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(54) **WIRELESS COMMUNICATION SYSTEM, TERMINAL, AND PROCESSING METHOD**

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(30) **Foreign Application Priority Data**

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(52) **U.S. Cl.**
CPC ***H04W 72/10*** (2013.01)

(57) **ABSTRACT**

A wireless system includes a plurality of terminals and a wireless base station. Each of the plurality of terminals determines a priority of a local terminal related to transmission of a certain signal according to a certain rule when the certain signal is not received from the wireless base station.

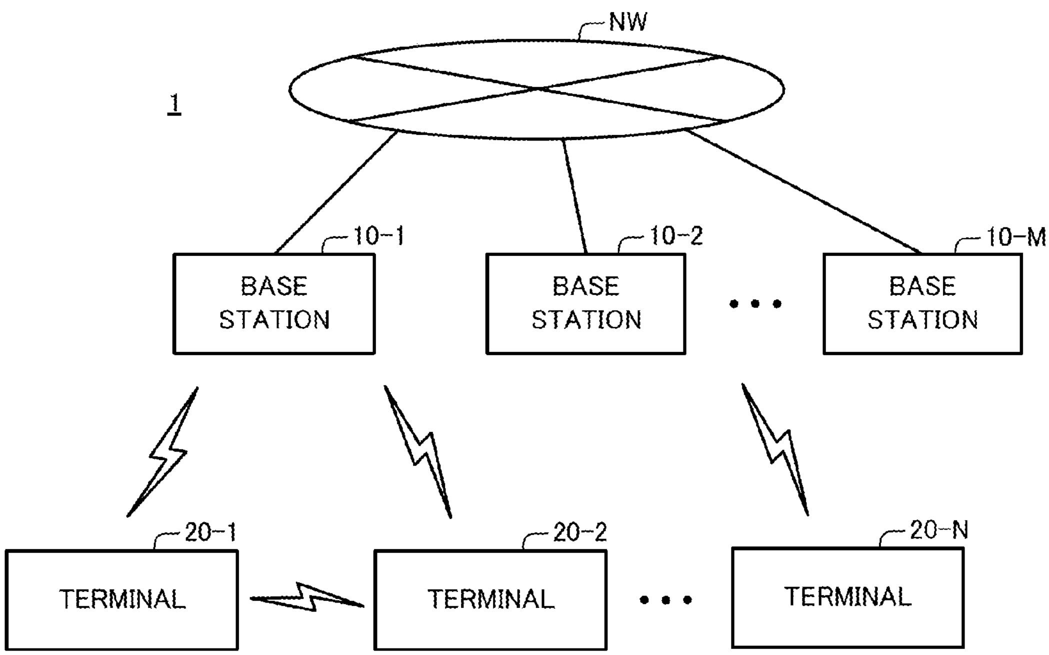


FIG. 1

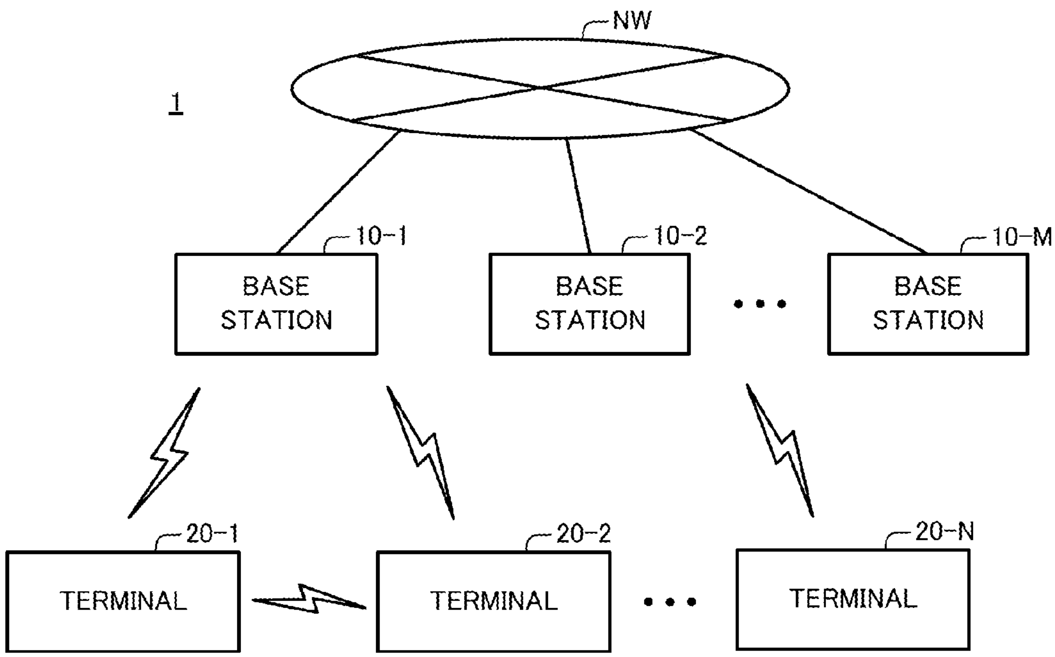

NW
1
10-1
BASE STATION
10-2
BASE STATION
10-M
BASE STATION
20-1
TERMINAL
20-2
TERMINAL
20-N
TERMINAL

FIG. 2

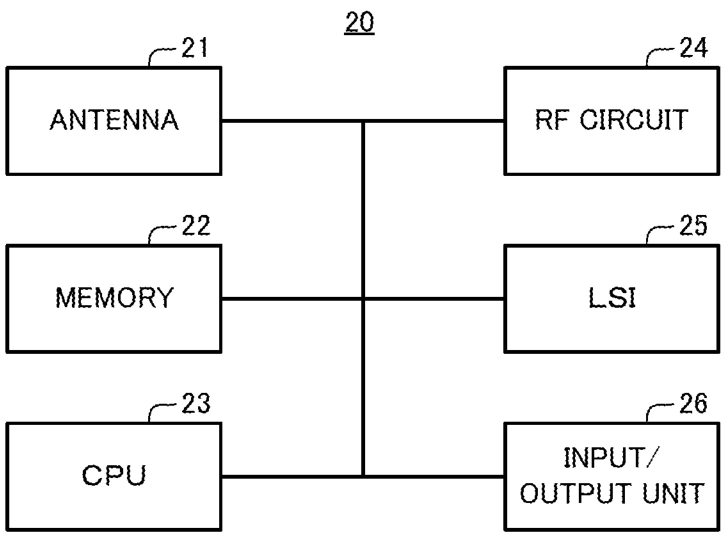

20
21
ANTENNA
22
MEMORY
23
CPU
24
RF CIRCUIT
25
LSI
26
INPUT/
OUTPUT UNIT

FIG. 3

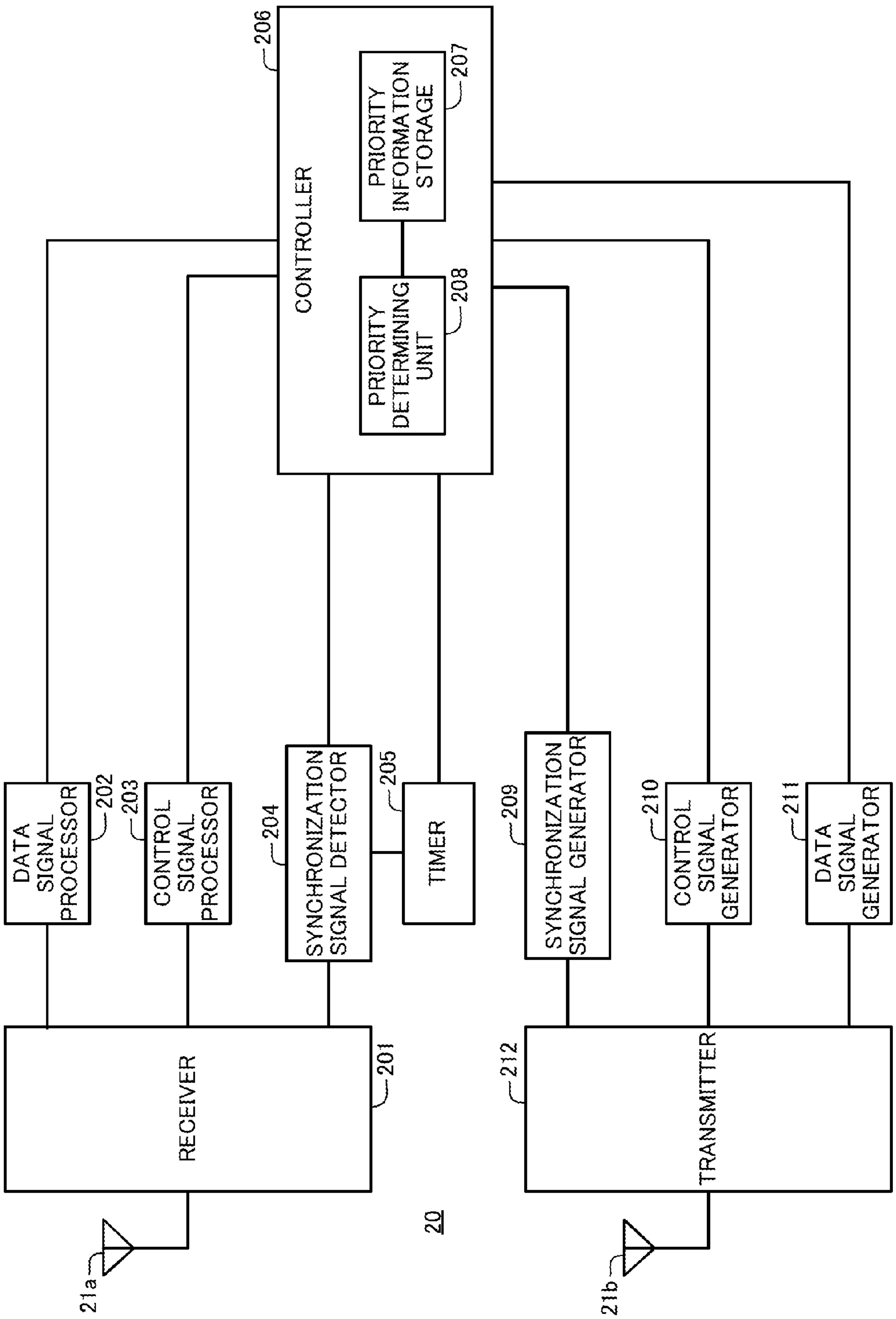

20
21a
21b
RECEIVER
201
TRANSMITTER
212
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
CONTROLLER
206
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208

FIG. 4

USER TYPE	TERMINAL POSITION	WHETHER OR NOT POWER IS SUPPLIED	REMAINING AMOUNT OF BATTERY	AVAILABILITY OF OTHER COMMUNICATION FUNCTIONS	AVAILABILITY OF GPS FUNCTION	PRIORITY
POLICE/FIRE-FIGHTING	URBAN AREA	YES	HIGH	AVAILABLE	AVAILABLE	0
POLICE/FIRE-FIGHTING	URBAN AREA	YES	HIGH	AVAILABLE	NOT AVAILABLE	1
POLICE/FIRE-FIGHTING	URBAN AREA	YES	HIGH	NOT AVAILABLE	AVAILABLE	2
POLICE/FIRE-FIGHTING	URBAN AREA	YES	HIGH	NOT AVAILABLE	NOT AVAILABLE	3
POLICE/FIRE-FIGHTING	URBAN AREA	YES	LOW	AVAILABLE	AVAILABLE	4
POLICE/FIRE-FIGHTING	URBAN AREA	YES	LOW	AVAILABLE	NOT AVAILABLE	5
POLICE/FIRE-FIGHTING	URBAN AREA	YES	LOW	NOT AVAILABLE	AVAILABLE	6
POLICE/FIRE-FIGHTING	URBAN AREA	YES	LOW	NOT AVAILABLE	NOT AVAILABLE	7
POLICE/FIRE-FIGHTING	URBAN AREA	NO	HIGH	AVAILABLE	AVAILABLE	8
POLICE/FIRE-FIGHTING	URBAN AREA	NO	HIGH	AVAILABLE	NOT AVAILABLE	9
POLICE/FIRE-FIGHTING	URBAN AREA	NO	HIGH	NOT AVAILABLE	AVAILABLE	10
POLICE/FIRE-FIGHTING	URBAN AREA	NO	HIGH	NOT AVAILABLE	NOT AVAILABLE	11
POLICE/FIRE-FIGHTING	URBAN AREA	NO	LOW	AVAILABLE	AVAILABLE	12
POLICE/FIRE-FIGHTING	URBAN AREA	NO	LOW	AVAILABLE	NOT AVAILABLE	13
POLICE/FIRE-FIGHTING	URBAN AREA	NO	LOW	NOT AVAILABLE	AVAILABLE	14
POLICE/FIRE-FIGHTING	URBAN AREA	NO	LOW	NOT AVAILABLE	NOT AVAILABLE	15
POLICE/FIRE-FIGHTING	SUBURB	YES	HIGH	AVAILABLE	AVAILABLE	16
⋮	⋮	⋮	⋮	⋮	⋮	⋮
ORDINARY PEOPLE	URBAN AREA	YES	HIGH	AVAILABLE	AVAILABLE	32
⋮	⋮	⋮	⋮	⋮	⋮	⋮
ORDINARY PEOPLE	SUBURB	YES	HIGH	AVAILABLE	AVAILABLE	48
⋮	⋮	⋮	⋮	⋮	⋮	⋮
ORDINARY PEOPLE	SUBURB	NO	LOW	NOT AVAILABLE	NOT AVAILABLE	63

