN SERVICE
S401
IS OPEN SLOT PRODUCED BY CALL DISCONNECT?
NO
YES
S402
OPERATION MODE IS HIGH TRAFFIC MODE?
NO
YES
S403
IS TRANSMISSION AND RECEPTION OF CONTROL CHANNEL DISABLED?
NO
YES
S404
READ FRAME TRANSMISSION/ RECEPTION TIMING FOR CONTROL CHANNEL
S405
PERFORM CARRIER SENSING FOR CONTROL CHANNEL IN OPEN SLOT AT FRAME TRANSMISSION/ RECEPTION TIMING WHICH HAS BEEN READ
S406
IS INTERFERENCE DETECTED?
YES
NO
S407
SWITCH TRAFFIC CHANNEL TO OPEN SLOT AND MAKE ANOTHER SLOT OPEN
S408
ALLOCATE CONTROL CHANNEL TO OPEN SLOT
S409
RESUME TRANSMISSION AND RECEPTION OF CONTROL CHANNEL AT READ TRANSMISSION/RECEPTION TIMING

FIG.8

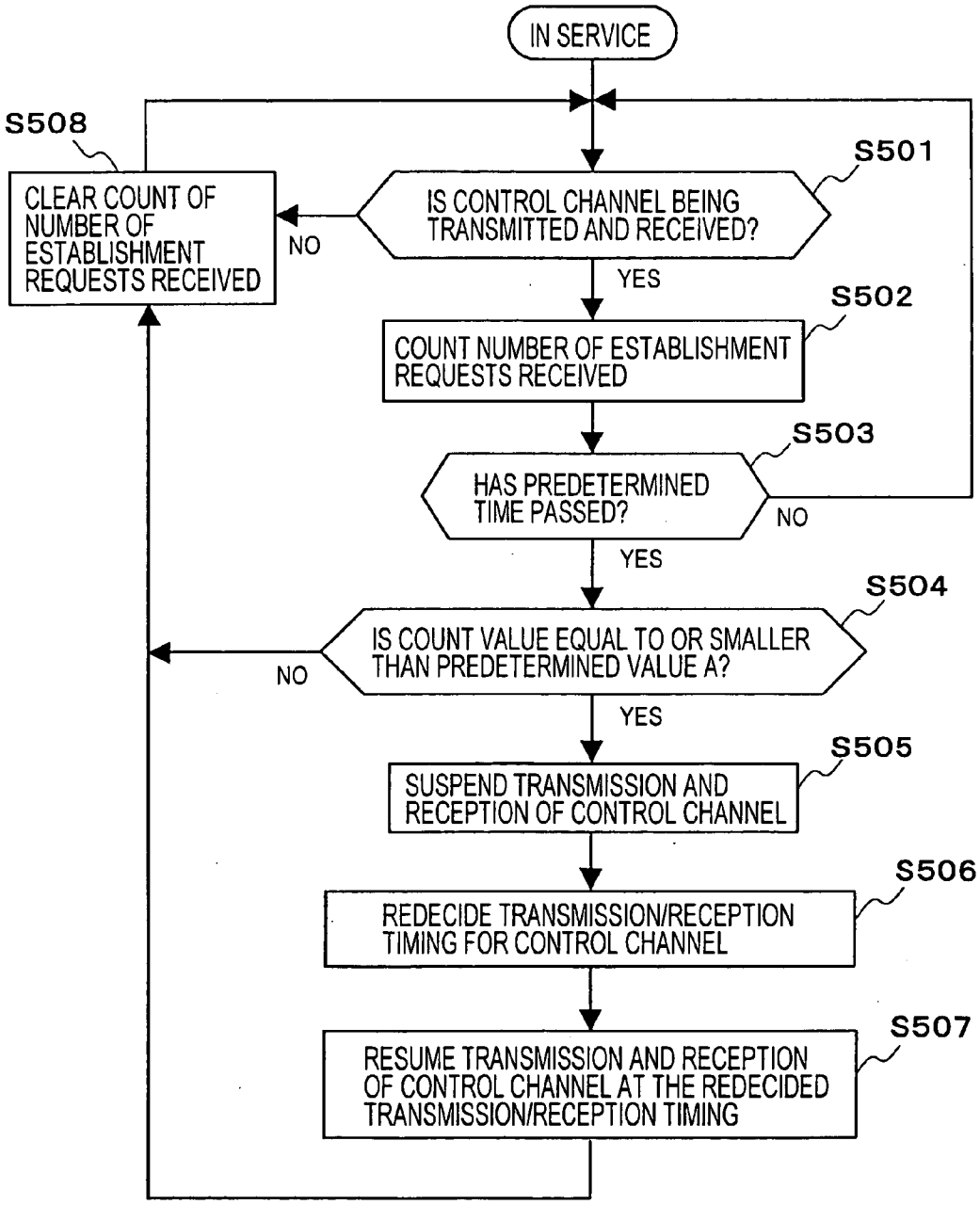
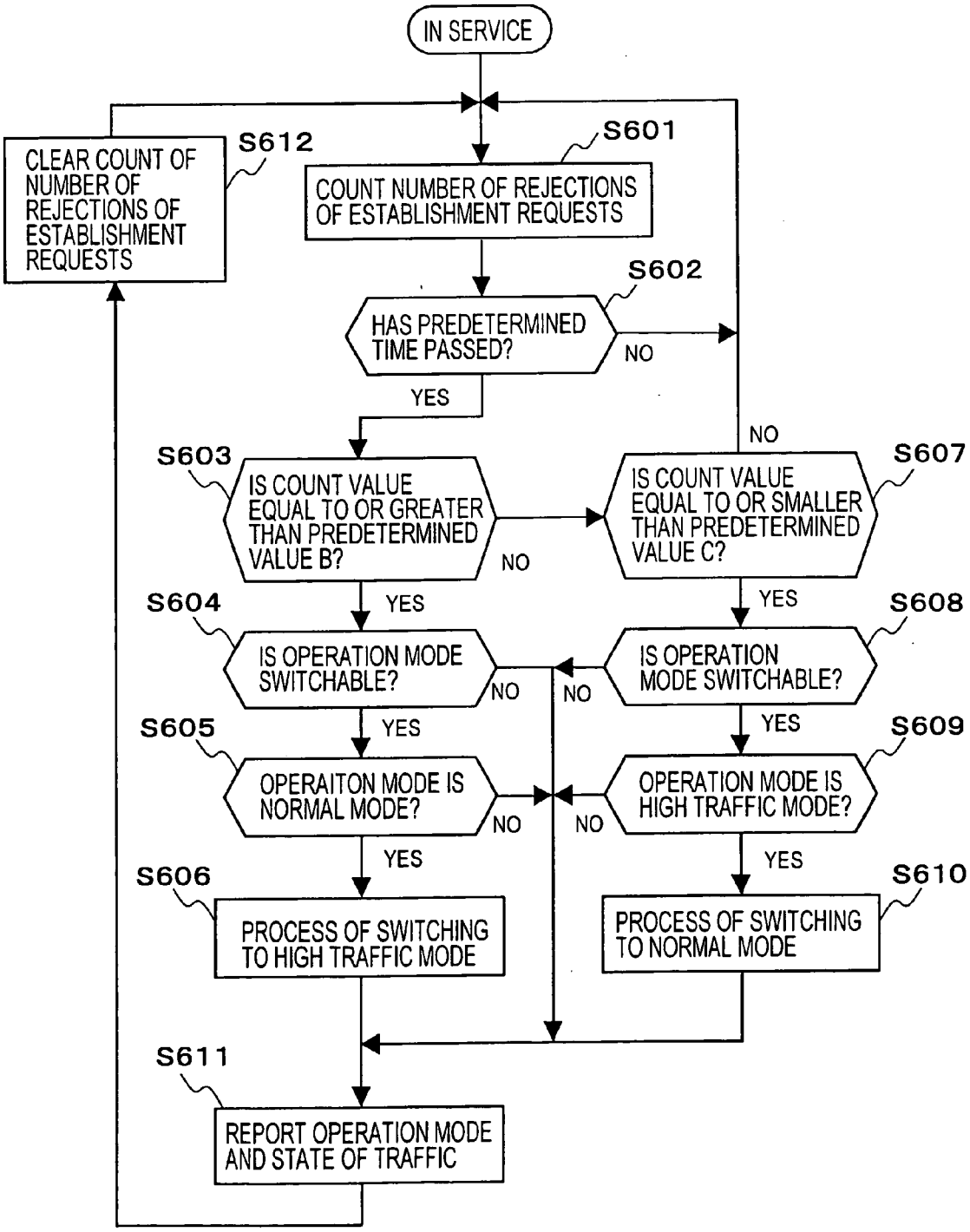