FIG. 5

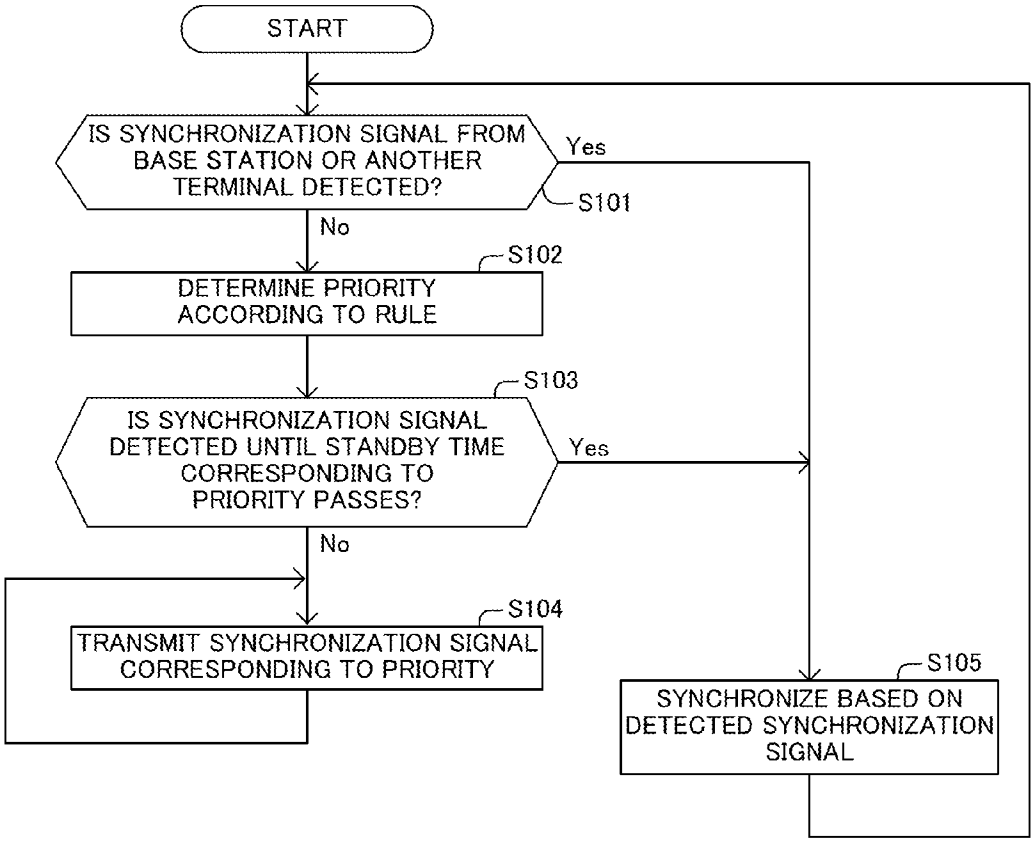

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL

FIG. 6

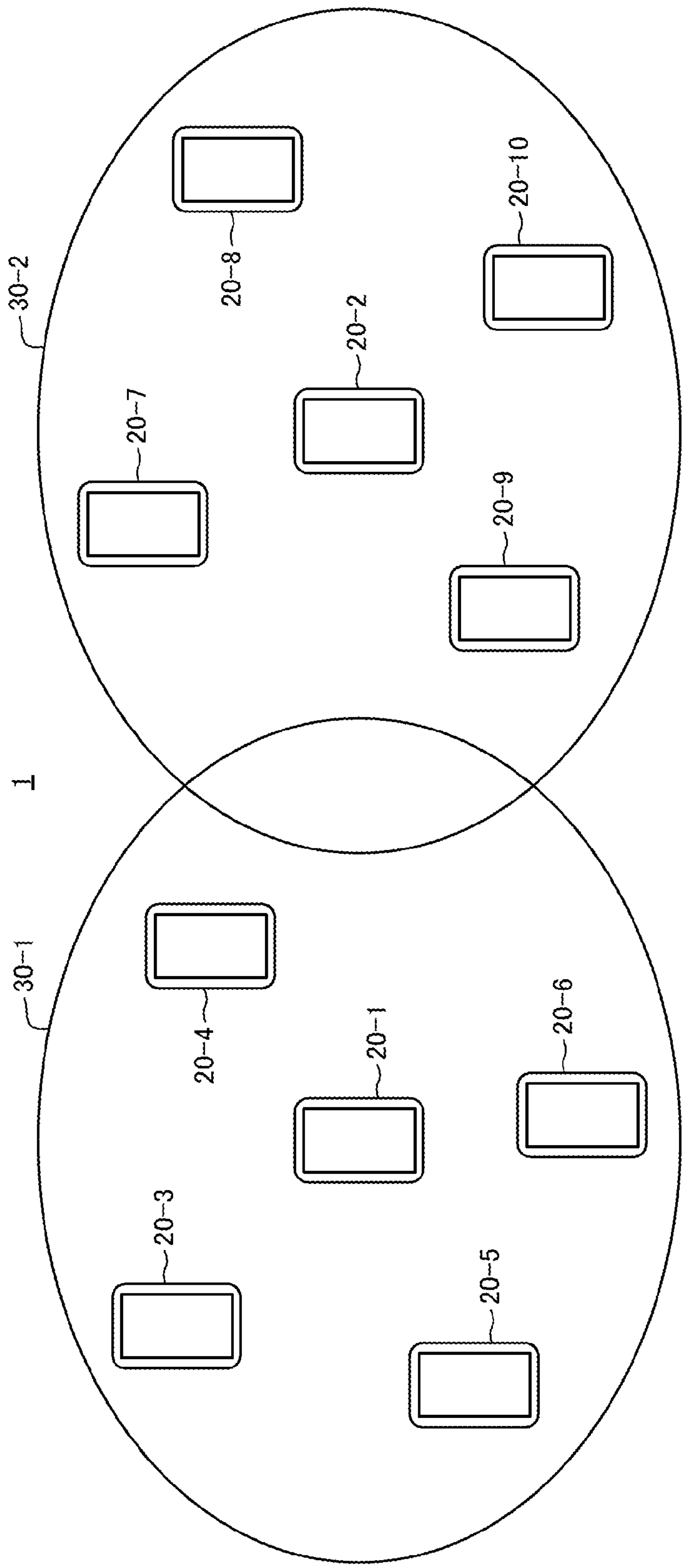


FIG. 7

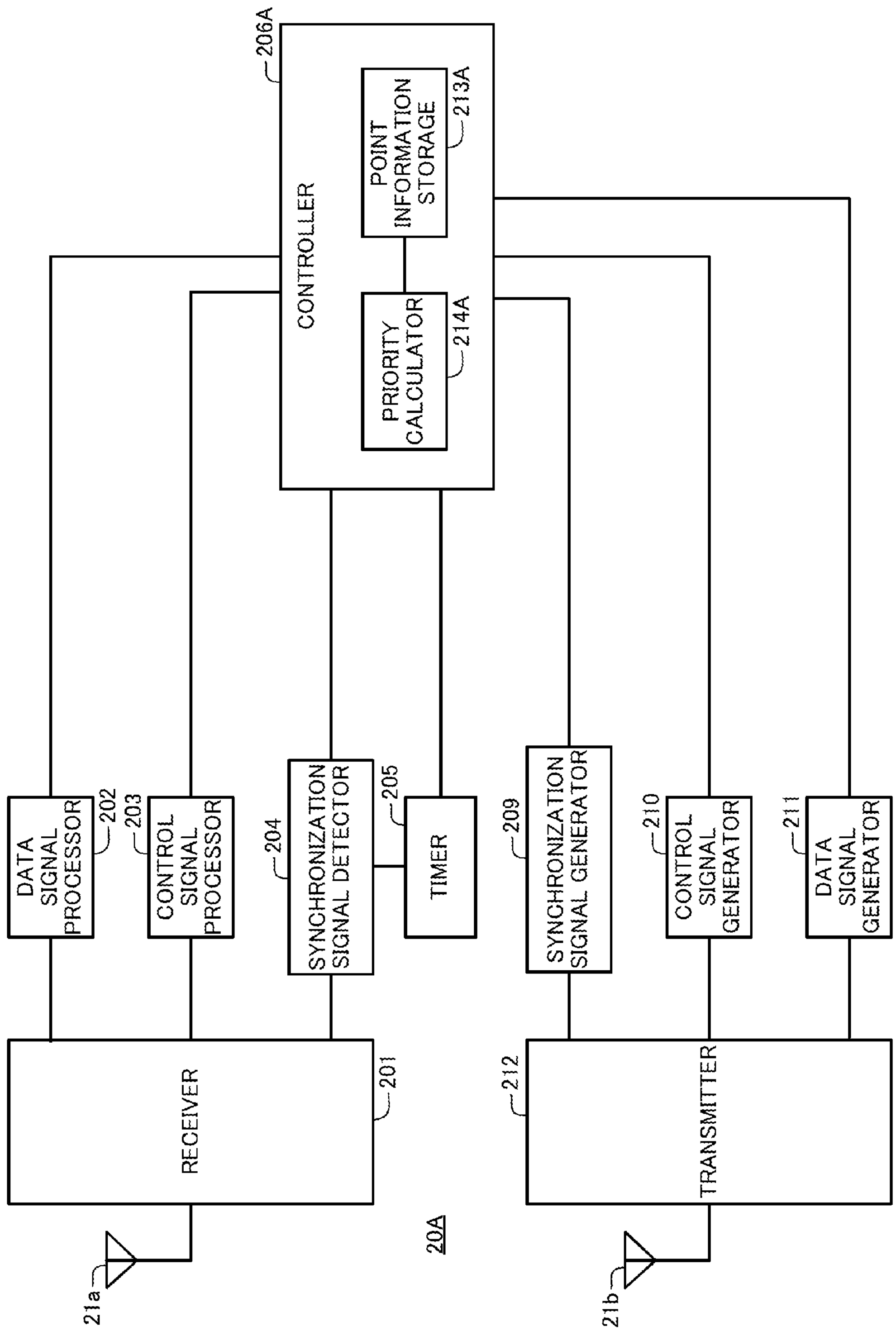

206A
CONTROLLER
POINT INFORMATION STORAGE
213A
PRIORITY CALCULATOR
214A
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
21a
21b
20A

FIG. 8

ELEMENT INFORMATION	CONTENTS	POINT
USER TYPE	POLICE/FIRE-FIGHTING	0
	ORDINARY PEOPLE	32
TERMINAL POSITION	URBAN AREA	0
	SUBURB	16
WHETHER OR NOT POWER IS SUPPLIED	YES	0
	NO	8
REMAINING AMOUNT OF BATTERY	HIGH	0
	LOW	4
AVAILABILITY OF OTHER COMMUNICATION FUNCTIONS	AVAILABLE	0
	NOT AVAILABLE	2
AVAILABILITY OF GPS FUNCTION	AVAILABLE	0
	NOT AVAILABLE	1

FIG. 9

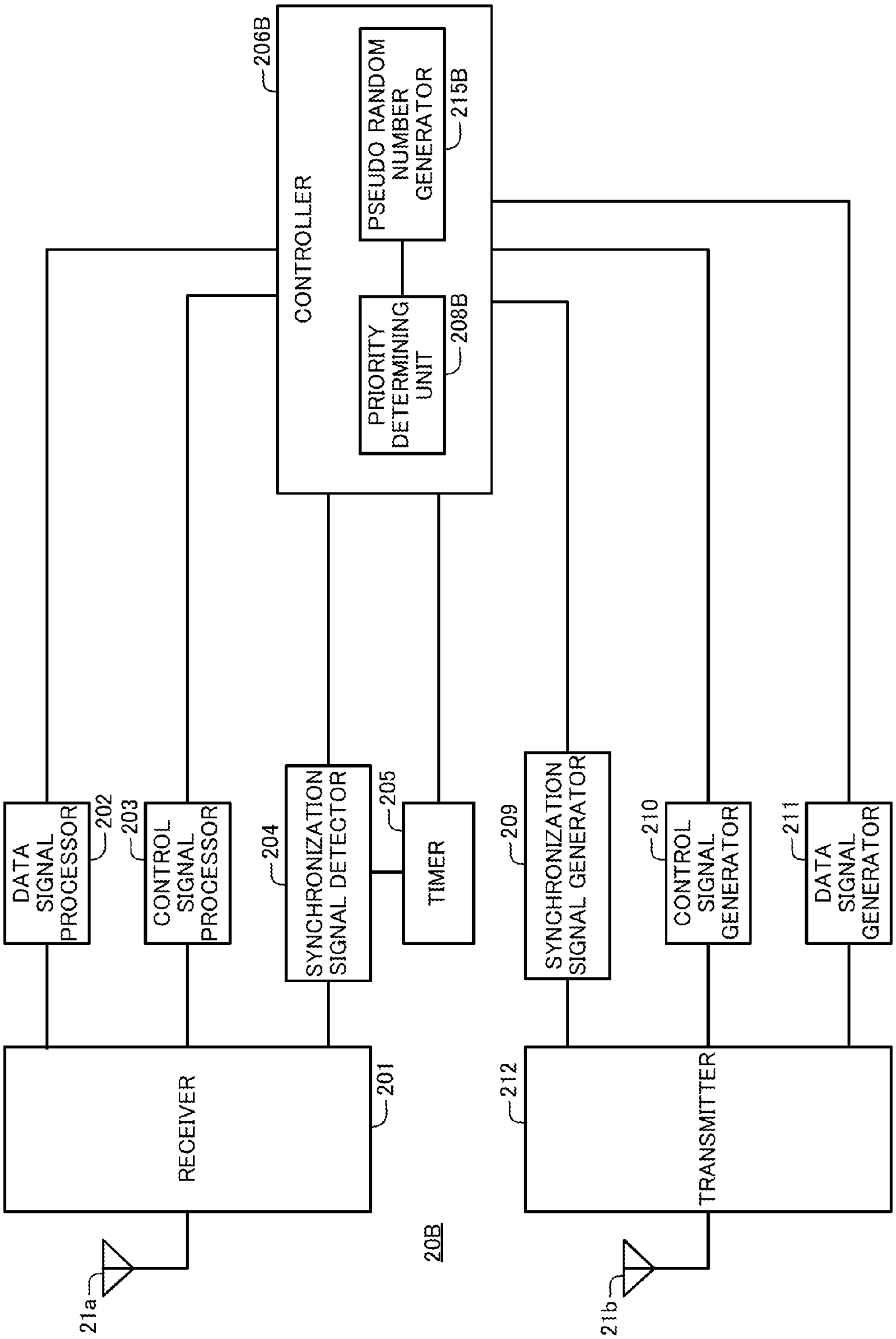

206B
CONTROLLER
PSEUDO RANDOM NUMBER GENERATOR
215B
PRIORITY DETERMINING UNIT
208B
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
20B
21a
21b

FIG. 10

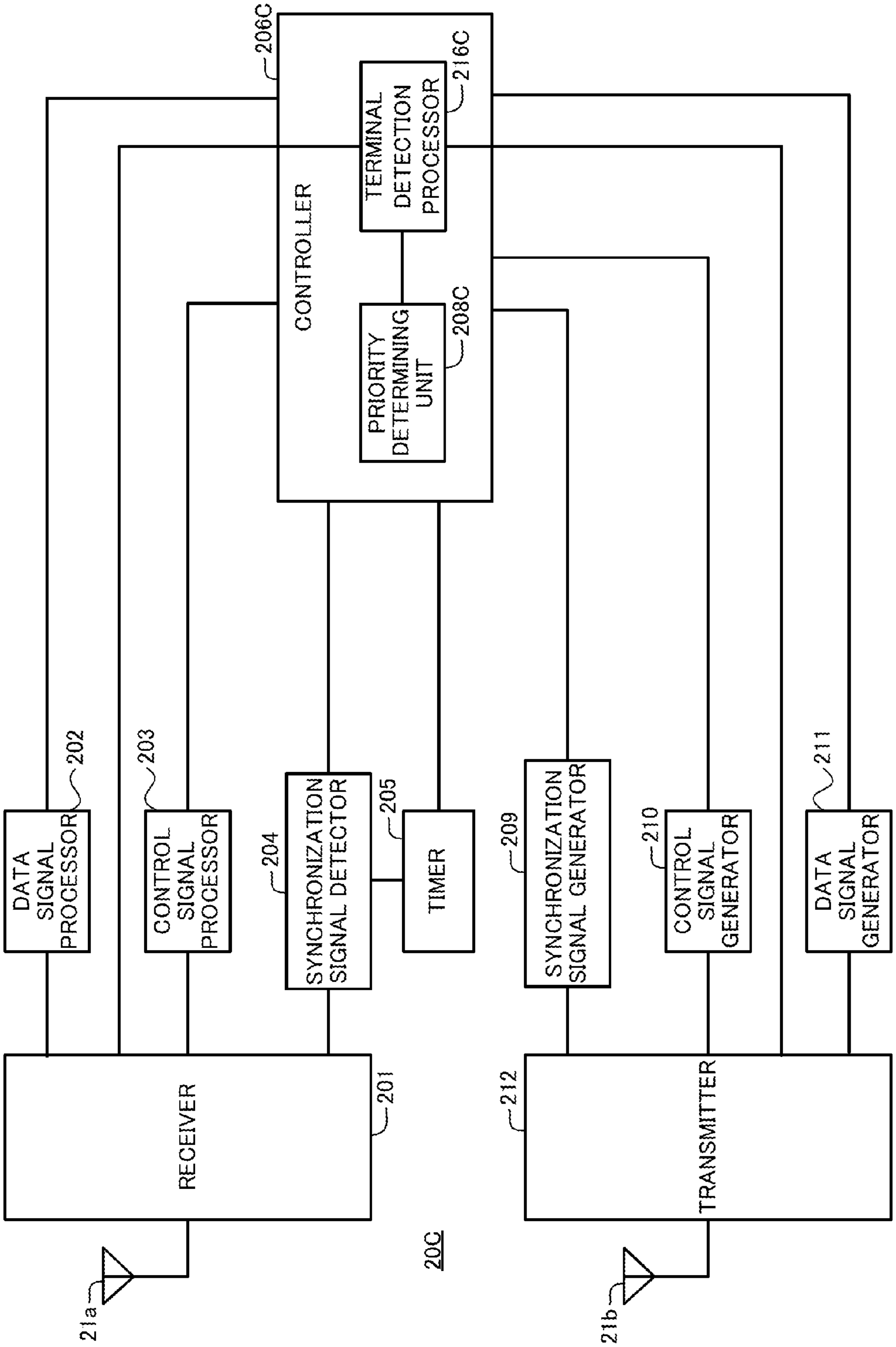

206C
CONTROLLER
TERMINAL DETECTION PROCESSOR
216C
PRIORITY DETERMINING UNIT
208C
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
20C
21a
21b

FIG. 11

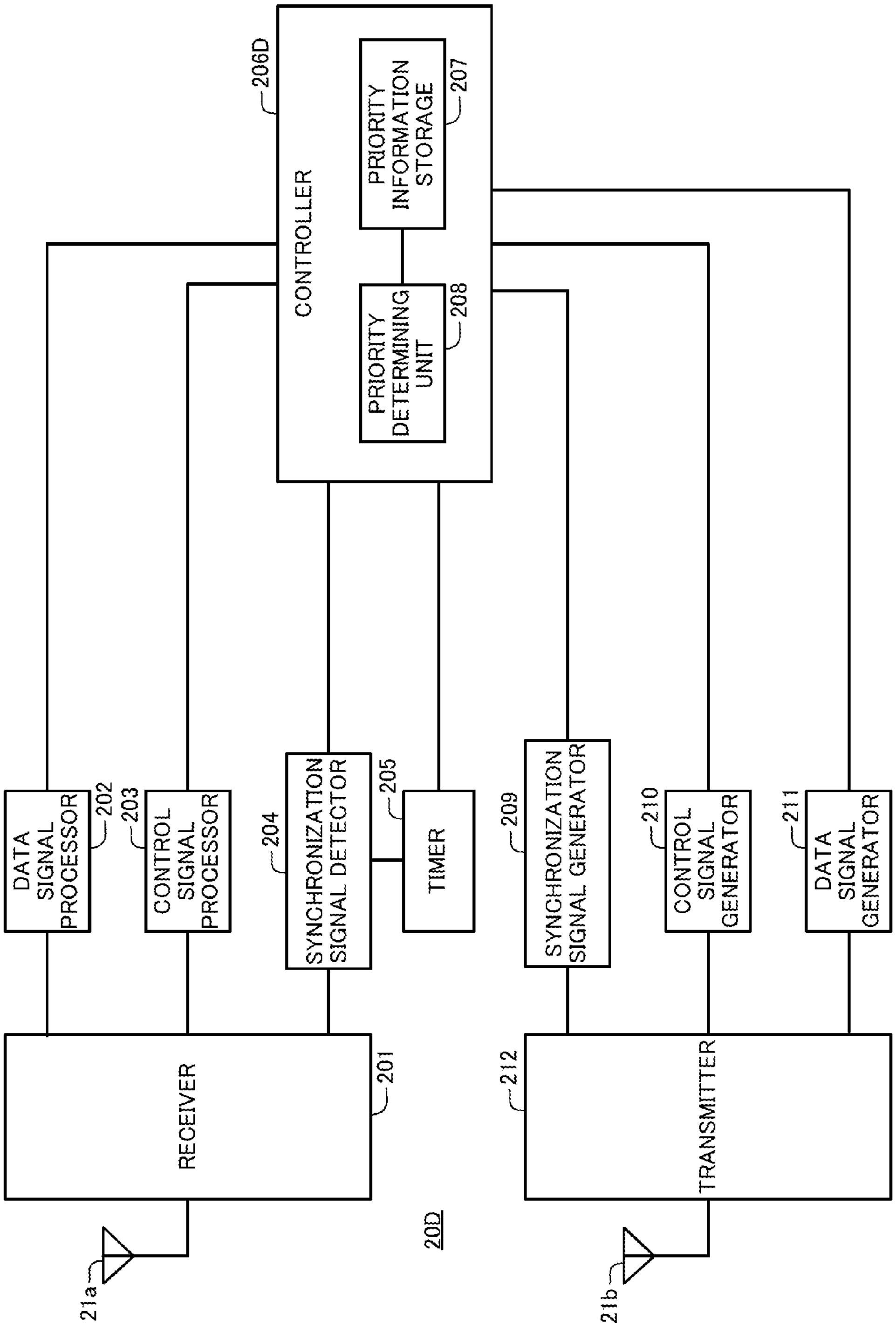

20D
21a
RECEIVER
201
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
CONTROLLER
206D
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
TRANSMITTER
212
21b

FIG. 12

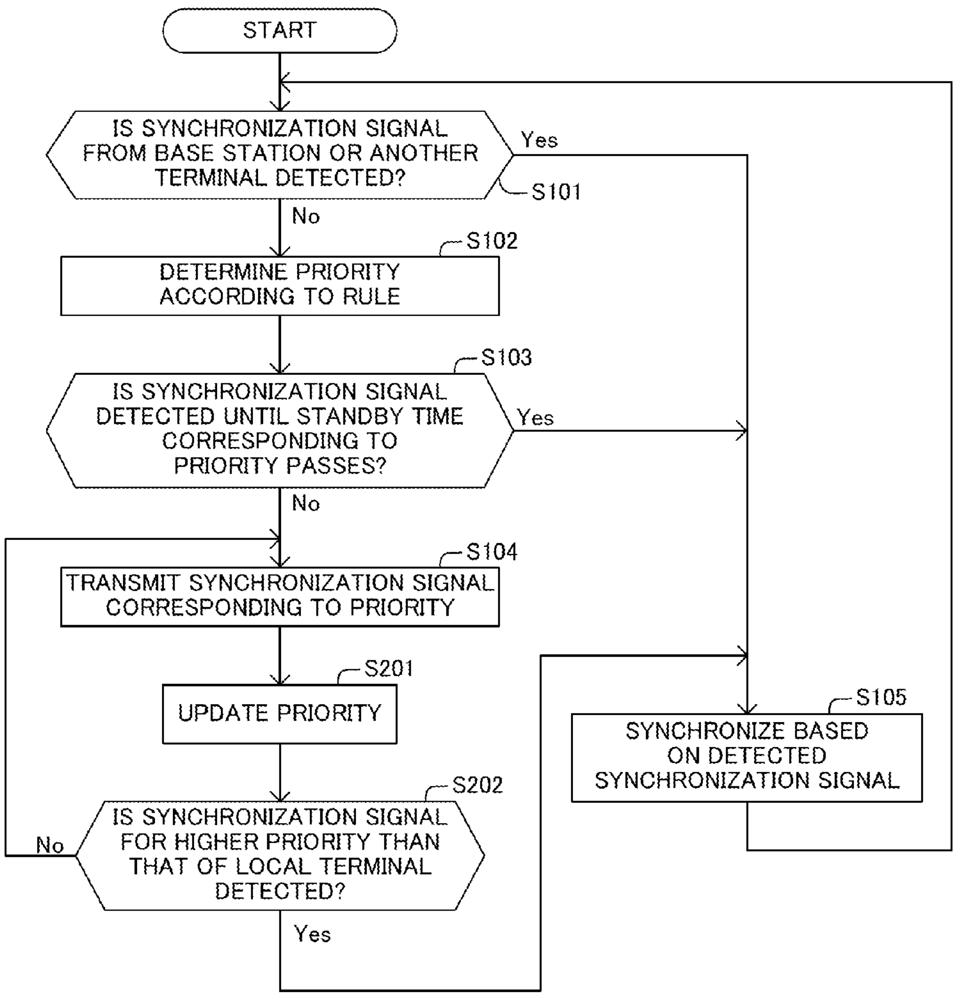

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S201
UPDATE PRIORITY
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes

FIG. 13

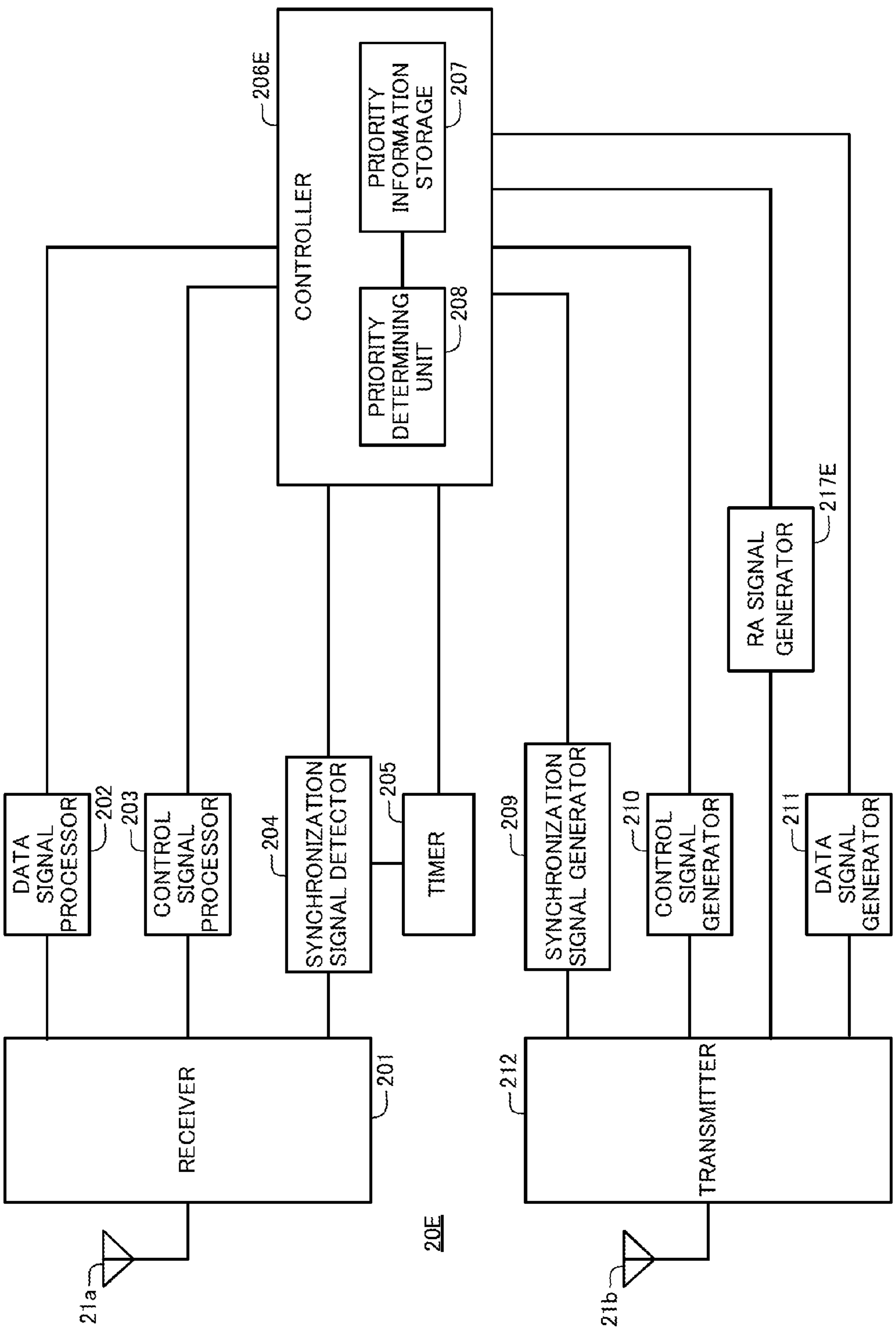

20E
CONTROLLER
206E
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208
RA SIGNAL GENERATOR
217E
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
21a
21b

FIG. 14

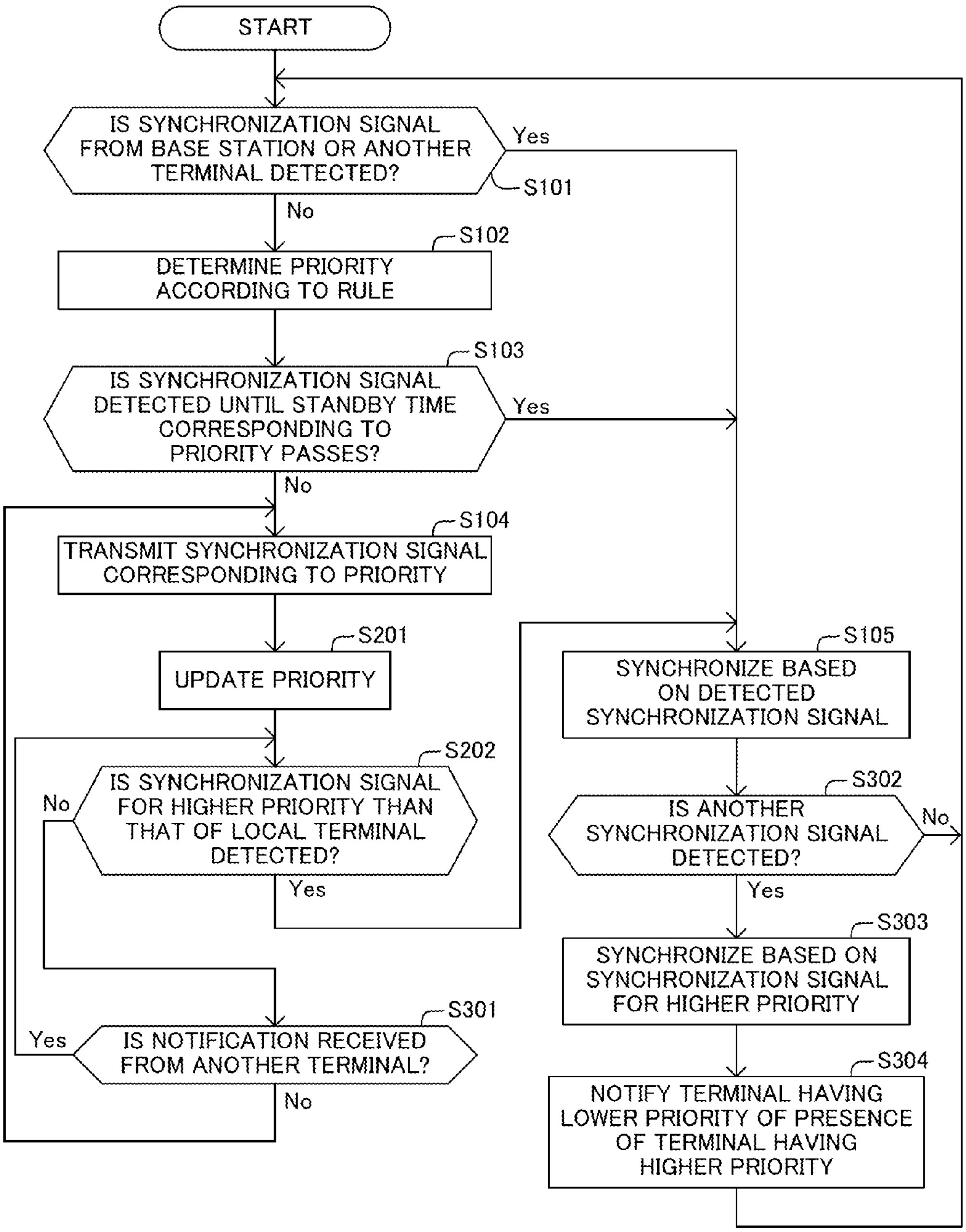

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
DETERMINE PRIORITY ACCORDING TO RULE
S102
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
S103
Yes
No
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S104
UPDATE PRIORITY
S201
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
S202
No
Yes
IS NOTIFICATION RECEIVED FROM ANOTHER TERMINAL?
S301
Yes
No
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S105
IS ANOTHER SYNCHRONIZATION SIGNAL DETECTED?
S302
No
Yes
SYNCHRONIZE BASED ON SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY
S303
NOTIFY TERMINAL HAVING LOWER PRIORITY OF PRESENCE OF TERMINAL HAVING HIGHER PRIORITY
S304

FIG. 15

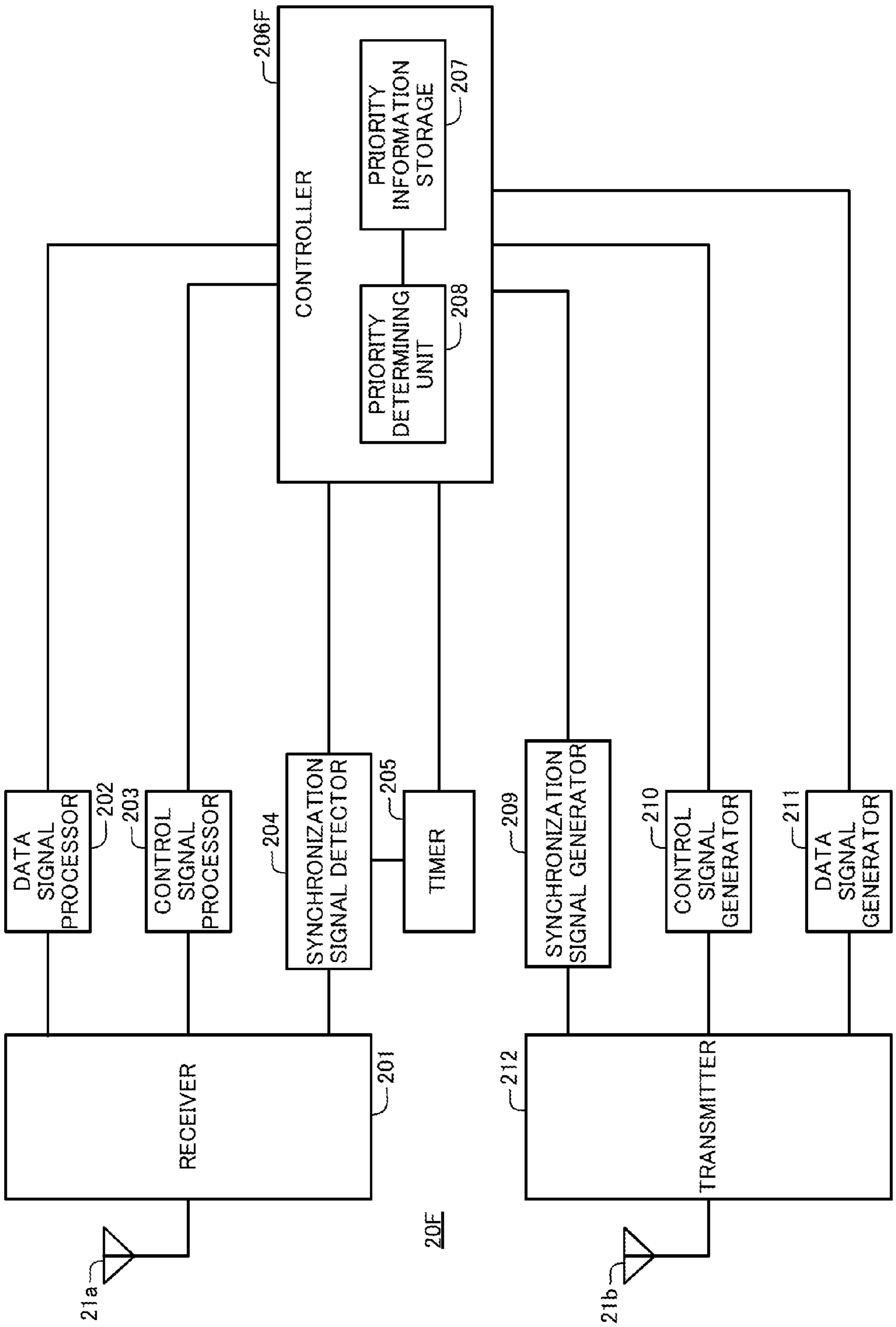

206F
CONTROLLER
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
20F
21a
21b

FIG. 16

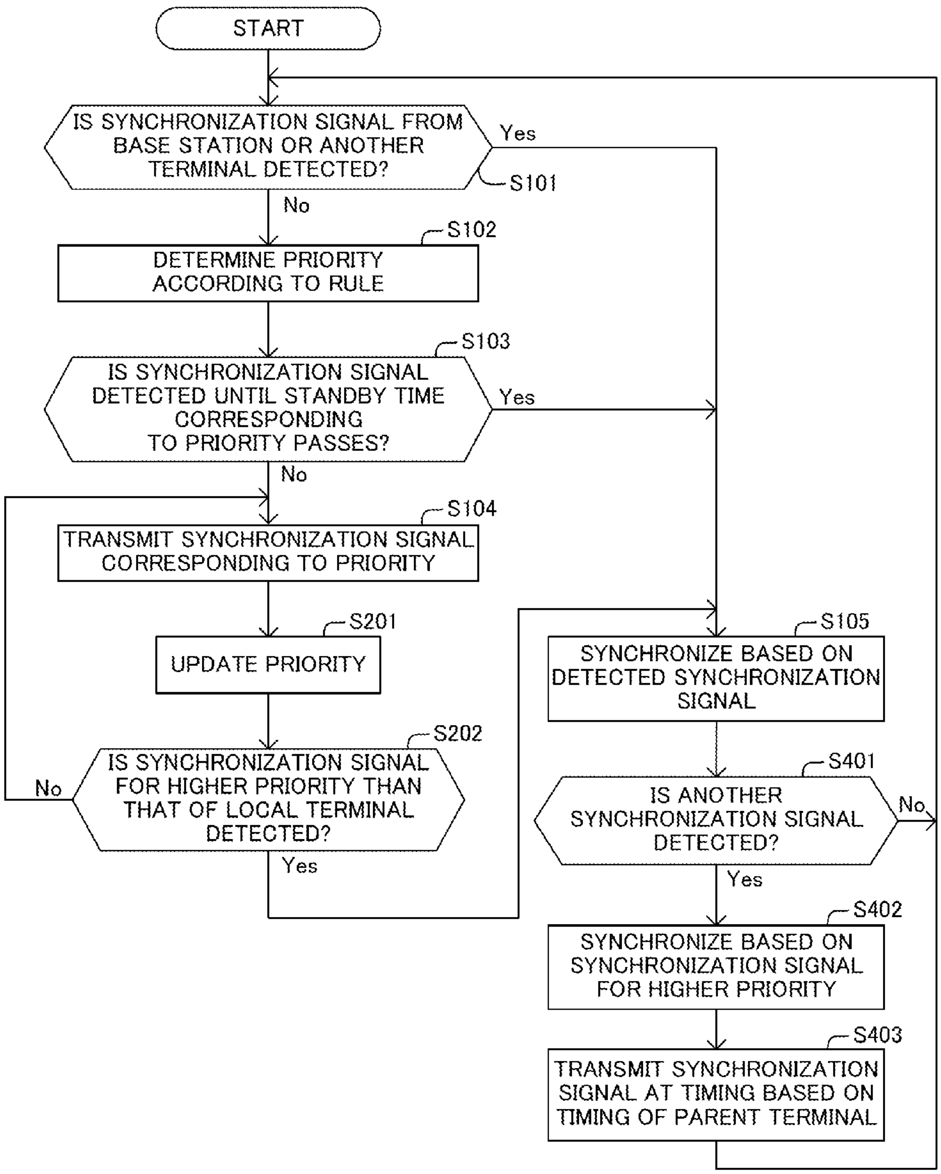
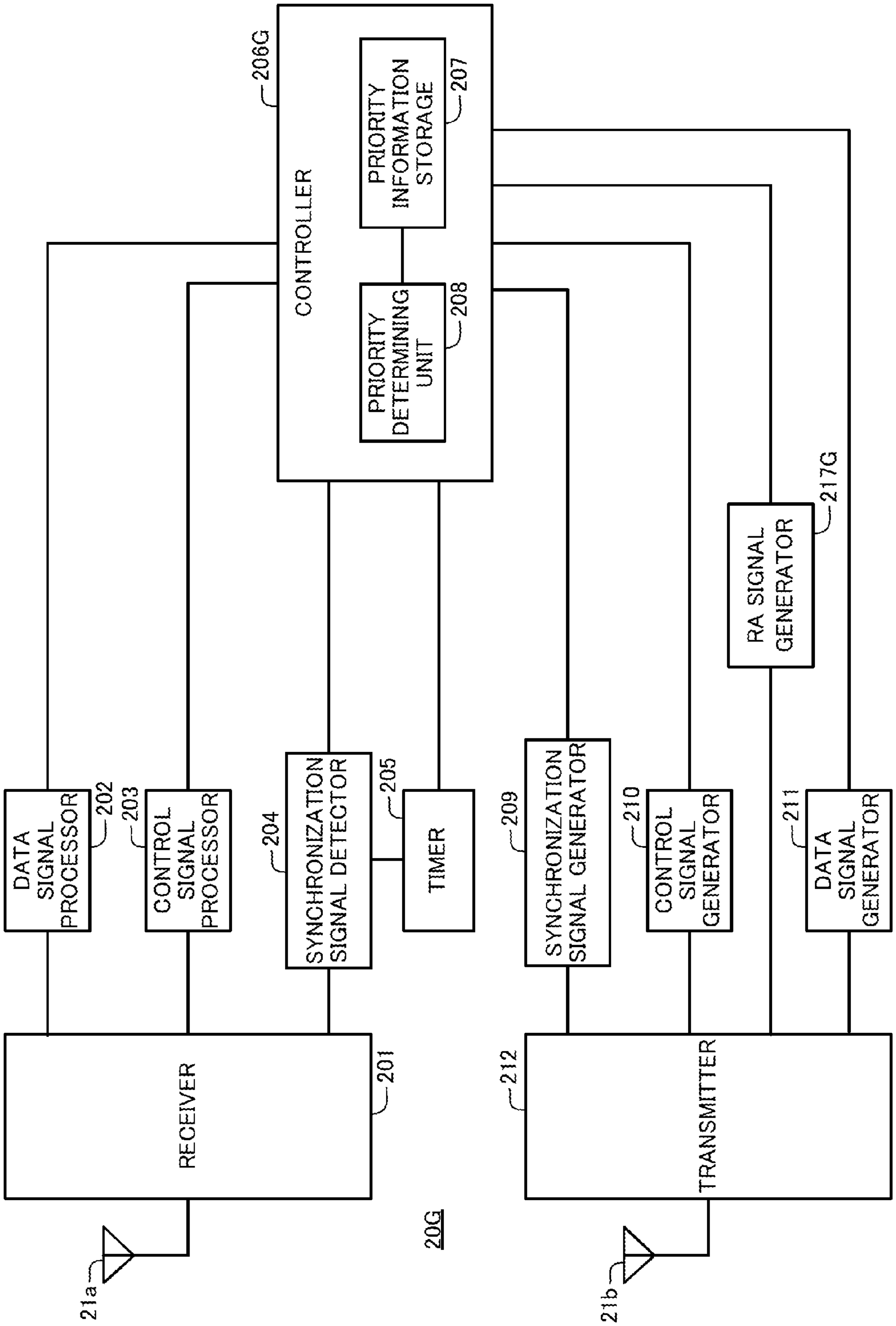