IN SERVICE
S508
CLEAR COUNT OF NUMBER OF ESTABLISHMENT REQUESTS RECEIVED
NO
S501
IS CONTROL CHANNEL BEING TRANSMITTED AND RECEIVED?
YES
S502
COUNT NUMBER OF ESTABLISHMENT REQUESTS RECEIVED
S503
HAS PREDETERMINED TIME PASSED?
NO
YES
S504
IS COUNT VALUE EQUAL TO OR SMALLER THAN PREDETERMINED VALUE A?
NO
YES
S505
SUSPEND TRANSMISSION AND RECEPTION OF CONTROL CHANNEL
S506
REDECIDE TRANSMISSION/RECEPTION TIMING FOR CONTROL CHANNEL
S507
RESUME TRANSMISSION AND RECEPTION OF CONTROL CHANNEL AT THE REDECIDED TRANSMISSION/RECEPTION TIMING

FIG.9


IN SERVICE
S601
COUNT NUMBER OF REJECTIONS OF ESTABLISHMENT REQUESTS
S612
CLEAR COUNT OF NUMBER OF REJECTIONS OF ESTABLISHMENT REQUESTS
S602
HAS PREDETERMINED TIME PASSED?
NO
YES
S603
IS COUNT VALUE EQUAL TO OR GREATER THAN PREDETERMINED VALUE B?
NO
S607
IS COUNT VALUE EQUAL TO OR SMALLER THAN PREDETERMINED VALUE C?
NO
YES
YES
S604
IS OPERATION MODE SWITCHABLE?
NO
S608
IS OPERATION MODE SWITCHABLE?
NO
YES
YES
S605
OPERAITON MODE IS NORMAL MODE?
NO
S609
OPERATION MODE IS HIGH TRAFFIC MODE?
NO
YES
YES
S606
PROCESS OF SWITCHING TO HIGH TRAFFIC MODE
S610
PROCESS OF SWITCHING TO NORMAL MODE
S611
REPORT OPERATION MODE AND STATE OF TRAFFIC

CELL STATION, RADIO COMMUNICATION SYSTEM, COMMUNICATION CONTROL METHOD OF CELL STATION, AND METHOD OF BUILDING RADIO COMMUNICATION NETWORK

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a communication control technique and, more particularly, a technique for accommodating personal stations by using the time division multiple access method.

[0002] For example, one communication control technique for accommodating personal stations by using the time division multiple access method is the personal handyphone system defined in "Second Generation Cordless Telephone system RCR STD-28", issued by Research & Development Center for Radio System. Japanese Patent Laid-Open Publication No. H10-136438 (hereinafter referred to as Patent Document 1) is disclosed a technique for accommodating a greater number of personal stations in such a radio communication system using the time division multiple access method.

[0003] Referring to Patent Document 1, in the case that, when a channel is allocated to every time slot constituting frames transmitted and received, a cell station receives a link channel establishment request from a personal station through a control channel allocated to any time slot when a channel is allocated to every time slot constituting frames transmitted and received, the cell station stops transmission of the control channel and allocates a time slot which has been allocated to the control channel to a traffic channel. Thus, a greater number of personal stations are accommodated.

[0004] Referring again to Patent Document 1, before a cell station starts the service, the cell station checks from an identifier set for itself whether the cell station can operate in both of a first mode in which a control channel is always allocated to any time slot constituting a frame and a second mode in which traffic channels can be allocated to all of time slots constituting a frame. When it can operate in both modes, the cell station obtains identifiers informed from other cell stations located in the neighborhood and checks whether there is any cell station operating only in the first mode among those cell stations. The cell station sets itself for operations in the second mode only when such a cell station exists and sets itself for operations in the first mode when no such cell station exists. Such an arrangement prevents a situation wherein all cell stations belonging to the same service area stop transmission over the control channel and personal stations in a ready state are handled as location being outside the area.

SUMMARY OF THE INVENTION

[0005] However, the technique disclosed in Patent Document 1 has the following problems.

[0006] Let us assume that a time slot for a control channel is allocated to a traffic channel of a certain personal station. In the case that the personal station cannot recognize the allocated traffic channel as a result of carrier sensing, the personal station transmits a re-request for allocation to the cell station. However, according to the technique disclosed in Patent Document 1, the re-request for allocation cannot be received because the cell station has already stopped transmission and reception of the control channel. As a result, the personal station continues transmitting the re-request for allocation until the personal station becomes in a ready state for another cell station, and a call to the personal station may not be connected.

[0007] Let us assume that, in the case that time slots constituting a frame which have been allocated to respective traffic channels at a cell station, a call is terminated and an open slot is produced. In this case, carrier sensing for the control channel is performed in the open slot, and the control channel is allocated to the open slot after it is confirmed that there is no interference. However, when a plurality of cell stations in the same service area perform such an allocating process, a plurality of cell stations can transmit and receive the control channel at close timing. In this case, interference can be detected during the carrier sensing for the control channel because of time lags in transmitting and receiving the time slot attributable to an error in the operating clock of each of the cell stations, and the control channel may not be allocated to the open slot. This results in call loss and a reduction in the traffic. No consideration to such a situation is reflected in the technique disclosed in Patent Document 1.