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S201
UPDATE PRIORITY
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S401
IS ANOTHER SYNCHRONIZATION SIGNAL DETECTED?
No
Yes
S402
SYNCHRONIZE BASED ON SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY
S403
TRANSMIT SYNCHRONIZATION SIGNAL AT TIMING BASED ON TIMING OF PARENT TERMINAL

FIG. 17



CONTROLLER
206G
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RA SIGNAL GENERATOR
217G
RECEIVER
201
TRANSMITTER
212
21a
21b
20G

FIG. 18

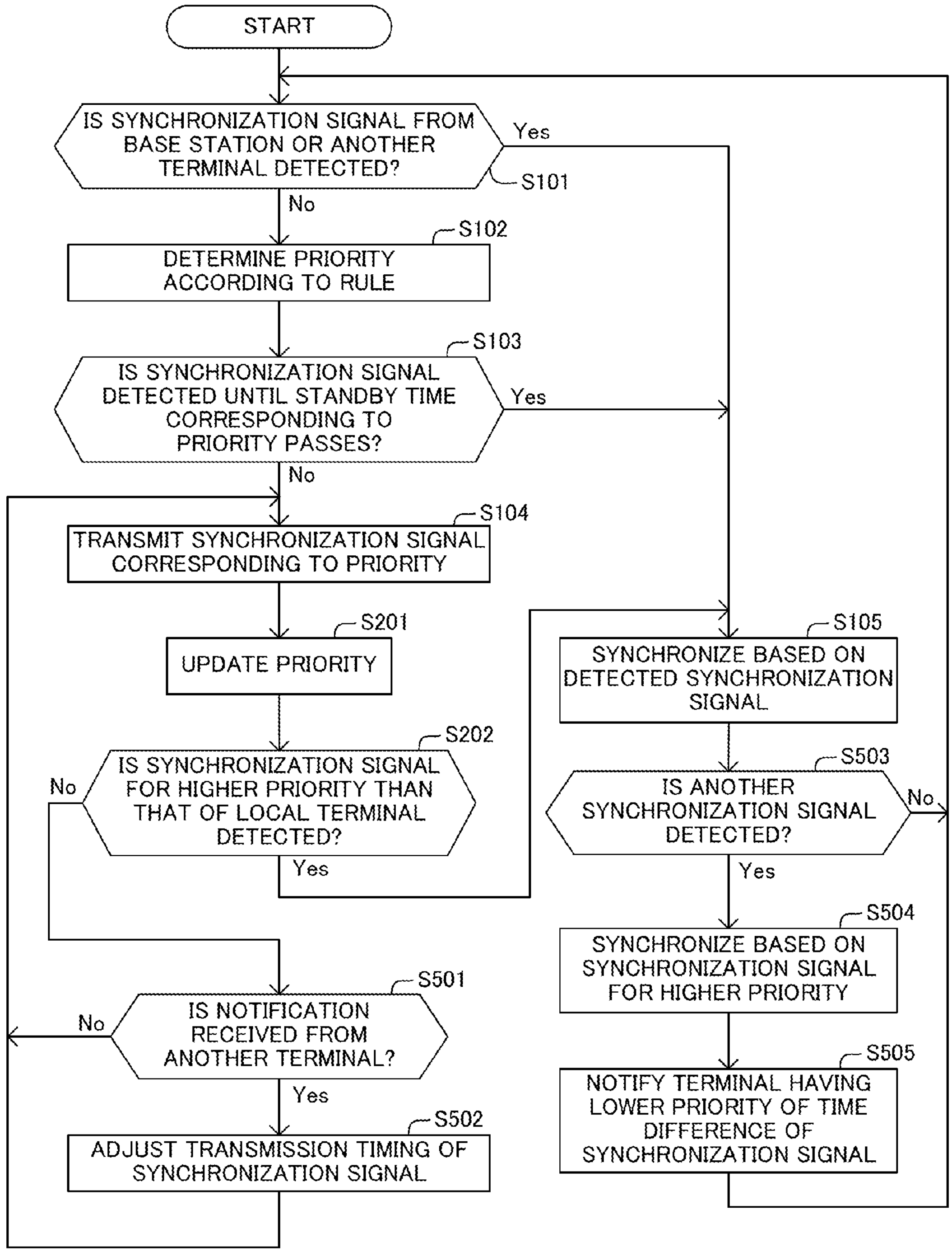

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S201
UPDATE PRIORITY
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S501
IS NOTIFICATION RECEIVED FROM ANOTHER TERMINAL?
No
Yes
S502
ADJUST TRANSMISSION TIMING OF SYNCHRONIZATION SIGNAL
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S503
IS ANOTHER SYNCHRONIZATION SIGNAL DETECTED?
No
Yes
S504
SYNCHRONIZE BASED ON SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY
S505
NOTIFY TERMINAL HAVING LOWER PRIORITY OF TIME DIFFERENCE OF SYNCHRONIZATION SIGNAL

FIG. 19

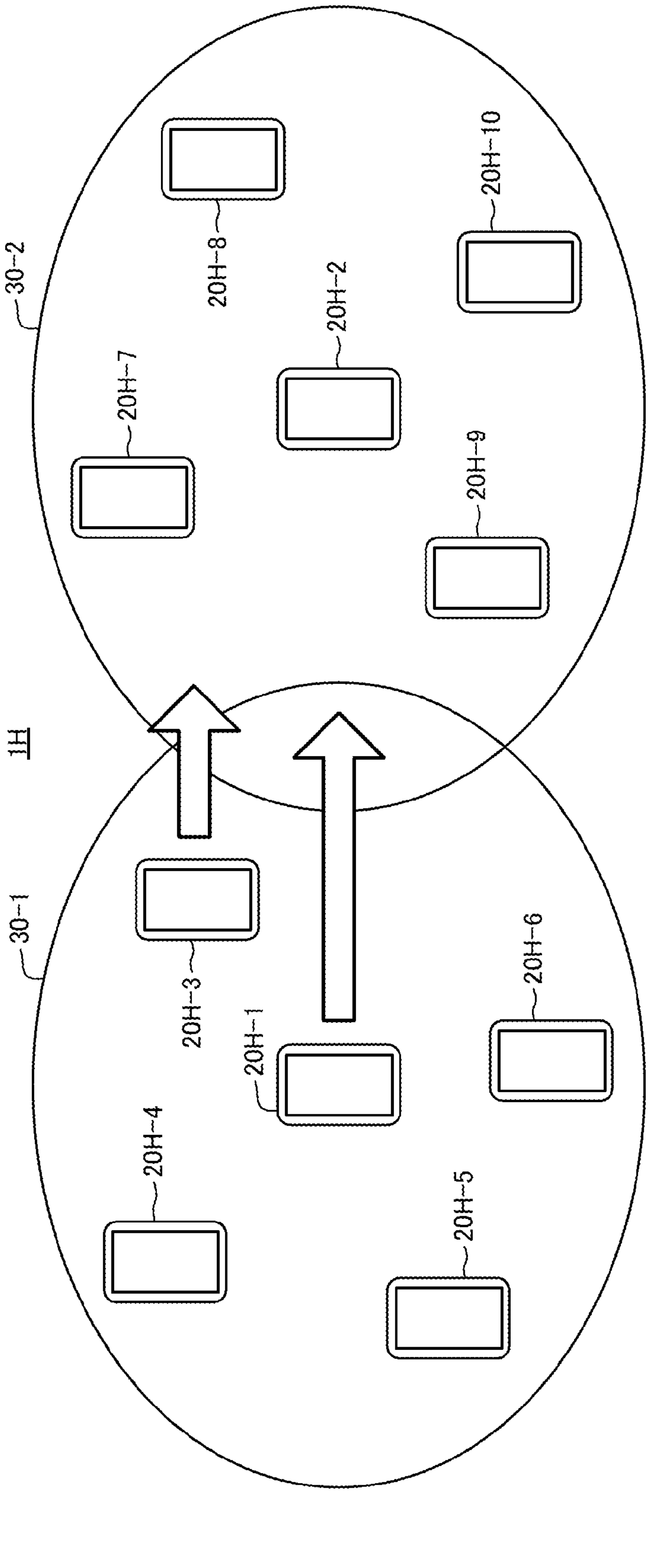


FIG. 20

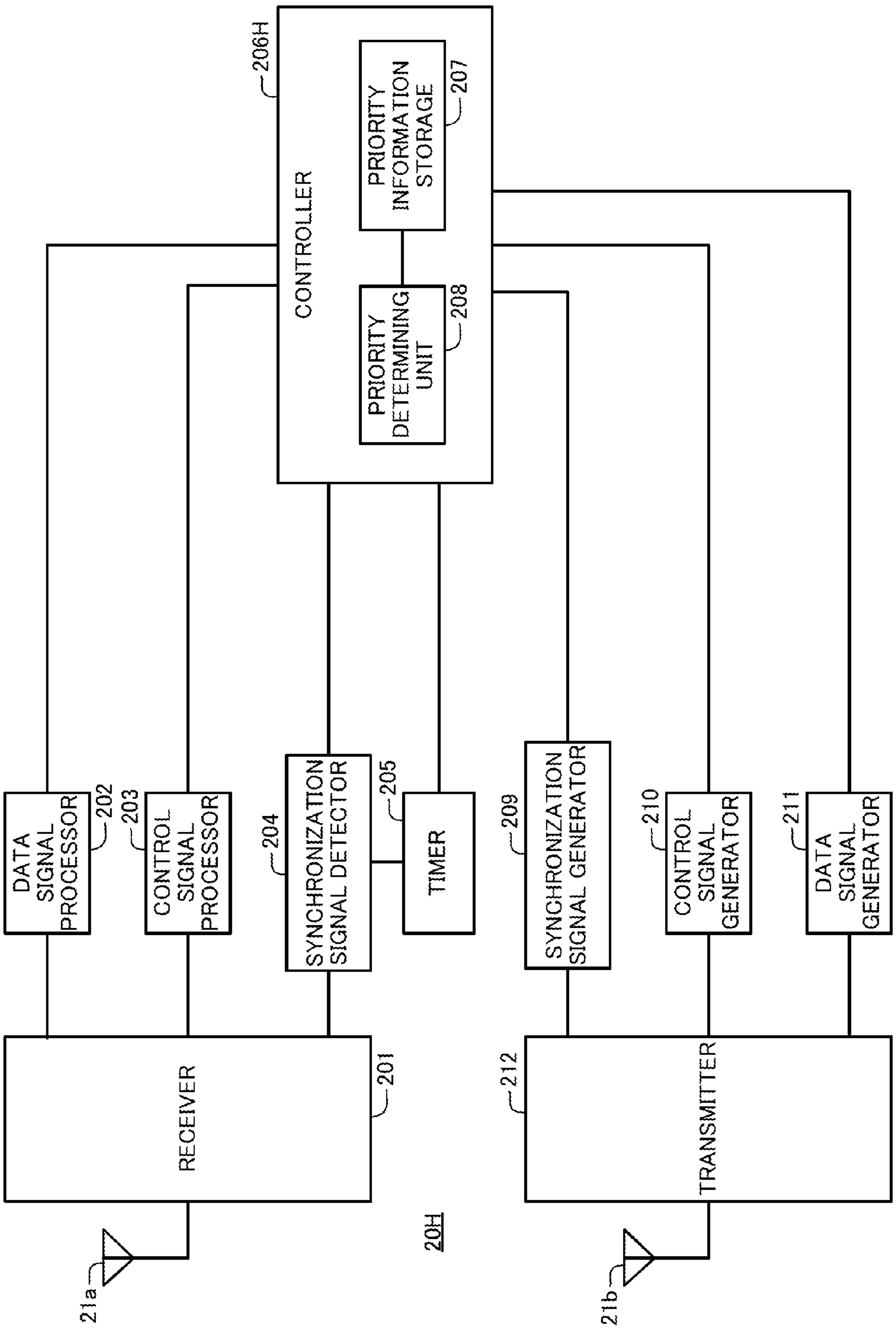

CONTROLLER
206H
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
20H
21a
21b

FIG. 21

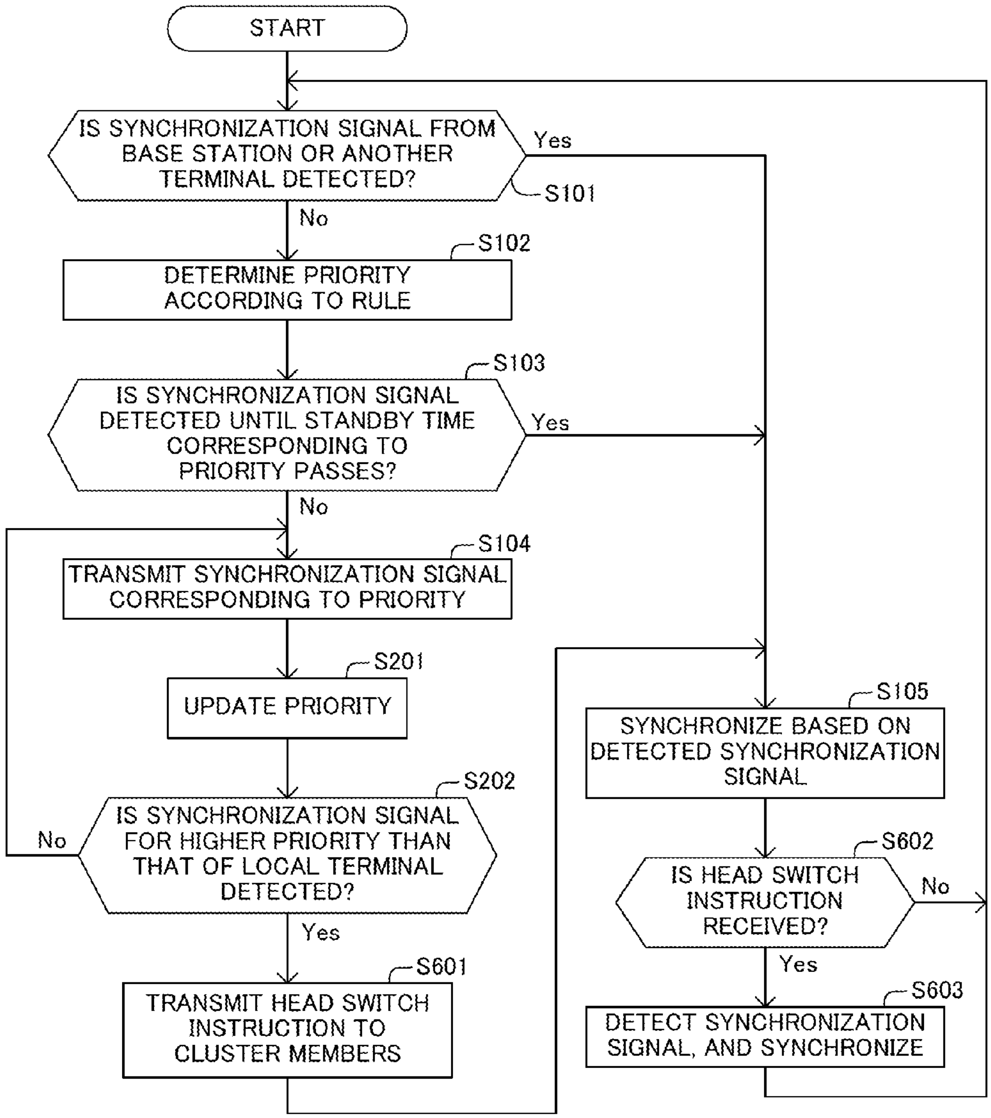

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S201
UPDATE PRIORITY
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S601
TRANSMIT HEAD SWITCH INSTRUCTION TO CLUSTER MEMBERS
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S602
IS HEAD SWITCH INSTRUCTION RECEIVED?
No
Yes
S603
DETECT SYNCHRONIZATION SIGNAL, AND SYNCHRONIZE

FIG. 22

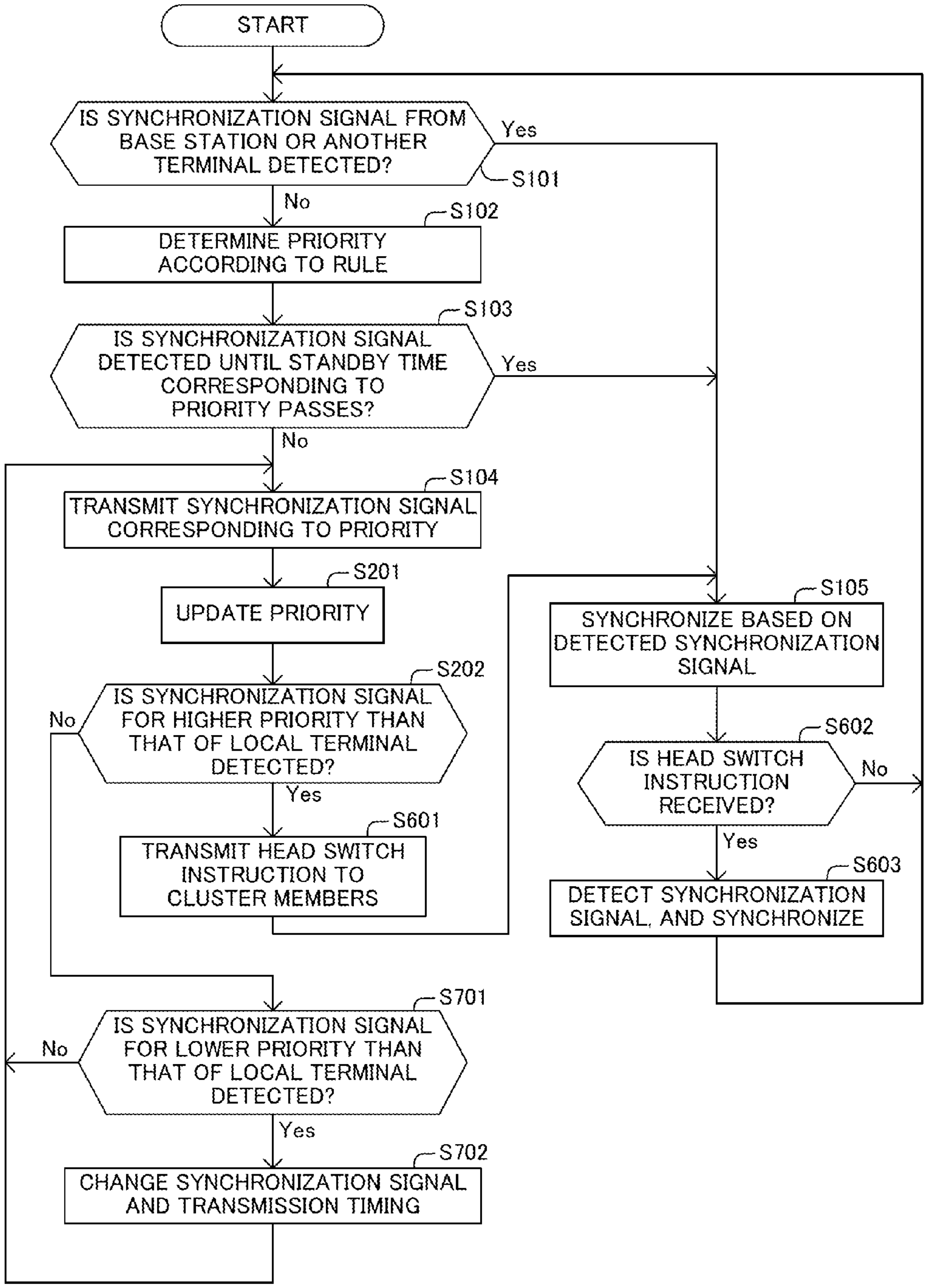

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S201
UPDATE PRIORITY
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S602
IS HEAD SWITCH INSTRUCTION RECEIVED?
No
Yes
S601
TRANSMIT HEAD SWITCH INSTRUCTION TO CLUSTER MEMBERS
S603
DETECT SYNCHRONIZATION SIGNAL, AND SYNCHRONIZE
S701
IS SYNCHRONIZATION SIGNAL FOR LOWER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S702
CHANGE SYNCHRONIZATION SIGNAL AND TRANSMISSION TIMING

FIG. 23

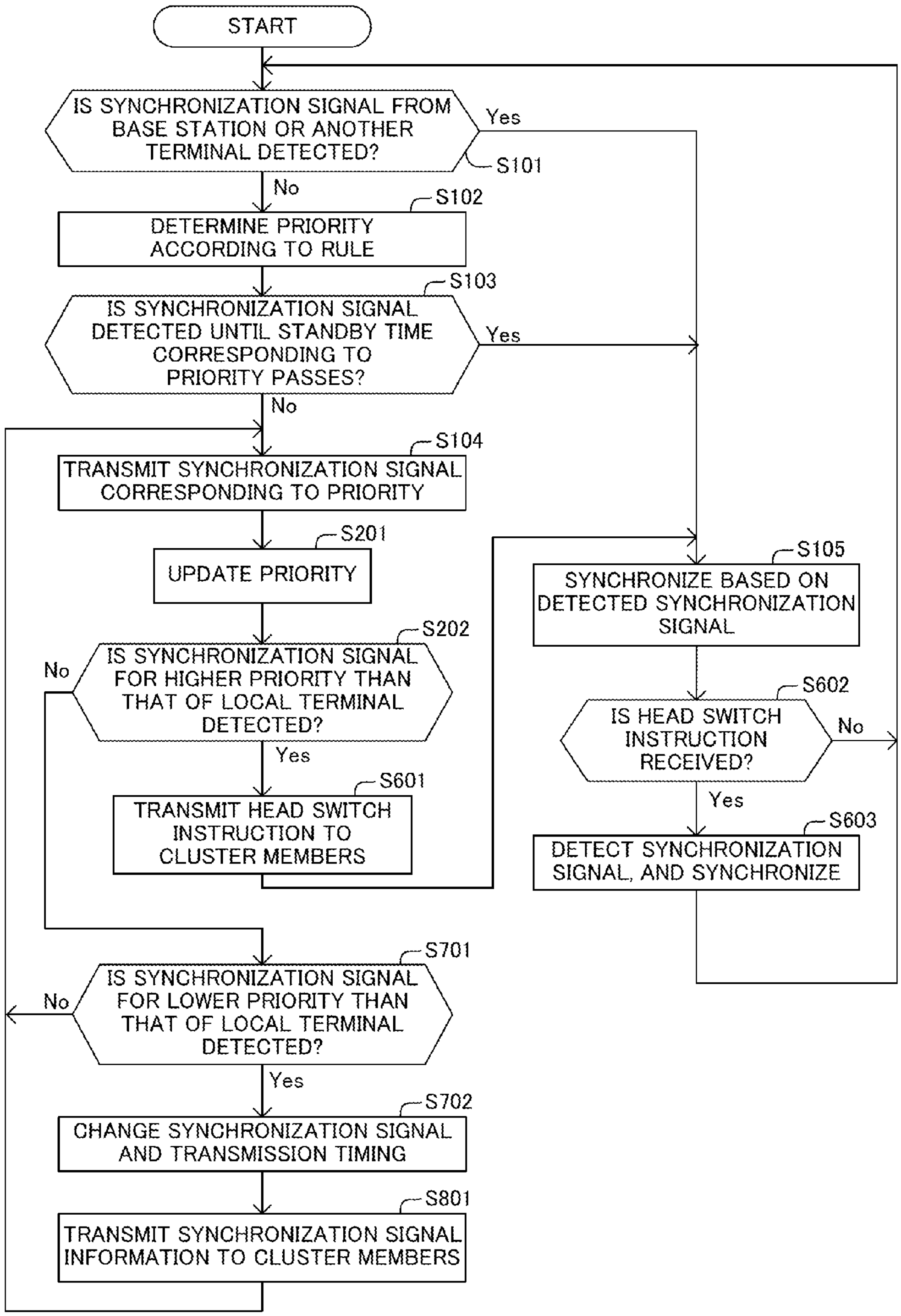

START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S201
UPDATE PRIORITY
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S602
IS HEAD SWITCH INSTRUCTION RECEIVED?
No
Yes
S601
TRANSMIT HEAD SWITCH INSTRUCTION TO CLUSTER MEMBERS
S603
DETECT SYNCHRONIZATION SIGNAL, AND SYNCHRONIZE
S701
IS SYNCHRONIZATION SIGNAL FOR LOWER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes
S702
CHANGE SYNCHRONIZATION SIGNAL AND TRANSMISSION TIMING
S801
TRANSMIT SYNCHRONIZATION SIGNAL INFORMATION TO CLUSTER MEMBERS

FIG. 24

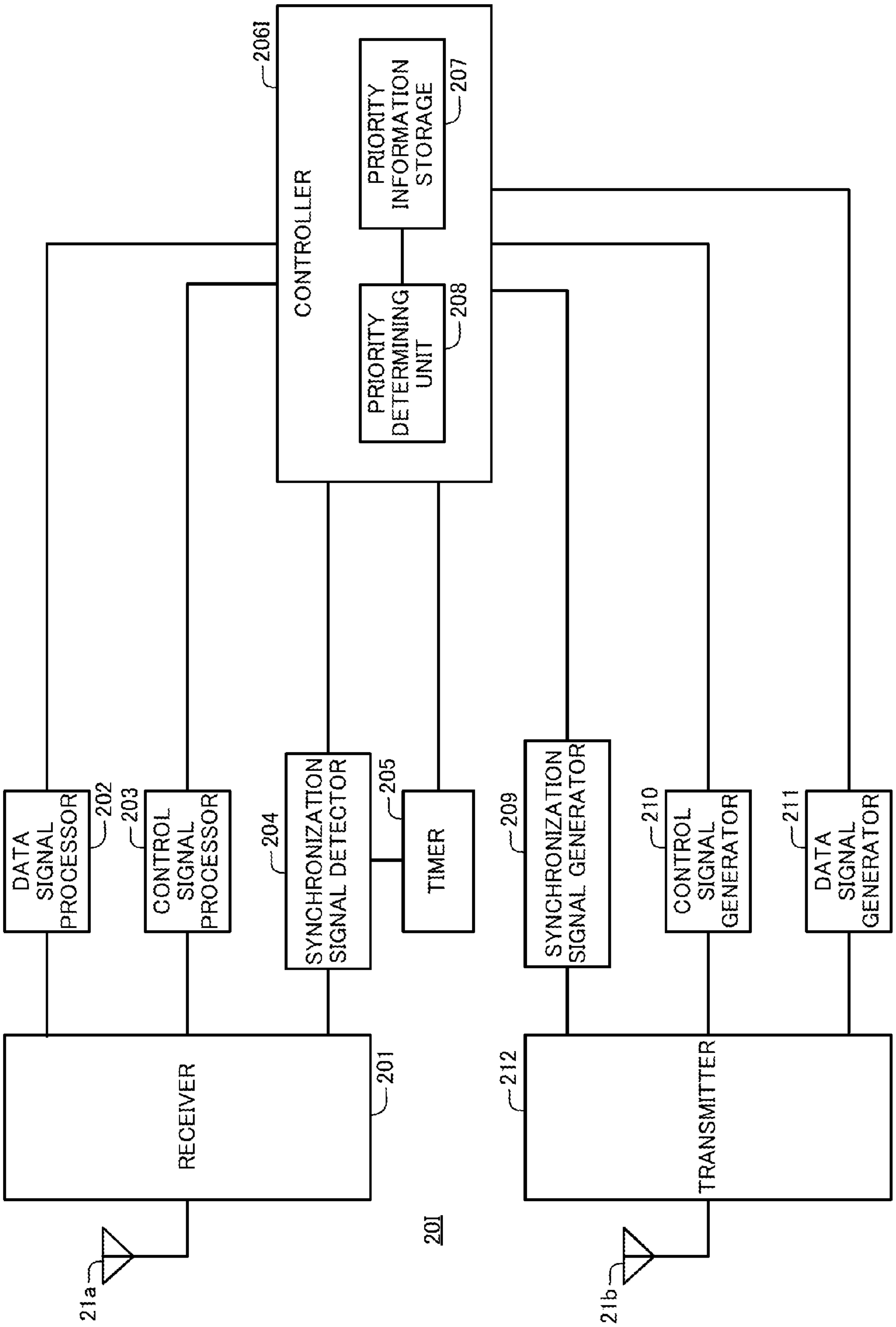
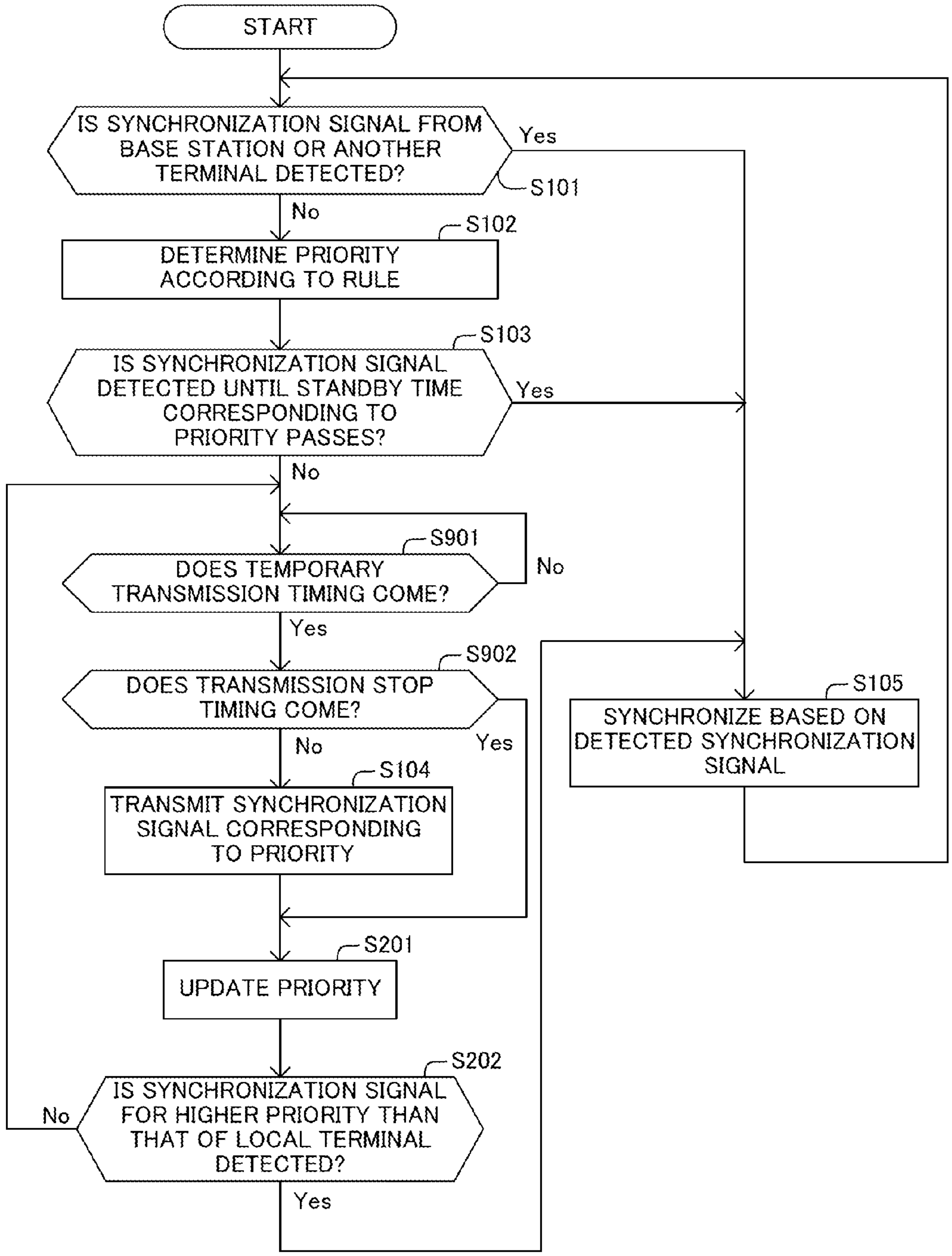

206I
CONTROLLER
PRIORITY INFORMATION STORAGE
207
PRIORITY DETERMINING UNIT
208
DATA SIGNAL PROCESSOR
202
CONTROL SIGNAL PROCESSOR
203
SYNCHRONIZATION SIGNAL DETECTOR
204
TIMER
205
SYNCHRONIZATION SIGNAL GENERATOR
209
CONTROL SIGNAL GENERATOR
210
DATA SIGNAL GENERATOR
211
RECEIVER
201
TRANSMITTER
212
20I
21a
21b

FIG. 25


START
IS SYNCHRONIZATION SIGNAL FROM BASE STATION OR ANOTHER TERMINAL DETECTED?
S101
Yes
No
S102
DETERMINE PRIORITY ACCORDING TO RULE
S103
IS SYNCHRONIZATION SIGNAL DETECTED UNTIL STANDBY TIME CORRESPONDING TO PRIORITY PASSES?
Yes
No
S901
DOES TEMPORARY TRANSMISSION TIMING COME?
No
Yes
S902
DOES TRANSMISSION STOP TIMING COME?
No
Yes
S104
TRANSMIT SYNCHRONIZATION SIGNAL CORRESPONDING TO PRIORITY
S105
SYNCHRONIZE BASED ON DETECTED SYNCHRONIZATION SIGNAL
S201
UPDATE PRIORITY
S202
IS SYNCHRONIZATION SIGNAL FOR HIGHER PRIORITY THAN THAT OF LOCAL TERMINAL DETECTED?
No
Yes

WIRELESS COMMUNICATION SYSTEM, TERMINAL, AND PROCESSING METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of International Application PCT/JP2014/066801, filed on Jun. 25, 2014 and designated the U.S., which is based upon and claims the benefit of priority of the prior International Application PCT/JP2014/057317, filed on Mar. 18, 2014. The entire contents of these applications are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a wireless communication system, a terminal, and a processing method.

BACKGROUND ART

[0003] In recent years, a next-generation wireless communication technique of providing further sophistication, a larger capacity and a higher functionality of wireless communication in wireless communication systems such as a mobile telephone system (cellular system) and the like has been studied.

[0004] For example, 3GPP (3rd Generation Partnership Project) studies D2D (Device to Device) communication for realizing direct communication between a plurality of terminals without wireless base stations.

[0005] The D2D communication is assumed to be executed for public safety, for instance. For example, when each wireless base station stops functioning due to a disaster such as an earthquake or a fire, it is possible to transmit useful information for saving lives of people between terminals by executing the D2D communication.

[0006] Further, for example, the D2D communication is assumed to be executed to disperse a communication traffic in a wireless communication system. For example, by executing the D2D communication, it is possible to reduce a load at a higher level side than each wireless base station in the wireless communication system.

[0007] Further, wireless communication systems which each include a plurality of terminals and in which terminals directly communicate with each other are known (see, for example, Patent Literatures 1 to 11 and Non Patent Literature 1).

[0008] In the wireless communication systems disclosed in Patent Literatures 1 to 11 and Non Patent Literature 1, a plurality of neighboring terminals forms clusters (also referred to as groups). In each cluster, one terminal serves as a cluster head (also referred to as a group owner) and other terminals are cluster members. Each cluster member performs communication via the cluster head.

[0009] Further, in the wireless communication systems disclosed in Patent Literatures 1 to 11 and Non Patent Literature 1, a parent terminal selects parent terminal candidates from a plurality of child terminals, and notifies the parent terminal candidates of a priority order. Thus, when a broadcast signal is not broadcast for a certain period of time, the parent terminal candidate serves as a new parent terminal in order according to the priority order and transmits broadcast signals.

CITATION LIST

[0010] Patent Literature 1: JP 2008-235961 A

[0011] Patent Literature 2: JP 2005-6327 A

[0012] Patent Literature 3: JP 2004-282758 A

[0013] Patent Literature 4: JP 2012-109827 A

[0014] Patent Literature 5: JP 2010-263349 A

[0015] Patent Literature 6: JP 2010-141726 A

[0016] Patent Literature 7: JP 2011-514716 A

[0017] Patent Literature 8: JP 2006-311172 A

[0018] Patent Literature 9: JP 2010-28636 A

[0019] Patent Literature 10: JP 2008-28445 A

[0020] Patent Literature 11: JP 2012-156976 A

[0021] Non Patent Literature 1: T. Koskela, three others, "Clustering Concept Using Device-To-Device Communication in Cellular System", Wireless Communications and Networking Conference (WCNC) 2010, IEEE, pp. 1-6, April 2010

SUMMARY

[0022] By the way, it is difficult to effectively utilize radio resources in the wireless communication systems disclosed in Patent Literatures 1 to 11 and Non Patent Literature 1 in some cases.

[0023] According to one aspect, a wireless communication system includes a plurality of terminals and a wireless base station. Each of the plurality of terminals determines a priority of a local terminal related to transmission of a certain signal according to a certain rule when the certain signal is not received from the wireless base station (e.g., each of the plurality of terminals fails to receive the certain signal).

[0024] According to another aspect, a wireless communication system includes a plurality of terminals and a wireless base station. Each of the plurality of terminals changes a priority according to a state of a local terminal, the priority being related to transmission of a certain signal in place of the wireless base station.