[0008] Before starting a service, the cell station decides a mode of operation, i.e., a first mode in which a control channel is always allocated to any of time slots that constitute a frame or a second mode in which a traffic channel can be allocated to every time slot constituting a frame. However, the mode of operation decided prior to the operation may not be appropriate for an actual traffic. No consideration to this point is reflected in the technique disclosed in Patent Document 1.

[0009] The present invention is made taking the above-described situations into consideration, and it is an object of the present invention to improve the traffic that can be processed at a cell station without any reduction in communication quality.

[0010] In order to solve the above-described problems, in a first aspect of a cell station according to the present invention, when a time slot for a control channel is allocated to a traffic channel of a certain personal station and the personal station cannot recognize the allocated traffic channel, the cell station can receive a re-request for allocation transmitted by the personal station.

[0011] For example, a cell station in this aspect of the present invention is a cell station accommodating a personal station by using a time division multiple access method including communication unit which transmits and receives a frame including a plurality of time slots and control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame. In the case that a channel is allocated to every time slot constituting the frame, when the communication unit receives a link channel establishment request from the personal station through the control channel allocated to any of the time slots, the control unit notifies the personal station through the control channel that the time slot allocated to the control channel will be allocated to a traffic channel and stops transmission and reception of the control channel when a predetermined time passes after the notice.

[0012] In a second aspect of a cell station according to the present invention, when a time slot which has been allocated

to a traffic channel is to be allocated to a control channel, the control channel is allocated to the time slot at timing for transmitting and receiving a frame including the control channel which has been registered in advance. The frame transmission/reception timing registered in advance is timing at which no interference has been detected as a result of carrier sensing for the control channel.

[0013] For example, a cell station in this aspect of the present invention is a cell station accommodating a personal station by using a time division multiple access method, including communication unit which transmits and receives a frame including a plurality of time slots, control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame, and timing storing unit which stores timing for transmitting and receiving a frame including the control channel. In the case that a traffic channel is allocated to every time slot constituting the frame, when any of the traffic channels is disconnected to make a time slot open, the control unit controls the communication unit such that the control channel is transmitted and received in the time slot which has become open in a frame transmitted and received at the timing.

[0014] In a third aspect of a cell station according to the present invention, when traffic is reduced, the cell station judges that there is call loss attributable to interference with control channels of other cell stations, and adjusts a timing for transmitting and receiving a frame including the control channel is adjusted.

[0015] For example, a cell station in this aspect of the present invention is a cell station accommodating a personal station by using a time division multiple access method, including communication unit which transmits and receives a frame including a plurality of time slots, control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame, and traffic monitoring unit which monitors communication traffic. The control unit performs carrier sensing for the control channel in a time slot to which the control channel is allocated according to results of the monitoring by the traffic monitoring unit and adjusts timing for transmitting and receiving a frame including the control channel.

[0016] In a fourth aspect of a cell station according to the present invention, the cell station automatically switches an operation mode decided before service is started according to actual traffic.

[0017] For example, a cell station in this aspect of the present invention is a cell station accommodating a personal station by using a time division multiple access method, including communication unit which transmits and receives a frame including a plurality of time slots, control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame, and traffic monitoring unit which monitors communication traffic. The control unit operates in either of a first mode in which the control channel is always allocated to at least one of the time slots constituting the frame and a second mode in which a traffic channel can be allocated to every time slot constituting the frame, and switches the operation mode according to results of the monitoring by the traffic monitoring unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a schematic diagram of a radio communication system to which an embodiment of the present invention is applied;

[0019] **FIG. 2** shows an example of a format of communication frames transmitted and received between a cell station **10** and a personal station **30**;

[0020] **FIG. 3** is a schematic configuration diagram of the cell station **10**;

[0021] **FIG. 4** is a flow chart for explaining an operation of a main control section **105** performed when the cell station **10** is started up;

[0022] **FIG. 5** is a flow chart for explaining a process of canceling allocation of a control channel to a time slot performed by the main control section **105** at a call connecting process;

[0023] **FIG. 6** is a sequence diagram showing a flow of processes until a traffic channel is established between the cell station **10** whose operation is set in a high traffic mode and the personal station **30**;

[0024] **FIG. 7** is a flow chart for explaining a process of reallocating a control channel to a time slot performed by the main control section **105** at a call disconnecting process;

[0025] **FIG. 8** is a flow chart for explaining a process of adjusting transmission/reception timing for a communication frame **60** carrying a control channel performed by the main control section **105**; and

[0026] **FIG. 9** is a flow chart for explaining an operation mode switching process performed by the main control section **105**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0027] A preferred embodiment of the present invention will now be described.

[0028] **FIG. 1** is a schematic diagram of a radio communication system to which an embodiment of the present invention is applied.

[0029] For example, the radio communication system according to the present embodiment is a personal handyphone system as defined in "Second Generation Cordless Telephone System RCR STD-28" issued by Research & Development Center for Radio System, and it is used in a service area having a high traffic such as a flourishing town. As illustrated, the system is configured by connecting a plurality of cell stations **101** to $\mathbf{10}_n$ (hereinafter also simply referred to as cell stations **10**) and a maintenance terminal **20** which monitors the states of operation of the cell stations **10** through a communication network **50** such as a PSTN (Public Switched Telephone Network)

[0030] The cell stations **10** accommodate a personal station **30** by using the time division multiple access method. A plurality of the cell station **10** forms a service area **40** in which the personal station **30** can communicate with the communication network **50**. Although only one personal station **30** is shown in **FIG. 1**, it is obvious that there may be a plurality of personal stations **30**.

[0031] For example, the personal station **30** selects a cell station **10** in a good environment for communication based on receiving condition of a control channel transmitted by each of the cell stations **10**. It performs communication by transmitting and receiving communication frames to and from the selected cell station **10**.

[0032] **FIG. 2** shows an example of a format of communication frames transmitted and received between the cell station **10** and the personal station **30**. As illustrated, the cell station **10** performs communication by sequentially transmitting and receiving communication frames **60** formed by a plurality of time slots to and from the personal station **30**. A communication frame **60** has a plurality of transmission slots **601** which are transmitted from the cell station **10** to the personal station **30** and a plurality of reception frames **602** which are received by the cell station **10** from the personal station **30**. The transmission slots **601** and the reception slots **602** are equal in quantity. For example, in the case of a personal handyphone system as described above, a communication frame **60** is formed by eight time slots in total, i.e., four transmission slots **601** and four reception slots **602**, and it has a frame period of 5 ms.