[0025] According to another aspect, a wireless communication system includes a plurality of terminals and a wireless base station. A first terminal of the plurality of terminals controls transmission of a certain signal based on a priority of a second terminal of the plurality of terminals in response to reception of the certain signal, the certain signal being transmitted by the second terminal in place of the wireless base station, and the priority of the second terminal being related to the transmission of the certain signal.

[0026] According to another aspect, a wireless communication system includes a plurality of terminals and a wireless base station. A first terminal of the plurality of terminals notifies at least one of a second terminal of the plurality of terminals and a third terminal of the plurality of terminals of a timing difference in response to reception of a certain signal from each of the second terminal and the third terminal, while the certain signal is transmitted in place of the wireless base station. The timing difference is a difference between a timing at which the certain signal is received from the second terminal and a timing at which the certain signal is received from the third terminal.

[0027] The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

[0028] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

BRIEF DESCRIPTION OF DRAWINGS

[0029] FIG. **1** illustrates a block diagram illustrating a configuration example of a wireless communication system according to a first embodiment.

[0030] FIG. **2** illustrates a block diagram illustrating an example of a configuration of each terminal illustrated in FIG. **1**.

[0031] FIG. **3** illustrates a block diagram illustrating an example of a function of each terminal illustrated in FIG. **1**.

[0032] FIG. **4** is a table illustrating an example of priority information stored in each terminal illustrated in FIG. **1**.

[0033] FIG. **5** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **1** to control transmission of a synchronization signal.

[0034] FIG. **6** illustrates an explanatory view illustrating an example of an operation of the wireless communication system illustrated in FIG. **1**.

[0035] FIG. **7** illustrates a block diagram illustrating an example of a function of each terminal according to Modified Example 1 of the first embodiment.

[0036] FIG. **8** is a table illustrating an example of point information stored in each terminal illustrated in FIG. **7**.

[0037] FIG. **9** illustrates a block diagram illustrating an example of a function of each terminal according to Modified Example 2 of the first embodiment.

[0038] FIG. **10** illustrates a block diagram illustrating an example of a function of each terminal according to Modified Example 3 of the first embodiment.

[0039] FIG. **11** illustrates a block diagram illustrating an example of a function of each terminal according to a second embodiment.

[0040] FIG. **12** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **11** to control transmission of a synchronization signal.

[0041] FIG. **13** illustrates a block diagram illustrating an example of a function of each terminal according to Modified Example 1 of the second embodiment.

[0042] FIG. **14** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **13** to control transmission of a synchronization signal.

[0043] FIG. **15** illustrates a block diagram illustrating an example of a function of each terminal according to Modified Example 2 of the second embodiment.

[0044] FIG. **16** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **15** to control transmission of a synchronization signal.

[0045] FIG. **17** illustrates a block diagram illustrating an example of a function of each terminal according to a third embodiment.

[0046] FIG. **18** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **17** to control transmission of a synchronization signal.

[0047] FIG. **19** illustrates explanatory view illustrating an example of an operation of a wireless communication system according to a fourth embodiment.

[0048] FIG. **20** illustrates a block diagram illustrating an example of a function of each terminal according to the fourth embodiment.

[0049] FIG. **21** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **20** to control transmission of a synchronization signal.

[0050] FIG. **22** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **20** to control transmission of a synchronization signal.

[0051] FIG. **23** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **20** to control transmission of a synchronization signal.

[0052] FIG. **24** illustrates a block diagram illustrating an example of a function of each terminal according to a fifth embodiment.

[0053] FIG. **25** is a flowchart illustrating an example of a process executed by each terminal illustrated in FIG. **24** to control transmission of a synchronization signal.

DESCRIPTION OF EMBODIMENTS

[0054] Embodiments of the present invention will be described below with reference to the drawings. However, the embodiments described below are exemplary embodiments. Hence, application of various deformations and techniques which will not be explicitly described below to the embodiments is not excluded. In addition, in the drawings used in the following embodiments, components assigned the same reference numerals will indicate identical or same components unless changes or deformations are not explicitly described.

First Embodiment

[0055] As described above, in wireless communication systems disclosed in Patent Literatures 1 to 11 and Non Patent Literature 1, a parent terminal serving as a cluster head (also referred to as a group owner) gives a notification of a priority order to child terminals serving as cluster members in advance. In this regard, application of techniques disclosed in Patent Literatures 1 to 11 and Non Patent Literature 1 to a wireless communication system in which each terminal performs communication via each wireless base station will be assumed.

[0056] In this case, terminals move, and therefore unless each wireless base station determines and sends a notification of a priority order every time a sufficiently short cycle passes, an appropriate terminal fails to be used as a cluster head when, for example, a disaster takes place. Hence, radio resources used to send a notification of the priority order are large.

[0057] Further, when each terminal of an idle state moves in the wireless communication system, and even when a wireless base station which is to be a connection destination of this terminal changes, this change is sometimes not notified to the wireless base station. Hence, there is a case where each wireless base station fails to recognize a terminal to be connected to this local wireless base station, which may result in failure of appropriately determination of a priority order.

[0058] By the way, when a terminal serving as a cluster head is changed, radio resources are used by each cluster member to change a terminal which is to be a destination of connection. When a priority order fails to be appropriately determined, a terminal serving as a cluster head is frequently changed. Hence, in this case, radio resources used by each cluster member to change a terminal which is to be a destination of connection tend to be large.

[0059] Further, when a priority order fails to be appropriately determined, the number of cluster heads tends to be large. As the number of cluster heads is larger, radio resources used to perform communication between cluster heads and control cluster heads, for example, are greater.

[0060] Thus, in the above-described wireless communication systems, it is difficult to effectively utilize radio resources in some cases. By contrast with this, radio resources are effectively used in the present embodiment.

[0061] A wireless communication system according to the first embodiment will be described in detail below.

[0062] (Configuration)

[0063] As illustrated in FIG. **1**, a wireless communication system **1** according to the first embodiment illustratively includes M base stations **10-1**, **10-2**, . . . , and **10**-M, and N terminals **20-1**, **20-2**, . . . , and **20**-N.

[0064] In the present embodiment, the symbol M represents an integer equal to or more than 1. Hereinafter, a base station **10**-*m* will be also referred to as a base station **10** below when distinction is not needing. Here, the symbol m represents an integer from one to M. In the present embodiment, the symbol N represents an integer equal to or more than two. Hereinafter, a terminal **20**-*n* will be also referred to as a terminal **20** below when distinction is not needing. Here, the symbol n represents an integer from one to N.

[0065] The wireless communication system **1** performs wireless communication between the base stations **10** and the terminals **20** according to a predetermined wireless communication scheme. For example, the wireless communication scheme is an LTE-Advanced scheme. The LTE is an abbreviation of Long Term Evolution. In addition, the wireless communication scheme may be a scheme (e.g., an LTE or WiMAX (registered trademark) scheme different from the LTE-Advanced scheme. The WiMAX is an abbreviation of Worldwide Interoperability for Microwave Access.

[0066] In the present embodiment, each base station **10** forms one wireless area. In addition, each base station **10** may form a plurality of wireless areas. Each wireless area may be referred to as a coverage area or a communication area. For example, a wireless area is a cell such as a macrocell, a microcell, a nanocell, a picocell, a femtocell, a home cell or a sector cell.

[0067] Further, each base station **10** may be an eNB (Evolved Node B), a NB (Node B), a macro base station, a micro base station, a nano base station, a pico base station, a femto base station or a home base station. Note that, each base station **10** is an example of a wireless base station.

[0068] In the present embodiment, each base station **10** is connected to a communication network (e.g., core network) NW which enables wired communication. In addition, each base station **10** may be connected to the communication network NW which enables wireless communication. An interface between the base station **10** and the communication network NW may be referred to as an S1 interface. Further, an interface between the base stations **10** may be referred to as an X2 interface.

[0069] Furthermore, each base station **10** and a portion closer to the communication network (i.e., upper level) NW side than each base station **10** in the wireless communication system **1** may be referred to as E-UTRAN. The E-UTRAN is an abbreviation of Evolved Universal Terrestrial Radio Access Network.

[0070] In the present embodiment, each terminal **20** may be referred to as a mobile station, a terminal device or a user terminal (UE; User Equipment). For example, each terminal **20** is a device such as a mobile telephone, a smartphone, a sensor or a meter (measuring equipment). Each terminal **20** may be carried by a user, may be mounted on a moving body such as a vehicle or may be fixed.

[0071] Each base station **10** transmits a synchronization signal (SS) in a wireless area. Each terminal **20** detects a synchronization signal in a wireless area including a position of the corresponding each terminal **20** to identify this wireless area, and synchronizes a communication timing with that of the base station **10** which forms this wireless area.

[0072] Note that, that it is possible to identify a start time point of a radio frame of a radio signal is an example where communication timings are synchronized. Further, that it is possible to identify a start time point of a symbol of a radio signal is an example where communication timings are synchronized. Furthermore, that communication timings are synchronized between the base station **10** and the terminal **20** in a wireless area formed by the base station **10** is an example where the base station **10** and the terminal **20** are connected.

[0073] A synchronization signal is an example of a signal used to detect a wireless area. The synchronization signal may be used to make frequencies used for wireless communication match between the base station **10** and the terminal **20**. The synchronization signal is an example of a certain signal.

[0074] Each base station **10** allocates radio resources to the terminal **20** with a synchronized communication timing in a wireless area formed by each local base station **10**. In the present embodiment, radio resources may include a time and a frequency. In other words, the radio resources may be identified based on the time and the frequency. In a wireless area with a synchronized communication timing, each terminal **20** performs wireless communication with the base station **10** by using radio resources allocated by the base station **10** forming this wireless area.

[0075] Further, each terminal **20** performs direct wireless communication with terminals **20** (in other words, other terminals **20**) different from the local terminal **20** when a synchronization signal from the base station **10** is not received (e.g., the local terminal **20** fails to receive the synchronization signal). In the present embodiment, part of the terminals **20** among the terminals **20** which do not receive synchronization signals yet from the base station **10** operate as the terminal **20** which backs up at least part of functions of the base station **10**. The terminal **20** which backs up at least the part of functions of the base station **10** is also referred to as a cluster head **20** (also referred to as a group owner). The rest of the terminals **20** among the terminals **20** which do not receive synchronization signals yet from the base station **10** will be also referred to as cluster members **20** (also referred to as group members).

[0076] In the present embodiment, each cluster head **20** forms a wireless area, and transmits a synchronization signal in the wireless area. Each cluster member **20** detects a synchronization signal in a wireless area including a position of the corresponding each cluster member **20** to identify this wireless area, and synchronize a communication timing with that of the cluster head **20** which forms this wireless area. That communication timings are synchronized between the cluster head **20** and the cluster members **20** in the wireless area formed by the cluster head **20** is an example where the cluster head **20** and the cluster members **20** are connected.

[0077] Each cluster head **20** allocates radio resources to the cluster members **20** with the synchronized communication timings in a wireless area formed by each local terminal. In a wireless area with the synchronized communication timing, each cluster member **20** performs wireless communication with the cluster head **20** by using the radio resources allocated by the cluster head **20** forming this wireless area. For example, the cluster members **20** may communicate with the cluster head **20**. Further, the cluster members **20** may communicate with other cluster members **20** via the cluster head **20**. Furthermore, the cluster members **20** may directly communicate with other cluster members **20** by using radio resources allocated by the cluster head **20**.

[0078] In the present embodiment, the cluster members **20** communicate with the cluster head **20** or other cluster members **20** by using radio resources allocated by the cluster head **20**. By the way, the cluster members **20** may select radio resources to be used by the each local cluster member **20** among predetermined radio resource candidate (also referred to as a resource pool), and communicate with the cluster head **20** or other cluster members **20** by using the selected radio resources. The same applies to other embodiments and Modified Examples, too.

[0079] As illustrated in FIG. **2**, the terminal **20** illustratively includes an antenna **21**, a memory **22**, a CPU **23**, a RF circuit **24**, an LSI **25** and an input/output unit **26**. The CPU is an abbreviation of a Central Processing Unit. The RF is an abbreviation of a Radio Frequency. The LSI is an abbreviation of Large Scale Integration.

[0080] The memory **22** stores information in a readable and writable way. For example, the memory **22** may be a RAM, a semiconductor memory or an organic memory. The RAM is an abbreviation of a Random Access Memory. The memory **22** may include a ROM. The ROM is an abbreviation of a Read Only Memory.

[0081] The CPU **23** executes a program stored in the memory **22** to control the antenna **21**, the memory **22**, the RF circuit **24**, the LSI **25** and the input/output unit **26**.

[0082] The RF circuit **24** transmits and receives radio signals via the antenna **21**. In the present embodiment, transmission and reception of the radio signals include conversion of digital signals and analog signals to and from each other, conversion of a frequency and amplification of the radio signals.

[0083] The LSI **25** processes a digital signal for performing wireless communication. The LSI **25** outputs the digital signal based on the radio signal to be transmitted, to the RF circuit **24**. The LSI **25** receives an input of the digital signal based on the received radio signal, from the RF circuit **24**. In addition, the LSI **25** may include a programmable logic device (PLD).

[0084] The input/output unit **26** receives an input of information. For example, this information may be input by a user of the terminal **20**. Further, the input/output unit **26** outputs information. In the present embodiment, the input/output unit **26** is a touch panel-type display. In addition, the input/output unit **26** may include a key-type button in addition to a display. Further, the input/output unit **26** may include a display of a different scheme from a touch panel-type.

[0085] (Function)

[0086] As illustrated in FIG. **3**, the terminal **20** functionally includes a receiver **201**, a data signal processor **202**, a control signal processor **203**, a synchronization signal detector **204**, a timer **205** and a controller **206**. The controller **206** includes, for example, a priority information storage **207** and a priority determining unit **208**. Further, the terminal **20** functionally includes a synchronization signal generator **209**, a control signal generator **210**, a data signal generator **211** and a transmitter **212**.

[0087] In the present embodiment, the receiver **201** and the transmitter **212** are realized by the RF circuit **24**. Further, in the present embodiment, the antenna **21** includes a reception antenna **21***a* and a transmission antenna **21***b*. In addition, the antenna **21** includes a duplexer, and one antenna may be shared by the duplexer for transmission and reception.

[0088] In the present embodiment, the function units **202** to **211** different from the receiver **201** and the transmitter **212** among the functions of the terminal **20** are realized by the LSI **25**. In addition, at least part of the function units **202** to **211** may be realized by the CPU **23** and the memory **22**.

[0089] The receiver **201** executes a reception process for a radio signal received via the reception antenna **21***a*, and outputs an execution result as a received signal. For example, the reception process includes amplifying a radio signal, converting (in other words, down-converting) a radio frequency into a base frequency and converting an analog signal into a digital signal.

[0090] Hereinafter, a communication state of the terminal **20** will be described. In the present embodiment, the communication state of the terminal **20** includes first to third communication states.

[0091] In the first communication state, the terminal **20** receives a synchronization signal transmitted at the base station **10** without transmitting a synchronization signal, and communicates with the base station **10** based on the received synchronization signal.

[0092] In the second communication state, the terminal **20** receives a synchronization signal transmitted at the another terminal **20** without transmitting a synchronization signal, and communicates with the another terminal **20** or the still another terminal **20** whose communication state is the second communication state based on the received synchronization signal. That the communication state of the terminal **20** is the second communication state is an example where the terminal **20** is used as a cluster member.

[0093] In the third communication state, the terminal **20** transmits a synchronization signal, and communicates with the another terminal **20** which has received the synchronization signal. That the communication state of the terminal **20** is the third communication state is an example where the terminal **20** is used as a cluster head.

[0094] Next, an operation mode of the terminal **20** will be described.

[0095] In the present embodiment, the terminal **20** operates in one operation mode among a plurality of operation modes. A plurality of operation modes includes a first operation mode and a second operation mode.

[0096] In the present embodiment, when the terminal **20** operates in the first operation mode, the communication state of the terminal **20** is the first or second communication state. Hence, in the present embodiment, when the terminal

20 operates in the first operation mode, the terminal **20** is sometimes used as a cluster member.

[0097] Further, in the present embodiment, when the terminal **20** operates in the second operation mode, the communication state of the terminal **20** is the third communication state. Hence, in the present embodiment, when the terminal **20** operates in the second operation mode, the terminal **20** is used as a cluster head.

[0098] The first operation mode is an operation mode that the terminal **20** communicates with the base station **10** or the another terminal **20** operating in the first operation mode or the second operation mode. In the first operation mode, the terminal **20** receives a synchronization signal from the base station **10** or the another terminal **20** operating in the second operation mode. Further, in the first operation mode, the terminal **20** identifies a wireless area based on the received synchronization signal, and synchronizes a communication timing with that of the base station **10** or the another terminal **20** forming this wireless area.

[0099] In addition, in the first operation mode, in the wireless area with the synchronized communication timing, the terminal **20** performs wireless communication with the base station **10** and the another terminal **20** operating in the first operation mode or the second operation mode. This wireless communication is performed by using radio resources allocated by the base station **10** or the another terminal **20** forming the above wireless area.

[0100] An example where the terminal **20** performs wireless communication by using radio resources allocated by the another terminal **20** forming a wireless area is described herein. By the way, the terminal **20** may select radio resources to be used by the local terminal **20**, from a predetermined radio resource candidate (also referred to as a resource pool). In this case, the terminal **20** may perform wireless communication with the another terminal **20** operating in the first operation mode or the second operation mode by using the selected radio resources.

[0101] The second operation mode is an operation mode that the terminal **20** communicates with the another terminal **20** operating in the first operation mode. In the second operation mode, the terminal **20** transmits a synchronization signal. Further, in the second operation mode, the terminal **20** allocates radio resources to other terminals **20** positioned in a wireless area formed by the local terminal **20**. In addition, in the second operation mode, the terminal **20** performs wireless communication with the another terminal **20** by using radio resources allocated to the another terminal **20**.

[0102] The data signal processor **202** processes a data signal from the radio resources allocated to the local terminal **20** by the base station **10** or the another terminal **20** in the first operation mode.

[0103] Further, the data signal processor **202** processes a data signal from radio resources allocated to the another terminal **20** by the local terminal **20** in the second operation mode.

[0104] In the present embodiment, the data signal processor **202** executes a demodulation/decoding process for the data signal. In the present embodiment, the demodulation/decoding process includes a process of demodulating a data signal, and an error correction decoding process based on an error correction coding performed on a data signal. In addition, the demodulation/decoding process may include an error detection process based on an error detection code added to a data signal.

[0105] The control signal processor **203** processes a control signal from the radio resources allocated by the base station **10** or the another terminal **20** in the first operation mode.

[0106] Further, the control signal processor **203** processes the control signal from the radio resources allocated by the local terminal **20** in the second operation mode.

[0107] In the present embodiment, the control signal processor **203** executes a demodulation/decoding process for the control signal. In the present embodiment, the demodulation/decoding process includes a process of demodulating a control signal, and an error correction decoding process based on an error correction coding performed on the control signal. In addition, the demodulation/decoding process may include an error detection process based on an error detection code added to a control signal.