[0033] The cell stations **10** of the present embodiment operate in either of a first mode in which a pair of a transmission slot **601** and a reception slot **602** in a communication frame **60** is always allocated to a control channel (referred to as normal mode) and a second mode in which all time slots in a communication frame **60** can be allocated to the traffic channel (referred to as high traffic mode). By way of example, **FIG. 2** shows a case in which a pair of a transmission slot (a third transmission slot) **601** and a reception slot (a third reception slot) **602** in a communication frame **60** is allocated to the traffic channel. It is not essential that the traffic channel is stored in each of the communication frames **60**. The control channel may be transmitted or received by storing the control channel in a predetermined transmission slot **601** and/or a predetermined reception slot **602** of communication frames **60** which are transmitted and received at an arbitrary frame period. In the example shown in **FIG. 2**, the frame period of a control channel transmission frame for transmission of the control channel from the cell station **10** to the personal station **30** comes at every 5n-th (n is a natural number, e.g., 20) frame.

[0034] The cell station **10** will be described in detail. An existing personal station such as a personal handyphone system that communicates with the cell station **10** by using the time division multiple access method may be used as the personal station **30**. The maintenance terminal **20** is a common terminal which manages and outputs various kinds of information transmitted thereto from the cell station **10**. Therefore, no detailed description is given on the personal station **30** and the maintenance terminal **20**.

[0035] **FIG. 3** is a schematic configuration diagram of the cell station **10**.

[0036] As illustrated, the cell station **10** has a transmission system radio device **102**, a reception system radio device **103**, a radio control section **104**, a main control section **105**, a storage section **106**, a channel control section **107**, and an antenna **108**. For example, the cell station **10** of the present embodiment is realized through the execution of a program in a memory by a CPU of an information processing apparatus which has the CPU, the memory, a communication device, and a radio communication device. In this case, the memory is used as the storage section **106**.

[0037] The transmission system radio device **102** performs a predetermined modulation process on transmission slots **601** received from the radio control section **104** and transmits them from the antenna **108**. The reception system radio device **103** performs a predetermined demodulation process on signals received by the antenna **108** to restore reception slots **602** and passes the reception slot **602** thus restored to the radio control section **104**. The radio control section **104** transmits and receives communication frames **60** to and from the personal station **30** through the transmission system radio device **102** and the reception system radio device **103**. The channel control section **107** transmits and receives communication data and control data to and from the communication network **50** according to a communication protocol adopted by the communication network **50**. Various kinds of information (such as the operation mode of the cell station **10**, information on whether the operation mode can be switched or not, and a threshold for operation mode switching) to be used by the main control section **105** are stored in the storage section **106**. The main control section **105** controls operations of the cell station **10** as a whole.

[0038] Specifically, the main control section **105** transmits and receives call control data to and from the communication network **50** through the channel control section **108**. Whereby the main control section **105** performs a call control process to establish a channel to the communication network **50**. The main control section **105** also transmits and receives call control data to and from the personal station **30** through the radio control section **104** using transmission slots **601** for transmitting a control channel and reception slots **602** for receiving the control channel. Thus, a call control process is performed to allocate a traffic channel with the personal station **30** to a pair of a transmission slot **601** and a reception slot **602** of a communication frame **60** to establish a radio channel to the personal station **30**. Timing for a control channel transmission frame is instructed by the main control section **105** to the radio control section **104**. According to the instruction from the main control section **105**, the radio control section **104** stores call control data in a predetermined transmission slot of the control channel transmission frame and transmits the control channel transmission frame by using the transmission system radio device **102**. The main control section **105** also exchanges communication data transmitted and received through the channel established between the channel control section **108** and the communication network **50** and communication data transmitted and received through the radio channel established between the radio control section **104** and the personal station **30**. Whereby, the personal station **30** is connected to the communication network **50**. The main control section **105** also receives information on the control channel transmitted by other cell stations **10** through the reception system radio device **103**.

[0039] In addition to the above-described processes, the main control section **105** performs a process for increasing the traffic that can be processed by the cell station **10** without reducing communication quality.

[0040] First, the main control section **105** decides the operation mode (either of the normal mode and high traffic

mode) when the cell station **10** is started up (initial operation). **FIG. 4** is a flow chart for explaining the operation of the main control section **105** performed when the cell station **10** is started up.

[**0041**] The main control section **105** sets an operation mode by reading operation mode identification information for the cell station **10** which has been set by an operator and stored in advance in the storage section **106** (step S**101**). The main control section **105** receives control channel information transmitted by other cell stations **10** located in the neighborhood of own cell station **10** through the reception system radio device **103** and the radio control section **104** and stores the information in the storage section **106** (step S**102**).

[**0042**] Next, the main control section **105** judges which of the normal mode and the high traffic mode has been set (step S**103**). When the normal mode has been set, the process proceeds to step S**106**. When the high traffic mode has been set, it is checked whether the number of cell stations **10** transmitting the control channel stored in the storage section **106** is equal to or greater than a threshold which has been set by the operator and stored in advance in the storage section **106** (step S**104**). When the number is equal to or greater than the threshold, the process proceeds to step S**106**. When the number is not equal to or greater than the threshold, the main control section **105** changes the operation mode setting from the high traffic mode to the normal mode (step S**105**), and then the process proceeds to step S**106**.

[**0043**] Next, at step S**106**, the main control section **105** reads operation mode switchability information for own cell station **10** which has been set by the operator and stored in advance in the storage section **106** and makes a setting accordingly. The main control section **105** then performs carrier sensing to determine slots to be allocated to the control channel and frame transmission/reception timing such that no interference with control channels of the other cell stations **10** occurs (step S**107**). Since existing techniques are used for determining slots to be allocated to a control channel and frame transmission/reception timing through carrier sensing, no detailed description will be made in this regard.

[**0044**] When slots to be allocated to the control channel and frame transmission/reception timing are determined as described above, the main control section **105** controls the radio control section **104** such that communication frames having control channel information stored in the allocated slots thereof are transmitted and received at the frame transmission/reception timing (step S**108**). Then, the operation of the cell station **10** is started.

[**0045**] When the flow shown in **FIG. 4** terminates and the cell station **10** enters an operating state, the main control section **105** performs a process of canceling the allocation of time slots to the control channel and a process of reallocating time slots to the control channel according to the operation mode which has been set, the operation mode switchability information, and the state of occupation of time slots that constitute a communication frame **60**.

[**0046**] **FIG. 5** is a flow chart for explaining the process of canceling the allocation of time slots to the control channel that is performed by the main control section **105** at a call connecting process.

[**0047**] First, when a link channel establishment request is received from the personal station **30** through a communication frame **60** for transmitting and receiving the control channel (YES at step S**201**), the main control section **105** checks whether there is a pair of open slots (a transmission slot **601** and a reception slot **602**) in the communication frame **60** transmitted and received by the radio control section **104** (step S**202**).

[**0048**] When it is found at step S**202** that a pair of open slots exists, the main control section **105** allocates the traffic channel of the personal station **30** which has transmitted the link channel establishment request to the pair of open slots and performs carrier sensing in the open slots to determine the frequency of the traffic channel (step S**203**). The main control section **105** then performs a process of synchronizing the traffic channel between the personal station **30** which has transmitted the link channel establishment request (step S**204**) and own cell station **10**. When the synchronization process is successful and the traffic channel is established (YES at step S**205**), the traffic channel synchronizing process is followed by a call control process (step S**206**) that is performed between the personal station **30** and own cell station **10** to establish a radio channel to the personal station **30**. The process then returns to step S**201**. When the synchronizing process fails and the traffic channel is not established (NO at step S**205**), the process returns to step S**201**.

[**0049**] When there is no pair of open slots at step S**202** or when a traffic channel or control channel has been allocated to every time slot constituting the communication frame **60**, the main control section **105** checks whether the operation mode set for itself in the flow shown in **FIG. 4** is the high traffic mode (step S**207**).

[**0050**] When it is found at step S**207** that the operation mode is not the high traffic mode or when the operation mode is the normal mode, the main control section **105** increments the value in a counter which is, for example, automatically reset when a predetermined time passes to update the number of rejections of link establishment requests per the predetermined time (step S**208**). Then, the main control section **105** notifies the personal station **30** of the rejection of the link establishment request through the communication frame **60** for the transmission and reception of the control channel (step S**209**), and the process thereafter returns to step S**201**.

[**0051**] When it is found at step S**207** that the operation mode is the high traffic mode, the main control section **105** performs carrier sensing in the time slots to which the control channel is allocated to retrieve frequencies for traffic channels (step S**210**). When the carrier sensing reveals that interference occurs at any frequency that traffic channels can use in the time slots to which the control channel is allocated and that no traffic channel can be allocated to the times lots (NO at step S**211**), the main control section **105** notifies the personal station **30** of there jection of time slot allocation through the communication frame **60** for transmitting and receiving the control channel (step S**209**), and the process thereafter returns to step S**201**. On the contrary, when a frequency that traffic channels can use is detected in the time slots to which the control channel is allocated as a result of the carrier sensing (YES at step S**211**), the main control section **105** notifies the personal station **30** of the allocation of time slots through the communication frame **60** for transmitting and receiving the control channel (step S**212**).

[0052] After notifying the personal station **30** of the time slot allocation, the main control section **105** stores the timing of transmission and reception of the communication frame **60** for transmitting and receiving the control channel at the radio control section **104** in the storage section **106** (step S**213**). Then, it waits for transmission of a re-request for link channel establishment from the personal station **30** (steps S**214** and S**215**) for a predetermined time. The predetermined time is set such that it is longer than an estimated time until the reception of the re-request for link channel establishment when the request is sent as a response of the personal station **30** to the allocation notice and such that it is shorter than an estimated time until the reception of an up synchronization burst signal when the signal is transmitted as the response. This makes it possible to process either of a link channel establishment re-request and an up synchronization burst signal using the same time slot.

[0053] When a link channel establishment re-request is sent from the personal station **30** within the predetermined time (YES at step S**214**), the process returns to step S**210** to continue the retrieval of frequencies for traffic channels. On the contrary, when no link channel establishment re-request is sent from the personal station **30** within the predetermined time (YES at step S**215**, in which case an up synchronization burst signal is sent as a response of the personal station **30** to the allocation notice), the main control section **105** causes the radio control section **104** to stop transmitting and receiving the control channel and cancels the allocation of the control channel to time slots (step S**216**). Then, it instructs the radio control section **104** to perform a traffic channel synchronizing process according the time slot and frequency allocated to the personal station **30** (step S**217**). Whereby, the radio control section **104** performs a traffic channel synchronizing process by exchanging synchronization burst signals with the personal station **30** through the transmission system radio device **102** and the reception system radio device **103**.

[0054] When the synchronizing process at step S**217** is successful and a traffic channel is established (YES at step S**218**), the main control section **105** performs a call control process with the personal station **30** to establish a radio channel (S**219**). On the contrary, when the synchronizing process at step S**217** fails and no traffic channel is established (NO at step S**218**), the main control section **105** re-allocates the control channel to the time slots for which control channel allocation has been canceled (step S**220**). Then, the main control section **105** reads the timing for transmission and reception of the communication frame **60** for transmitting and receiving the control channel stored in the storage section **106** and causes the radio control section **104** to resume transmission and reception of the communication frame **60** for transmitting and receiving the control channel at the timing for transmission and reception (step S**221**).

[0055] **FIG. 6** is a sequence diagram showing a flow of the process performed until a traffic channel is established between the cell station **10** whose operation mode is set to the high traffic mode and the personal station **30**. It is assumed that there is no open slot in communication frames **60** transmitted and received by the cell station **10**.

[0056] First, the personal station **30** transmits a link channel establishment request message to the cell station **10** (step SQ**301**). Upon receipt of the link channel establishment request message, the cell station **10** performs step S**210** in **FIG. 5** because there is no open slot in the communication frames **60** transmitted and received by itself and the high traffic mode is set as the operation mode. That is, the time slot to which the control channel is allocated is chosen as a time slot to be allocated to the traffic channel, and carrier sensing is performed in the time slot to retrieve frequencies for traffic channels (step SQ**302**). Then, an allocation message including specification of the allocated times lot and frequency is transmitted to the personal station **30** (step SQ**303**).

[0057] When the allocation message from the cell station **10** is received, the personal station **30** performs carrier sensing according to the time slot and frequency specified by the allocation message to check whether the time slot and frequency can be used as a traffic channel (SQ**304**). When they cannot be used because of reasons such as interference, a link channel establishment re-request message is transmitted to the cell station **10** (step SQ**305**).

[0058] The cell station **10** receives the link channel establishment re-request message transmitted by the personal station **30** within a predetermined time (a control channel transmission/reception duration **701**) after the transmission of the allocation message in the processes at steps S**214** and S**215** shown in **FIG. 5**. The cell station **10** then performs step S**210** in **FIG. 5** to re-retrieve frequencies for traffic channels (step SQ**306**) and transmits an allocation message including specification of a time slot and a frequency to be allocated to the personal station **30** again (step SQ**307**) Upon receipt of the allocation message again from the cell station **10**, the personal station **30** performs a process similar to step SQ**304** to check whether the time slot and frequency specified by the allocation message can be used as a traffic channel (step SQ**308**). When they can be used, it transmits an up synchronization burst signal to the cell station **10** using the time slot and frequency (step SQ**310**).

[0059] Since the cell station **10** has not received the link channel establishment re-request message transmitted by the personal station **30** within the control channel transmission/reception duration **701** after the transmission of the allocation message in the processes at steps S**214** and S**215** shown in **FIG. 5**, it performs the process at step S**216** in **FIG. 5** to stop transmission and reception of the control channel and to cancel the allocation of the control channel to a time slot (step SQ**309**). Thereafter, it receives an up synchronization burst signal transmitted by the personal station **30**.