[0108] The synchronization signal detector **204** detects a synchronization signal based on the received signal output by the receiver **201**. The synchronization signal detector **204** outputs the detection result.

[0109] The synchronization signal detector **204** determines whether or not a state where a synchronization signal is not detected continues for a certain determination time or more, by using the timer **205** in the first operation mode. In the present embodiment, the determination time has a predetermined value. The synchronization signal detector **204** outputs the determination result in the first operation mode.

[0110] The controller **206** identifies a wireless area based on a detection result from the synchronization signal detector **204** in the first operation mode. Further, the controller **206** performs control to synchronize a communication timing with that of the base station **10** or the another terminal **20** forming the above wireless area, based on the detection result from the synchronization signal detector **204** in the first operation mode.

[0111] In addition, the controller **206** performs control to perform wireless communication with the base station **10** or the another terminal **20** by using the radio resources allocated by the base station **10** or the another terminal **20** forming the above wireless area in the first operation mode.

[0112] Further, the controller **206** switches the operation mode of the terminal **20** to the second operation mode when the determination result from the synchronization signal detector **204** indicates that the state where the synchronization signal is not detected continues for the determination time or more in the first operation mode.

[0113] When the controller **206** switches the operation mode of the terminal **20** from the first operation mode to the second operation mode, the priority determining unit **208** determines a priority of the local terminal **20**.

[0114] As described below, the terminal **20** having a higher priority can more easily select the second operation mode for transmitting a synchronization signal. In other words, the terminal **20** having a lower priority can easily select the first operation mode for not transmitting a synchronization signal. Thus, the priority represents an extent of the priority of transmission of a synchronization signal at the terminal **20** in place of the base station **10**. The priority is an example of information related to transmission of a synchronization signal transmitted in place of the base station **10**.

[0115] The priority information storage **207** stores in advance priority information indicating a relationship between information related to the terminal **20** and a priority. Storage of priority information is an example where priority information is held. As illustrated in FIG. **4**, in the present embodiment, priority information is table format data. Further, in the present embodiment, a priority is higher as a value is smaller. The priority information may be distributed to each terminal **20** in the wireless communication system **1**.

[0116] The information related to the terminal **20** illustratively includes a user type, a terminal position, whether or not power is supplied, a remaining amount of a battery, availability of other communication functions and availability of a GPS function. The GPS is an abbreviation of a Global Positioning System.

[0117] The user type represents a type of a user who possesses the terminal **20**. Whether or not power is supplied represents whether or not power is supplied to the terminal **20**. The remaining amount of the battery represents remaining power of the battery of the terminal **20**. The availability of other communication functions represents whether or not the terminal **20** can use communication schemes different from a communication scheme used to perform wireless communication with the base station **10**. The availability of the other communication functions is an example where the number of communication schemes which the terminal **20** can use is two or more. For example, the other communication functions may be functions which comply with wireless LAN (Local Area Network) systems. The availability of the GPS function represents whether or not the terminal **20** includes the GPS function.

[0118] The information related to the terminal **20** may include at least one of whether the terminal **20** is positioned indoor or outdoor, a speed at which the terminal **20** moves, performance of the antenna of the terminal **20**, transmission power of the terminal **20** and a billing state of the terminal **20**. For example, the terminal **20** may obtain the number of GPS satellites which are transmission sources of GPS signals based on received GPS signals, and determine whether the terminal **20** is positioned indoor or outdoor, based on the obtained number of GPS satellites.

[0119] Further, the information related to the terminal **20** may be a combination of one or two or more pieces of the information illustrated above.

[0120] The type of the user whose possesses the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. When, for example, performance of the terminal **20** differs, the terminals **20** which police officers, firefighters or civil servants possess are sometimes more suitably used as cluster head than the terminals **20** which ordinary people possess. The performance of the terminal **20** is, for example, a security strength, an information processing speed or a communication speed.

[0121] The position of the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, the terminal **20** positioned in an urban area tends to have a larger number of the other communicable terminals **20** than the terminal **20** positioned in a suburb, and therefore is sometimes suitably used as a cluster head. Further, as, for example, a height of the terminal **20** is higher, a probability that an obstacle exists lowers. Hence, as the height is higher, the terminal **20** tends to have a larger number of other communicable terminals **20**, and therefore is sometimes suitably used as a cluster head.

[0122] Whether the terminal **20** is positioned indoor or outdoor, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, the terminal **20** existing outdoor tends to have a larger number of other communicable terminals **20** than the terminals **20** existing indoor, and therefore is sometimes suitably used as a cluster head.

[0123] Whether or not power is supplied to the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, the terminal **20** to which power is supplied is assumed to be able to operate for a longer period than the terminal **20** to which power is not supplied, and therefore is sometimes suitably used as a cluster head.

[0124] The remaining amount of the battery of the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, as the remaining amount of the battery is higher, the terminal **20** is assumed to be able to operate for a longer period, and therefore is sometimes suitably used as a cluster head.

[0125] The speed at which the terminal **20** moves, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, as the moving speed becomes slower, the terminal **20** is assumed to be able to maintain connection with cluster members for a longer period, and therefore is sometimes suitably used as a cluster head.

[0126] The performance of the antenna of the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, as the performance of the antenna is higher, the terminal **20** tends to have a larger number of the other communicable terminals **20**, and therefore is sometimes suitably used as a cluster head. For example, the performance of the antenna may be an antenna gain.

[0127] Further, the terminal **20** including the antenna which does not have directionality tends to have a larger number of the other communicable terminals **20** than the terminal **20** including the antenna which has directionality, and therefore is sometimes suitably used as a cluster head.

[0128] The transmission power of the terminal **20**, and the adequacy that the terminal **20** is used as a cluster head are correlated. For example, as the transmission power is higher, the terminal **20** tends to have a larger number of the other communicable terminals **20**, and therefore is sometimes suitably used as a cluster head.

[0129] The number of usable communication schemes by the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, as the terminal **20** has a larger number of usable communication schemes, and therefore is sometimes suitably used as a cluster head since a probability that it is possible to communicate with another device by using one of the communication schemes is high.

[0130] The availability of the GPS function of the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, the terminal **20** including the GPS function can obtain an accurate time which serves as a synchronization reference, by receiving a GPS signal, and therefore is sometimes suitably used as a cluster head.

[0131] The billing state of the terminal **20**, and adequacy that the terminal **20** is used as a cluster head are correlated. For example, to what degree the terminal **20** is suitably used as a cluster head is sometimes determined according to a billing amount.

[0132] In the present embodiment, the priority determining unit **208** obtains information related to the terminal **20**. For example, the priority determining unit **208** may detect whether or not power is supplied, and a remaining amount of the battery. For example, the priority determining unit **208** may store information indicating a user type, availability of other communication functions and availability of the GPS function in advance, and obtain the stored information.

[0133] The priority determining unit **208** determines a priority of the local terminal **20** based on the obtained information related to the terminal **20**, and priority information stored in the priority information storage **207**.

[0134] Consequently, the terminal **20** can appropriately determine the priority of the local terminal **20**. Further, determination of the priority of the local terminal **20** based on the priority information is an example where the priority of the local terminal **20** is determined according to a certain rule.

[0135] Thus, the terminal **20** determines the priority of the local terminal **20** related to transmission of a synchronization signal according to the certain rule when the synchronization signal is not received from the base station **10**.

[0136] Consequently, a notification of a priority to the terminal **20** from the base station **10** can be made unnecessary. As a result, it is possible to effectively use radio resources.

[0137] The controller **206** determines whether or not a synchronization signal has been received from the another terminal **20** until a standby time passes after the operation mode of the terminal **20** is switched from the first operation mode to the second operation mode. The standby time may be set to a shorter time as the priority determined by the priority determining unit **208** is higher. In the present embodiment, the controller **206** stores in advance information indicating a relationship between the priority and the standby time, and determines the standby time based on the determined priority and the stored information.

[0138] When determining that the synchronization signal has been received from the another terminal **20** until the standby time passes after the operation mode is switched from the first operation mode to the second operation mode, the controller **206** switches the operation mode of the terminal **20** from the second operation mode to the first operation mode.

[0139] When determining that the synchronization signal has not been received from the another terminal **20** until the standby time passes after the operation mode is switched from the first operation mode to the second operation mode, the controller **206** controls the synchronization signal generator **209** to start transmitting synchronization signals.

[0140] Thus, the terminal **20** starts transmitting a synchronization signal when not receiving the synchronization signal until the standby time corresponding to the determined priority passes. In other words, the terminal **20** determines whether or not to transmit a synchronization signal in place of the base station **10** according to the priority.

[0141] Consequently, the terminal **20** having a higher priority can increase a probability that the terminal **20** is used as a cluster head. Further, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0142] The synchronization signal generator **209** generates a synchronization signal associated with the priority determined by the priority determining unit **208** in the second operation mode. In the present embodiment, the synchronization signal generator **209** associates a priority and an identifier for identifying a Zadoff-Chu sequence in advance to store, and generates a synchronization signal by using the Zadoff-Chu sequence identified based on the identifier associated with the determined priority. Consequently, the another terminal **20** having received the synchronization signal can recognize the priority associated with this synchronization signal.

[0143] The synchronization signal generator **209** outputs the generated synchronization signal to transmit the synchronization signal by using predetermined radio resources under control of the controller **206**.

[0144] The control signal generator **210** generates a control signal indicating control information. In the present embodiment, the control signal generator **210** executes a coding/modulation process for the generated control signal. In the present embodiment, the coding/modulation process includes a process of performing error correction coding for a control signal and a process of modulating the control signal. In addition, the coding/modulation process may include a process of adding an error detection code for the control signal.

[0145] The control signal generator **210** outputs the generated control signal to transmit the control signal by using radio resources allocated to the local terminal **20** by the base station **10** or the another terminal **20** in the first operation mode.

[0146] Further, the control signal generator **210** outputs the generated control signal to transmit the control signal by using the radio resources allocated to the another terminal **20** by the local terminal **20** in the second operation mode.

[0147] The data signal generator **211** generates a data signal indicating user data. In the present embodiment, the data signal generator **211** executes a coding/modulation process for the generated data signal. In the present embodiment, the coding/modulation process includes a process of performing error correction coding for a data signal and a process of modulating the data signal. In addition, the coding/modulation process may include a process of adding an error detection code for the data signal.

[0148] The data signal generator **211** outputs the generated data signal to transmit the data signal by using the radio resources allocated to the local terminal **20** by the base station **10** or the another terminal **20** in the first operation mode.

[0149] Further, the data signal generator **211** outputs the generated data signal to transmit the data signal by using the radio resources allocated to the another terminal **20** by the local terminal **20** in the second operation mode.

[0150] The transmitter **212** executes a transmission process for signals output from each of the function units **209** to **211**, and transmits a radio signal which is an execution result via the transmission antenna **21***b*. For example, the transmission process includes converting a digital signal into an analog signal, converting a base frequency into a radio frequency (in other words, up-conversion) and amplifying the radio signal.

[0151] (Operation)

[0152] Next, an operation of the wireless communication system **1** will be described with reference to FIGS. **5** and **6**. Hereinafter, part of the operation of the wireless communication system **1** related to transmission of a synchronization signal at the terminal **20** will be described.

[0153] As illustrated in the flowchart in FIG. **5**, the terminal **20** determines whether or not a synchronization signal from the base station **10** or the another terminal **20** is detected until the determination time passes when the terminal **20** operates in the first operation mode (step S**101** in FIG. **5**).

[0154] In this regard, it is assumed that the terminal **20** does not detect a synchronization signal from the base station **10** or the another terminal **20** until the determination time passes. In this case, the terminal **20** determines "No", and determines a priority according to the rule (step S**102** in FIG. **5**). In the present embodiment, the terminal **20** obtains information related to the terminal **20**, and determines the priority based on the obtained information and the stored priority information.

[0155] That the synchronization signal is not detected until the determination time passes represents that a state where the synchronization signal is not detected continues for the determination time or more. In the present embodiment, that the terminal **20** determines No in step S**101** in FIG. **5** represents that the operation mode of the terminal **20** is switched from the first operation mode to the second operation mode. In the present embodiment, the terminal **20** determines a priority based on the stored priority information. In addition, the processes in steps S**101** and S**102** in FIG. **5** may be executed in order reverse to the order illustrated in FIG. **5**.

[0156] Next, the terminal **20** determines whether or not a synchronization signal from the another terminal **20** is detected until the standby time corresponding to the determined priority passes (step S**103** in FIG. **5**).

[0157] Hereinafter, a case where the synchronization signal from the another terminal **20** is not detected until the standby time passes will be assumed. In this case, the terminal **20** determines "No", and transmits a synchronization signal corresponding to the priority (step S**104** in FIG. **5**). Subsequently, the terminal **20** continues transmitting synchronization signals.

[0158] In addition, the terminal **20** determines "Yes" when detecting the synchronization signal from the base station **10** or the another terminal **20** until the determination time passes in step S**101** in FIG. **5**. In this case, the terminal **20** synchronizes a communication timing with that of the base station **10** or the another terminal **20** which has transmitted the synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **5**). Subsequently, the terminal **20** returns to step S**101** in FIG. **5** to repeatedly execute the processes in steps S**101** to S**105**.

[0159] Further, the terminal **20** determines "Yes" when detecting the synchronization signal from the another terminal **20** until the standby time passes in step S**103** in FIG. **5**. In the present embodiment, that the terminal **20** determines "Yes" in step S**103** in FIG. **5** represents that the operation mode of the terminal **20** is switched from the second operation mode to the first operation mode. In this case, the terminal **20** synchronizes a communication timing with that of the base station **10** or the another terminal **20** which has transmitted a synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **5**). Subsequently, the terminal **20** returns to step S**101** in FIG. **5** to repeatedly execute the processes in steps S**101** to S**105**.

[0160] For example, a case where, as illustrated in FIG. **6**, the wireless communication system **1** includes the ten terminals **20-1**, **20-2**, . . . and **20-10** will be assumed. In this case, a case where each terminal **20** fails to receive a synchronization signal from the base station **10** will be assumed.

[0161] Further, in this case, a case where the priorities of the terminals **20-1** and **20-2** are higher than priorities of the other terminals **20-3**, **20-4**, . . . , and **20-10** will be assumed. In this case, the terminals **20-1** and **20-2** start transmitting synchronization signals earlier than the other terminals **20-3**, **20-4**, . . . and **20-10**.

[0162] In the present embodiment, a case where the other terminals **20-3**, **20-4**, . . . and **20-6** are positioned in a wireless area **30-1** formed by the terminal **20-1** will be assumed. Further, in the present embodiment, a case where the other terminals **20-7**, **20-8**, . . . and **20-10** are positioned in a wireless area **30-2** formed by the terminal **20-2** will be assumed.

[0163] In this case, the other terminals **20-3**, **20-4**, . . . and **20-10** receive synchronization signals from the terminal **20-1** or **20-2** until the standby time passes.

[0164] Hence, in the present embodiment, the terminals **20-1** and **20-2** operate in the second operation mode. Further, the other terminals **20-3**, **20-4**, . . . and **20-10** operate in the first operation mode.

[0165] As described above, in the wireless communication system **1** according to the first embodiment, each of a plurality of terminals **20** determines the priority of the local terminal **20** related to transmission of a synchronization signal according to the certain rule when not receiving a synchronization signal from the base station **10**.

[0166] Consequently, a notification of the priority to the terminal **20** from the base station **10** can be made unnecessary. As a result, it is possible to effectively use radio resources.

[0167] In addition, the terminal **20** may determine the priority based on information input by a user of the local terminal **20**.

[0168] Further, each synchronization signal need not to be associated with a priority. In this case, information indicating a priority may be transmitted together with each synchronization signal.

Modified Example 1 of First Embodiment

[0169] Next, a wireless communication system according to Modified Example 1 of the first embodiment of the present invention will be described. The wireless communication system according to Modified Example 1 of the first embodiment differs from the wireless communication system according to the first embodiment in assigning weights to a plurality of pieces of element information included information related to each terminal, and determining a priority. Such a difference will be mainly described below. In addition, in description of Modified Example 1 of the first embodiment, components assigned the same reference numerals as those used in the first embodiment will be identical or substantially same components.

[0170] As illustrated in FIG. **7**, a terminal **20**A according to Modified Example 1 functionally includes a controller **206**A instead of the controller **206** in FIG. **3**. The controller **206**A includes the same functions as those of the controller **206** except that the controller **206**A includes a point information storage **213**A and a priority calculator **214**A instead of the priority information storage **207** and the priority determining unit **208**.

[0171] The point information storage **213**A stores in advance point information indicating a relationship between information contents and points for each of a plurality of pieces of element information included in the information related to the terminal **20**A. Storage of the point information is an example where point information is held. As illustrated in FIG. **8**, in this example, the point information is table format data.

[0172] The priority calculator **214**A calculates a total sum of points for a plurality of pieces of element information based on the relationship stored in the point information storage **213**A. The priority calculator **214**A determines the priority based on the calculated total sum of the points. In this example, the priority calculator **214**A determines the calculated total sum of the points as the priority. Determination of the priority based on the total sum of the points is an example where weights are assigned to a plurality of pieces of element information included in the information related to the terminal **20**A and determining a priority.

[0173] By the way, an influence on adequacy that the terminal **20**A is used as a cluster head differs per element information. Consequently, the terminal **20**A according to Modified Example 1 can reflect the difference of the influence in the priority. As a result, it is possible to appropriately determine the priority.

Modified Example 2 of First Embodiment

[0174] Next, a wireless communication system according to Modified Example 2 of the first embodiment of the present invention will be described. The wireless communication system according to Modified Example 2 of the first embodiment differs from the wireless communication system according to the first embodiment in determining a priority based on a pseudo random number. Such a difference will be mainly described below. In addition, in description of Modified Example 2 of the first embodiment, components assigned the same reference numerals as those used in the first embodiment will be identical or substantially same components.

[0175] As illustrated in FIG. **9**, a terminal **20**B according to Modified Example 2 functionally includes a controller **206**B instead of the controller **206** in FIG. **3**. The controller **206**B includes the same functions as those of the controller **206** except that the controller **206**B includes a pseudo random number generator **215**B and a priority determining unit **208**B instead of the priority information storage **207** and the priority determining unit **208**.

[0176] The pseudo random number generator **215**B generates pseudo random numbers. In this example, the pseudo random number generator **215**B generates a pseudo random number by using as a seed a combination of a terminal identifier for identifying the terminal **20**B and a current time.

[0177] The priority determining unit **208**B determines a priority based on the pseudo random number generated by the pseudo random number generator **215**B. For example, the priority determining unit **208**B may store in advance information indicating a relationship between a pseudo random number and a priority, and determine a priority based on the stored information and the generated pseudo random number. Further, the priority determining unit **208**B may determine the generated pseudo random number as a priority.

[0178] The terminal **20**B according to Modified Example 2 can reduce a probability that the priorities match between the terminals **20**B. As a result, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0179] Further, in this example, as the number of values of pseudo random numbers to be generated is larger, it is possible to further reduce the probability that the priorities match between the terminals **20**B.