[0060] In the case of the above-described personal handyphone system, the personal station **30** transmits the up synchronization burst signal before time-out of an up synchronization burst signal waiting timer (TR101C-1) **702** which is started after the transmission of the allocation message at the cell station **10**. The time-out comes 100 ms after the timer is started. Upon receipt of the allocation message, the personal station **30** performs carrier sensing in four communication frames **60**. Since a communication frame **60** of the above-described personal handyphone system is 5 ms, the carrier sensing is performed for **20** ms. Therefore, the timing of transmission of the link channel establishment re-request message from the personal station **30** comes at least **20** ms after the reception of the allocation message. When no allocation message is received from the

cell station **10**, the personal station **30** transmits another link channel establishment request message again 1200 ms after the transmission of the message requesting link channel establishment request message. This process is repeated up to three times.

[**0061**] Therefore, in the case of the personal handyphone system described above, the control channel transmission/reception duration **701** is set taking those points into consideration. Specifically, the duration is to start 1200 ms after the transmission of a link establishment request message and to end within a time range between 20 ms and 100 ms after the transmission of an allocation message. The duration is to be longer than an estimated time until the reception of a re-request for link channel establishment re-request message at the cell station **10** when the link channel establishment re-request message is sent as a response of the personal station **30** to the allocation message. The duration is to be shorter than an estimated time until the reception of an up synchronization burst signal at the cell station **10** when the up synchronization burst signal is transmitted as the response of the personal station **30** to the allocation message.

[**0062**] When the cell station **10** receives the up synchronization burst signal before the time-out of the up synchronization burst signal waiting timer **702**, it transmits a down synchronization burst signal to the personal station **30** (step SQ**311**). When the personal station **30** receives the down synchronization burst signal before time-out of a down synchronization burst signal waiting timer (TR101P-1) **703** which is started after the transmission of the up synchronization burst signal (the time out comes 100 ms after the timer is started), it transmits a TCH (traffic channel) idle burst signal to the cell station **10** (step SQ**312**). When the cell station **10** receives the TCH idle burst signal before time-out of a TCH idle burst signal waiting timer (TR101C-2) **704** which is started after the transmission of the down synchronization burst signal, it transmits a TCH idle burst signal to the personal station **30** (step SQ**313**). When the personal station **30** receives the TCH idle burst signal before time-out of a TCH idle burst signal waiting timer (TR101P-2) **705** which is started after the transmission of the TCH idle burst signal, a traffic channel is established (step SQ**314**).

[**0063**] **FIG. 7** is a flow chart for explaining a process of reallocating the control channel to a time slot that is performed by the main control section **105** at a call disconnect process.

[**0064**] When the radio control section **104** receives a call disconnect message from a certain personal station **30** through a traffic channel, the main control section **105** transmits the call disconnect message to the communication network **50** through the channel control section **107** and cancels the allocation of the traffic channel to a time slot is cancelled. When the cancellation of the allocation of the traffic channel to a time slot results in any open slot in communication frames **60** transmitted and received by the radio control section **104** through the transmission system radio device **102** and the reception system radio device **103** (YES at step S**401**), the main control section **105** checks whether the operation mode set for itself is the high traffic mode (step S**402**). When the operation mode is the high traffic mode, the main control section **105** further checks whether the transmission and reception of the control channel is currently stopped by the radio control section **104** (step S**403**).

[**0065**] When the transmission and reception of the control channel is stopped by the radio control section **104** (YES at step S**403**), the main control section **105** reads the timing of transmission and reception of a communication frame **60** carrying the control channel stored in the storage section **106** (step S**404**) Next, the main control section **105** performs carrier sensing for the control channel in the newly generated open slot at the read transmission/reception timing of the communication frame **60** to check whether there is any interference with the control channel (step S**405**).

[**0066**] When it is found that there is interference with the control channel as a result of the carrier sensing (YES at step S**406**), the main control section **105** transmits, through any of the traffic channels, a message to the personal station **30** that is communicating using this traffic channel to notify the personal station **30** that the time slot to which the traffic channel is allocated will be changed to the open slot (a TCH switch message in the case of the above-described personal handyphone system). Whereby, the time slot to which the traffic channel has been allocated is changed to the open slot (step S**407**). The process then returns to step S**405** at which the main control section **105** performs carrier sensing for the control channel in the newly generated open slot at the transmission/reception timing for the communication frame **60** for transmitting and receiving the control channel read as described above.

[**0067**] When it is found that there is no interference with the control channel as a result of the carrier sensing (NO at step S**406**), the main control section **105** allocates the control channel to the open slot (step S**408**). Then, it causes the radio control section **104** to resume the transmission and reception of the communication frame **60** for transmitting and receiving the control channel at the transmission/reception timing for the communication frame **60** for transmitting and receiving the control channel read from the storage section **106** (step S**409**).

[**0068**] When the flow shown in **FIG. 4** is terminated and the cell station **10** enters the operating state, the main control section **105** monitors the state of communication traffic. According to results of the monitoring, it performs a process of adjusting the transmission/reception timing of the communication frame **60** carrying the control channel and a process of switching the operation modes.

[**0069**] **FIG. 8** is a flow chart for explaining the process of adjusting the transmission/reception timing of the communication frame **60** carrying the control channel performed by the main control section **105**.

[**0070**] While the radio control section **104** transmits and receives the control channel, the main control section **105** counts the number of link channel establishment requests received by the radio control section **104** through the control channel within a predetermined time (e.g., one hour) (steps S**501**, S**502**, and S**503**). It is judged whether the count value is equal to or smaller than a predetermined threshold (referred to as adjustment reference value) stored in the storage section **106** (step S**504**). For example, the adjustment reference value is set at the number (an estimated value) of received link channel establishment requests in a case wherein it seems that proper transmission and reception of the control channel is not performed because of interference.

[**0071**] When the count value within the predetermined time is equal to or smaller than the adjustment reference

value (YES at step **S504**), the main control section **105** causes the radio control section **104** to suspend the transmission and reception of the control channel (step **S505**). Then the main control section **105** performs carrier sensing to decide again a slot to be allocated to the control channel and frame transmission/reception timing at which no interference with the control channels of other cell stations **10** occurs (step **S506**). The radio control section **104** is then caused to resume the transmission and reception of the communication frame **60** for transmitting and receiving the control channel at the slot and frame transmission/reception timing thus decided again (step **S507**).

[**0072**] When the radio control section **104** stops transmitting and receiving the control channel (NO at step **S501**), the count value is cleared (step **S508**).

[**0073**] In the flow shown in **FIG. 8**, the transmission/reception timing for the communication frame **60** carrying the control channel is re-decided each time a predetermined time passes during the transmission and reception of the control channel based on a value counted within the predetermined time. For example, values counted within the predetermined time may be stored in the storage section **106**; an average of such count values may be obtained when the number of the count values reaches a predetermined number (e.g., when the number of the count values is counted for a day); and the processes at steps **S504** to **S507** may be performed on the average value thus obtained.

[**0074**] **FIG. 9** is a flow chart for explaining the operation mode switching process performed by the main control section **105**.

[**0075**] The main control section **105** counts the number of allocation reject messages in response to link channel establishment requests transmitted by the radio control section **104** within a predetermined time (e.g., one hour) (steps **S601** and **S602**). Then, the main control section **105** judges whether the count value is equal to or greater than a predetermined threshold (referred to as reference value for switching to the high traffic mode) stored in the storage section **106** (step **S603**). The reference value for switching to the high traffic mode is set at the number (an estimated value) of allocation reject messages transmitted in a case wherein it seems that possibility of rejection of a link channel establishment request is higher because of an increase in the traffic.

[**0076**] When the count value within the predetermined time is equal to or greater than the reference value for switching to the high traffic mode (YES at step **S603**), the main control section **105** checks whether the operation mode switchability information read at step **S106** in **FIG. 4** indicates that operation mode switching is enabled (step **S604**). If the information indicates that operation mode switching is enabled, the main control section **105** further checks whether the operation mode set for own cell station **10** is the normal mode (step **S605**). When the operation mode set for own cell station **10** is the normal mode (YES at step **S605**), the main control section **105** changes the operation mode from the normal mode to the high traffic mode (step **S606**). The process thereafter proceeds to step **S611**. When the operation mode switchability information indicates that operation mode switching is disabled (NO at step **S604**) or when the operation mode set for own cell station **10** is the high traffic mode (NO at step **S605**), the process proceeds to step **S611** without changing the operation mode.

[**0077**] When the count value within the predetermined time is not equal to or greater than the reference value for switching to the high traffic mode (NO at step **S603**), the main control section **105** judges whether the count value is equal to or smaller than a predetermined threshold (referred to as reference value for switching to the normal mode) stored in the storage section **106** (step **S607**). The reference value for switching to the normal mode is set at the number (an estimated value) of allocation reject messages transmitted in a case wherein it seems that possibility of rejection of a link channel establishment request is lower because of a reduction in the traffic.

[**0078**] When the count value within the predetermined time is not equal to or smaller than the reference value for switching to the normal mode (NO at step **S607**), the process returns to step **S601**. When the count value is equal to or smaller than the reference value for switching to the normal mode (YES at step **S607**), the main control section **105** checks whether the operation mode switchability information indicates that operation mode switching is enabled (step **S608**). If the information indicates that operation mode switching is enabled, the main control section **105** further checks whether the operation mode set for own cell station **10** is the high traffic mode (step **S609**). When the operation mode set for own cell station **10** is the high traffic mode (YES at step **S609**), the main control section **105** changes the operation mode from the high traffic mode to the normal mode (step **S610**). The process thereafter proceeds to step **S611**. When the operation mode switchability information indicates that operation mode switching is disabled (NO at step **S608**) or when the operation mode set for own cell station **10** is the normal mode (NO at step **S609**), the process proceeds to step **S611** without changing the operation mode.

[**0079**] At step **S611**, the main control section **105** controls the channel control section **107** to transmit the operation mode set for own cell station **10**, the operation mode switchability information, and the state of communication traffic (the number of allocation reject messages within the predetermined time) to the maintenance terminal **20** through the communication network **50**. Then, the count value is cleared (step **S612**), and the process returns to step **S601**. Upon receipt of the above information, the maintenance terminal **20** notifies maintenance personnel of the operation mode, the operation mode switchability information, and the state of communication traffic notified by the cell station **10** by displaying them on a display. This allows the maintenance personnel to judge the state of service in the current operation mode and to reconsider the installation place, the operation mode and operation mode switchability information of own cell station **10**.

[**0080**] In the flow shown in **FIG. 9**, whether to switch the operation mode is judged each time a predetermined time passes based on a value counted within the predetermined time. For example, values counted within the predetermined time may be stored in the storage section **106**; an average of such count values may be obtained when the number of the count values reaches a predetermined number (e.g., when the number of the count values is counted for a day); and the processes at steps **S603** to **S611** may be performed on the average value thus obtained.

[0081] A preferred embodiment of the invention has been described above.

[0082] In the embodiment, when the radio control section **104** receives a link channel establishment request message from the personal station **30** through the control channel that is allocated to any time slot in a state in which a channel is allocated to every time slot constituting a communication frame **60**, the main control section **105** notifies the personal station **30** of an allocation message through the control channel to indicate that the time slot allocated to the control channel will be allocated to a traffic channel. The transmission of the control channel is stopped when a predetermined time (the control channel transmission/reception duration **701**) passes after the notification of the allocation message. Therefore, in the present embodiment, in a case wherein the time slot for the control channel is allocated to the traffic channel of a certain personal station **30** and the personal station **30** cannot recognize a traffic channel thus allocated, a re-request for allocation transmitted by the personal station **30** can be received. It is therefore possible to suppress any reduction in connectability of a call from the personal station **30**.

[0083] In the present embodiment, in a case wherein a traffic channel is allocated to every time slot constituting a communication frame **60** and any of the traffic channels is disconnected to produce an open slot, the main control section **105** controls the radio control section **104** such that a control channel is transmitted and received in the open slot in the communication frame **60** that is transmitted and received at frame transmission/reception timing stored in the storage section **106**. The frame transmission/reception timing is transmission/reception timing of the communication frame **60** of a control channel in which no interference has been detected during carrier sensing and which has been properly transmitted and received. Therefore, the possibility of detection of interference is reduced by performing carrier sensing in the control channel at that transmission/reception timing, and the possibility of successful allocation of the control channel to the open slot is thus increased.

[0084] Even if interference is detected, in the present embodiment, the open slot is changed to a slot to which a traffic channel is allocated, and another time slot is made open and is subjected to carrier sensing for the control channel. Since the control channel can be thus allocated to any time slot, the occurrence of call loss and a resultant reduction of traffic can be prevented.

[0085] In the present embodiment, the main control section **105** monitors the number of link channel establishment request messages received within a predetermined time. When the number of received requests is equal to or smaller than a predetermined adjustment reference value, carrier sensing for the control channel is performed in the time slot to which the control channel is allocated to adjust the timing for transmitting and receiving the frame including the control channel. This makes it possible to prevent proper transmission and reception of the control channel from being disabled by interference, and the occurrence of call loss and a resultant reduction in traffic can be prevented.

[0086] In the present embodiment, the main control section **105** monitors the number of link channel establishment request messages transmitted within a predetermined time and controls the switching of operation modes according to results of the monitoring. Specifically, the operation mode is switched from the normal mode to the high traffic mode when the number of transmitted messages is equal to or greater than a predetermined reference value for switching to the high traffic mode, and the operation mode is switched from the high traffic mode to the normal mode when the number of transmitted messages is equal to or smaller than a predetermined reference value for switching to the normal mode (provided that operation mode switchability information indicates that switching is enabled). This allows an operation mode decided before the starting of the service to be automatically switched to another according to actual traffic.

[0087] The present embodiment thus makes it possible to increase traffic that can be processed at a cell station without reducing communication quality.

[0088] The invention is not limited to the above-described embodiment and may be modified in various ways within the scope of the teaching thereof. For example, the above-described functions of the cell station **10** are not limited to implementation on a software basis through execution of a program in a memory by a CPU in an information processing apparatus having a CPU, a memory, and a communication device. Alternatively, the functions may be provided on a hardware basis using an integrated circuit such as an ASIC.

[0089] As described above, the invention makes it possible to increase traffic that can be processed by a cell station without reducing communication quality.

What is claimed is:

1. A cell station accommodating a personal station by using a time division multiple access method, comprising:

communication unit which transmits and receives a frame including a plurality of time slots; and

control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame, wherein,

in the case that a channel is allocated to every time slot constituting the frame and the communication unit receives a link channel establishment request from the personal station through the control channel allocated to any of the time slots, the control unit notifies the personal station through the control channel that the time slot allocated to the control channel will be allocated to a traffic channel and stops transmission and reception of the control channel when a predetermined time passes after the notice.

2. A cell station according to claim 1, wherein

the predetermined time is set such that it is longer than an estimated time until the reception of a link channel establishment re-request when the re-request is sent as a response of the personal station to the notice and is shorter than an estimated time until the reception of a synchronization burst signal when the signal is set as the response.

3. A cell station accommodating a personal station by using a time division multiple access method, comprising:

communication unit which transmits and receives a frame including a plurality of time slots;

control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame; and

timing storing unit which stores timing for transmitting and receiving a frame including the control channel, wherein,

in the case that a traffic channel is allocated to every time slot constituting the frame, when any of the traffic channels is disconnected to make a time slot open, the control unit controls the communication unit such that the control channel is transmitted and received in the time slot which has become open in a frame transmitted at said timing.

4. A cell station according to claim 3, wherein:

the control unit controls the communication unit to perform carrier sensing for the control channel in the time slot which has become open in the frame transmitted and received at said timing;

when no interference is detected, the control unit controls the communication unit to transmit and receive the control channel in the time slot which has become open in the frame transmitted and received at said timing; and

when interference is detected, the control unit controls the communication unit such that it repeats a process of switching a traffic channel allocated to another time slot to the time slot which has become open and performing carrier sensing for the control channel in the another time slot in a frame transmitted and received at timing stored in the timing storing unit until no interference is detected and it transmits and receives the control channel in a time slot in which no interference has been detected in the frame transmitted and received at said timing.

5. A cell station accommodating a personal station by using a time division multiple access method, comprising:

communication unit which transmits and receives a frame including a plurality of time slots;

control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame; and

traffic monitoring unit which monitors communication traffic, wherein

the control unit performs carrier sensing for the control channel in a time slot to which the control channel is allocated according to results of the monitoring by the traffic monitoring unit and adjusts timing for transmitting and receiving a frame including the control channel.

6. A cell station according to claim 5, wherein:

the traffic monitoring unit monitors the number of link channel establishment requests received from the personal station through the control channel within a predetermined time as the communication traffic; and

the control unit performs said adjustment when the communication traffic monitored by the traffic monitoring unit is equal to or smaller than a predetermined threshold.

7. A cell station accommodating a personal station by using a time division multiple access method, comprising:

communication unit which transmits and receives a frame including a plurality of time slots;

control unit which allocates a traffic channel or a control channel to each of the time slots constituting the frame; and

traffic monitoring unit which monitors communication traffic, wherein:

the control unit operates in either of a first mode in which the control channel is always allocated to at least one of the time slots constituting the frame and a second mode in which a traffic channel can be allocated to every time slot constituting the frame; and

the operation modes are switched according to results of the monitoring by the traffic monitoring unit.

8. A cell station according to claim 7, wherein:

the traffic monitoring unit monitors the number of rejections of link channel establishment requests received from the personal station through the control channel within a predetermined time as the communication traffic; and

the control unit switches the operation mode to the second mode when the communication traffic monitored by the traffic monitoring unit becomes equal to or greater than a predetermined threshold during an operation in the first mode.

9. A radio communication system having a plurality of cell stations and a communication network connecting the plurality of cell stations, wherein

at least one of the plurality of cell stations is a cell station according to claims **1**.

10. A communication control method for a cell station accommodating a personal station by using a time division multiple access method, wherein:

in the case that a channel is allocated to every time slot constituting the frame, when a link channel establishment request is received from the personal station through the control channel allocated to any of the time slots, the personal station is notified through the control channel that the time slot allocated to the control channel will be allocated to a traffic channel; and

transmission and reception of the control channel is stopped when a predetermined time passes after the notice.

11. A communication control method for a cell station accommodating a personal station by using a time division multiple access method, wherein,

in the case that a traffic channel is allocated to every time slot constituting the frame, when any of the traffic channels is disconnected to make a time slot open, the control channel is transmitted and received in the time slot which has become open in a frame transmitted and received at timing stored in advance in storing unit.

12. A communication control method for a cell station accommodating a personal station by using a time division multiple access method, comprising the steps of:

monitoring communication traffic; and

performing carrier sensing for a control channel in a time slot to which the control channel is allocated and adjusting timing for transmitting and receiving a frame including the control channel when results of the monitoring becomes equal to or greater than a predetermined threshold.

13. A communication control method for a cell station accommodating a personal station by using a time division multiple access method, comprising the steps of:

monitoring communication traffic; and

switching the operation mode to a second mode in which a traffic channel can be allocated to every time slot constituting a frame when results of the monitoring becomes equal to or greater than a predetermined threshold during an operation in a first mode in which a control channel is always allocated to at least one of time slots constituting a frame to be transmitted and received.

14. A method of constructing a radio communication network utilizing a plurality of cell stations connected to each other through a communication network, wherein

at least one of the plurality of cell stations carries out the communication control method for a cell station according to claim 10.

15. A method of constructing a radio communication network utilizing a plurality of cell stations connected to each other through a communication network, wherein

at least one of the plurality of cell stations carries out the communication control method for a cell station according to claim 11.

16. A method of constructing a radio communication network utilizing a plurality of cell stations connected to each other through a communication network, wherein

at least one of the plurality of cell stations carries out the communication control method for a cell station according to claim 12.

17. A method of constructing a radio communication network utilizing a plurality of cell stations connected to each other through a communication network, wherein

at least one of the plurality of cell stations carries out the communication control method for a cell station according to claim 13.

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