Modified Example 3 of First Embodiment

[0180] Next, a wireless communication system according to Modified Example 3 of the first embodiment of the present invention will be described. The wireless communication system according to Modified Example 3 of the first embodiment differs from the wireless communication system according to the first embodiment in determining a priority based on the number of communicable terminals. Such a difference will be mainly described below. In addition, in description of Modified Example 3 of the first embodiment, components assigned the same reference numerals as those used in the first embodiment will be identical or substantially same components.

[0181] As illustrated in FIG. **10**, a terminal **20**C according to Modified Example 3 functionally includes a controller **206**C instead of the controller **206** in FIG. **3**. The controller **206**C includes the same functions as those of the controller **206** except that the controller **206**C includes a terminal detection processor **216**C and a priority determining unit **208**C instead of the priority information storage **207** and the priority determining unit **208**.

[0182] The terminal detection processor **216**C executes a terminal detection process. The terminal detection process is a process of detecting the other terminals **20**C which can communicate with the local terminal **20**C. The terminal detection process may be referred to as D2D Discovery.

[0183] In this example, the terminal detection process includes a process of generating a probe signal (also referred to as a discovery signal), and outputting the generated probe signal to the transmitter **212** to transmit the probe signal. The other terminals **20**C transmit response signals in response to reception of the probe signal. In addition, information related to a probe signal may be broadcast or may be notified by using a paging signal. For example, the information related to the probe signal includes a timing to transmit the probe signal, and information for identifying the probe signal.

[0184] Further, the terminal detection process includes a process of detecting the other terminals **20**C which can communicate with the local terminal **20**C by detecting a response signal from a received signal output by the receiver **201**.

[0185] The terminal detection processor **216**C outputs the number of detected terminals. The number of detected terminals is a number of the other terminals **20**C which can communicate with the local terminal **20**C detected by the terminal detection process.

[0186] In addition, the terminal detection processor **216**C may execute the terminal detection process in the first operation mode.

[0187] The priority determining unit **208**C determines a priority based on the number of detected terminals output by the terminal detection processor **216**C. In this example, the priority determining unit **208**C determines a higher priority as the number of detected terminals is larger.

[0188] Consequently, it is possible to reduce the number of cluster heads. Thus, it is possible to reduce radio resources used to perform communication between cluster heads and control cluster heads, for example.

[0189] In this example, the priority determining unit **208**C stores in advance information indicating a relationship between the number of detected terminals and a priority, and determines the priority based on the stored information and the number of detected terminals output by the terminal detection processor **216**C.

[0190] Thus, the terminal **20**C according to Modified Example 3 executes a process of detecting the other terminals **20**C, and determines a priority of the local terminal **20**C based on the number of the other terminals **20**C detected by this process.

[0191] Consequently, it is possible to reflect the number of the terminals **20**C with which the each terminal **20**C can communicate in the priority. Consequently, it is possible to appropriately determine the priority.

[0192] In addition, the terminal **20**C may determine a higher priority as the number of the other terminals **20**C which have detected the local terminal **20**C by the terminal detection process is larger.

[0193] In this case, the terminal **20**C may detect the other terminals **20**C which have transmitted a probe signal as the other terminals **20**C which have detected the local terminal **20**C by the terminal detection process by detecting the probe signal from a received signal. In addition, the probe signal may include an identifier for identifying the transmission source terminal **20**C. Further, the terminal **20**C may obtain the number of received probe signals as the number of the other terminals **20**C which have detected the local terminal **20**C by the terminal detection process.

[0194] Consequently, it is possible to reduce the number of cluster heads. Thus, it is possible to reduce radio resources used to perform communication between cluster heads and control cluster heads, for example.

Second Embodiment

[0195] Next, a wireless communication system according to the second embodiment of the present invention will be described. The wireless communication system according to the second embodiment differs from the wireless communication system according to the first embodiment in changing a priority according to a state of each terminal. Such a difference will be mainly described below. In addition, in description of the second embodiment, components assigned the same reference numerals as those used in the first embodiment will be identical or substantially same components.

[0196] When a state of each terminal changes after a priority order is determined in wireless communication systems disclosed in Patent Literatures 1 to 11 and Non Patent Literature 1, each terminal fails to reflect this change in the priority order.

[0197] By the way, when a terminal serving as a cluster head is changed, radio resources are used by each cluster member to change a terminal which is to be a destination of connection. When the priority order fails to be appropriately determined, a terminal serving as a cluster head is frequently changed in some cases. Hence, in this case, radio resources used by each cluster member to change a terminal which is to be a destination of connection tend to be larger.

[0198] Further, when the priority order fails to be appropriately determined, the number of cluster heads tends to be larger. As the number of cluster heads is larger, radio resources used to perform communication between cluster heads and control cluster heads, for example, are greater. Further, in the above wireless communication systems, a synchronization signal is unnecessarily transmitted in some cases.

[0199] Thus, in the above wireless communication systems, it is difficult to effectively utilize radio resources in some cases. By contrast with this, in the present embodiment, radio resources are effectively used.

[0200] The wireless communication system according to the second embodiment will be described in detail below.

[0201] (Function)

[0202] As illustrated in FIG. **11**, a terminal **20**D according to the second embodiment functionally includes a controller **206**D instead of the controller **206** in FIG. **3**. The controller **206**D includes the same functions as those of the controller **206** except for performing control to change a priority of the local terminal **20**D and stop transmitting synchronization signals.

[0203] The controller **206**D changes the priority determined by the priority determining unit **208** according to a state of the local terminal **20**D.

[0204] In the present embodiment, the controller **206**D makes the priority of the local terminal **20**D higher as a time from starting transmitting a synchronization signal at the local terminal **20**D is longer.

[0205] The terminal **20**D which has passed a longer time from starting transmitting a synchronization signal has a larger number of the other terminals **20**D which change operation modes and a larger number of cluster members which change the terminal **20**D which is to be a destination of connection in response to a change from a cluster head to a cluster member.

[0206] By contrast with this, according to the terminal **20**D according to the second embodiment, the terminal **20**D which has passed a longer time from starting transmitting a synchronization signal is hardly changed from a cluster head to a cluster member. Thus, the terminal **20**D serving as a cluster head is hardly frequently changed. Further, it is thus possible to reduce the number of the terminals **20**D which change operation modes and the number of cluster members which change the terminal **20**D which is to be a destination of connection. As a result, it is possible to reduce radio resources used by each cluster member to change the terminal **20**D which is to be a destination of connection. Consequently, it is possible to effectively use radio resources.

[0207] For example, the controller **206**D stores in advance information indicating a relationship between a time and a priority, and updates the priority based on the stored information and a time from starting transmitting synchronization signals at the local terminal **20**D.

[0208] Further, for example, the controller **206**D may subtract a certain change from the priority every time a certain update cycle passes.

[0209] Furthermore, the controller **206**D determines whether or not synchronization signals from the other terminals **20**D have been detected, based on the detection result from the synchronization signal detector **204** in the second operation mode. When determining that the synchronization signals from the other terminals **20**D have been detected, the controller **206**D controls transmission of a synchronization signal at the local terminal **20**D based on the priority associated with each of the detected synchronization signals.

[0210] Consequently, the terminal **20**D having a higher priority can increase a probability that the terminal **20**D having a higher priority is used as a cluster head. Further, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0211] In the present embodiment, the controller **206**D switches the operation mode from the second operation mode to the first operation mode when the priority associated with each of the detected synchronization signals is higher than the priority of the local terminal **20**D. Hence, in this case, the controller **206**D stops transmitting synchronization signals at the local terminal **20**D.

[0212] Meanwhile, the priority associated with each of the detected synchronization signals is lower than the priority of the local terminal **20**D, the controller **206**D maintains the second operation mode as the operation mode. Hence, in this case, the controller **206**D continues transmitting synchronization signals at the local terminal **20**D.

[0213] Consequently, the terminal **20**D having a higher priority can increase a probability that the terminal **20**D having a higher priority is used as a cluster head. Further, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0214] In addition, when the priority associated with each of the detected synchronization signals is higher than the priority of the local terminal **20**D, the controller **206**D may continue transmitting synchronization signals without switching the operation mode, and decrease synchronization signal transmission power.

[0215] (Operation)

[0216] Next, an operation of the terminal **20**D according to the second embodiment will be described with reference to FIG. **12**.

[0217] The terminal **20**D according to the second embodiment executes a process additionally including steps S**201** and S**202** in FIG. **12** subsequent to step S**104** in FIG. **5** instead of the process in FIG. **5**. In addition, step S**201** may be executed before step S**104**.

[0218] The terminal **20**D transmits a synchronization signal (step S**104** in FIG. **12**), and then updates the priority of the local terminal **20**D (step S**201** in FIG. **12**). In the present embodiment, the terminal **20**D updates the priority of the local terminal **20**D to make the priority of the local terminal **20**D higher as a time from starting transmitting synchronization signals at the local terminal **20**D is longer.

[0219] Next, the terminal **20**D determines whether or not a synchronization signal associated with a higher priority than the priority of the local terminal **20**D has been detected (step S**202** in FIG. **12**).

[0220] Hereinafter, a case where a synchronization signal associated with a higher priority than the priority of the local terminal **20**D will be assumed. In this case, the terminal **20**D determines "Yes", and moves to step S**105** in FIG. **12**. In the present embodiment, that the terminal **20**D determines "Yes" in step S**202** in FIG. **12** represents that the operation mode of the terminal **20**D is switched from the second operation mode to the first operation mode. Hence, in this case, the terminal **20**D stops transmitting synchronization signals.

[0221] Further, when not detecting a synchronization signal associated with a higher priority than the priority of the local terminal **20**D in step S**202** in FIG. **12**, the terminal **20**D determines "No", and returns to step S**104** in FIG. **12**. In this case, the operation mode of the terminal **20**D is maintained as the second operation mode. Hence, the terminal **20**D continues transmitting synchronization signals.

[0222] As described above, the terminal **20**D according to the second embodiment changes the priority determined by the priority determining unit **208** according to a state of the local terminal **20**D.

[0223] Consequently, it is possible to reflect the change in the state of the terminal **20**D in the priority. Thus, it is possible to use an appropriate priority corresponding to the state of the terminal **20**D. As a result, it is possible to reduce a frequency that a cluster head is changed. Further, it is possible to reduce the number of cluster heads. As a result, it is possible to effectively use radio resources.

[0224] Furthermore, the terminal **20**D according to the second embodiment controls transmission of a synchronization signal at the local terminal **20**D based on priorities of the other terminals **20**D in response to reception of synchronization signals from the other terminals **20**D.

[0225] Consequently, the terminal **20**D having a higher priority can increase the probability that the terminal **20**D having a higher priority is used as a cluster head. Further, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0226] Furthermore, the terminal **20**D which is used as a cluster head may make the priority of the local terminal **20**D higher as the number of the other terminals **20**D communicating with the local terminal **20**D is larger.

[0227] For example, the number of the other terminals **20**D communicating with the terminal **20**D which is used as a cluster head may be obtained by sending a notification of an increase in cluster members by the terminal **20**D which has received a synchronization signal to the terminal **20**D which has transmitted this synchronization signal. In this case, this notification may be executed by executing a RA procedure. The RA is an abbreviation of a Random Access. For example, the RA procedure may be a competition-based or non-competition-based RA procedure.

[0228] Further, for example, the number of the other terminals **20**D communicating with the terminal **20**D which is used as a cluster head may be obtained by transmitting a certain probe signal by the terminal **20**D which is used as a cluster head every time a certain cycle passes. In this case, the other terminals **20**D may transmit response signals in response to reception of probe signals. Further, in this case, the terminal **20**D which is used as a cluster head may obtain the above number of the other terminals **20**D based on the received response signal.

[0229] Consequently, the terminal **20**D which has more connected cluster members is more hardly changed from a cluster head to a cluster member. Accordingly, it is possible to reduce the number of cluster members which change the terminal **20**D which is to be a destination of connection. As a result, it is possible to reduce radio resources used by cluster members to change the terminal **20**D which is to be a destination of connection. Accordingly, it is possible to effectively use radio resources.

[0230] In addition, when updating a priority, the terminal **20**D may broadcast the updated priority. Further, when updating a priority, the terminal **20**D may transmit a synchronization signal associated with the updated priority.

[0231] In addition, the terminal **20**D needs not to update the priority. Further, the terminal **20**D may use a priority received from the base station **10** as the priority of the local terminal **20**D without determining the priority of the local terminal **20**D. Furthermore, the terminal **20**D may continue transmitting synchronization signals when receiving synchronization signals from the other terminals **20**D having higher priorities than the priority of the local terminal **20**D in the second operation mode.

Modified Example 1 of Second Embodiment

[0232] Next, a wireless communication system according to Modified Example 1 of the second embodiment of the present invention will be described. The wireless communication system according to Modified Example 1 of the second embodiment differs from the wireless communication system according to the second embodiment in notifying another terminal of a presence of one terminal when each terminal receives synchronization signals from each of a plurality of terminals. Such a difference will be mainly described below. In addition, in description of Modified Example 1 of the second embodiment, components assigned the same reference numerals as those used in the second embodiment will be identical or substantially same components.

[0233] (Function)

[0234] As illustrated in FIG. **13**, a terminal **20**E according to Modified Example 1 functionally includes an RA signal generator **217**E in addition to the functions of the terminal **20**D in FIG. **11**. The RA is an abbreviation of a Random Access.

[0235] The RA signal generator **217**E generates an RA signal for executing an RA procedure. For example, the RA procedure may be a competition-based or non-competition-based RA procedure. The RA signal generator **217**E outputs a generated RA signal to transmit the RA signal by using predetermined radio resources under control of a controller **206**E described below.

[0236] Further, the terminal **20**E according to Modified Example 1 functionally includes the controller **206**E instead of the controller **206**D in FIG. **11**.

[0237] In this regard, for ease of description, the terminal **20**E of interest will be referred to as the first terminal **20**E or the local terminal **20**E, the terminal **20**E different from the first terminal **20**E will be referred to as the second terminal **20**E, and the terminal **20**E different from the first terminal **20**E and the second terminal **20**E will be referred to as the third terminal **20**E.

[0238] The controller **206**E has the same functions as those of the controller **206**D except for first and second differences. The first difference is that, when receiving synchronization signals from each of the second terminal **20**E and the third terminal **20**E, a presence of one of the second terminal **20**E and the third terminal **20**E is notified to the other one of the second terminal **20**E and the third terminal **20**E. The second difference is that transmission of a synchronization signal at the local terminal **20**E is controlled based on a notification from the terminal **20**E different from the local terminal **20**E.

[0239] In this example, the controller **206**E determines whether or not another synchronization signal has been detected, based on a detection result from the synchronization signal detector **204** in the first operation mode.

[0240] In this regard, the another synchronization signal is a synchronization signal transmitted by the third terminal **20**E different from the second terminal **20**E which has transmitted a synchronization signal based on which the first terminal **20**E determines to operate in the first operation mode. For example, a case where the first terminal **20**E receives a synchronization signal from the second terminal **20**E different from the local terminal **20**E, and determines to operate in the first operation mode in response to reception of the synchronization signal will be assumed. In this case, a case where the first terminal **20**E receives a synchronization signal from the third terminal **20**E, too, will be assumed. In this case, the above "another synchronization signal" is the synchronization signal transmitted by the third terminal **20**E.

[0241] When detecting the another synchronization signal, the controller **206**E sends a notification of a presence of the one terminal **20**E of the second terminal **20**E and the third terminal **20**E having a higher priority to the other one terminal **20**E of the second terminal **20**E and the third terminal **20**E having a lower priority. In this example, the controller **206**E sends the above notification based on a priority associated with the detected synchronization signal. In addition, the notification is also referred to as a report.

[0242] In this example, the above notification is sent when the first terminal **20**E executes the RA procedure between the first terminal **20**E and the notification destination terminal **20**E. In this example, the controller **206**E controls the RA signal generator **217**E to execute the RA procedure between the first terminal **20**E and the notification destination terminal **20**E. When radio resources are allocated by the notification destination terminal **20**E in response to a random access signal, the controller **206**E controls the control signal generator **210** or the data signal generator **211** to send the above notification by using the allocated radio resources.

[0243] Further, when receiving the above notification from the terminal **20**E different from the local terminal **20**E in the second operation mode, the controller **206**E stops transmitting synchronization signals at the local terminal **20**E.

[0244] Meanwhile, when not receiving the above notification from the terminal **20**E different from the local terminal **20**E in the second operation mode, the controller **206**E continues transmitting synchronization signals at the local terminal **20**E.

[0245] In addition, when receiving the above notification from the terminal **20**E different from the local terminal **20**E in the second operation mode, the controller **206**E may continue transmitting synchronization signals, and decrease synchronization signal transmission power.

[0246] (Operation)

[0247] Next, an operation of the first terminal **20**E according to Modified Example 1 will be described with reference to FIG. **14**.

[0248] The first terminal **20**E according to Modified Example 1 executes a process in FIG. **14** instead of the process in FIG. **12**. The process in FIG. **14** is a process additionally including step S**301** in FIG. **14** in a No route in step S**202** in FIG. **12**, and additionally including steps S**302** to S**304** in FIG. **14** subsequent to step S**105** in FIG. **12**.

[0249] The first terminal **20**E determines that a synchronization signal associated with a higher priority than the priority of the local terminal **20**E has not been detected (the No route in step S**202** in FIG. **14**), and then determines whether or not a notification has been received from the other terminal **20**E (step S**301** in FIG. **14**).

[0250] First, a case where the first terminal **20**E does not receive a notification from the other terminal **20**E will be assumed. In this case, the first terminal **20**E determines “No”, and returns to step S**104** in FIG. **14**. In this case, the first terminal **20**E continues transmitting synchronization signals.

[0251] Next, a case where the first terminal **20**E receives a notification from the other terminal **20**E will be assumed. In this case, the first terminal **20**E determines “Yes”, and returns to step S**202** in FIG. **14**. Hence, in this case, the first terminal **20**E does not execute step S**104** and therefore does not transmit synchronization signals. Accordingly, in this case, the first terminal **20**E stops transmitting synchronization signals.

[0252] Further, a case where a synchronization signal from the second terminal **20**E having a higher priority than the priority of the local terminal **20**E has been detected will be assumed. In this case, the first terminal **20**E determines “Yes” in step S**202** in FIG. **14**, and moves to step S**105** in FIG. **14**.

[0253] Then, the first terminal **20**E synchronizes a communication timing with that of the second terminal **20**E which has transmitted the synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **14**). Next, the first terminal **20**E determines whether or not another synchronization signal (a synchronization signal from the third terminal **20**E in this example) is detected (step S**302** in FIG. **14**).

[0254] When not detecting the another synchronization signal, the first terminal **20**E determines “No”, and returns to step S**101** in FIG. **14**. Meanwhile, when detecting the another synchronization signal, the first terminal **20**E determines “Yes”, and moves to step S**303** in FIG. **14**.

[0255] Then, the first terminal **20**E synchronizes a communication timing with that of the one terminal **20**E of the second terminal **20**E and the third terminal **20**E which has a higher priority and has transmitted a synchronization signal, based on the synchronization signal from the one terminal **20**E (step S**303** in FIG. **14**).

[0256] Next, the first terminal **20**E sends a notification of a presence of the one terminal **20**E of the second terminal **20**E and the third terminal **20**E having a higher priority to the other one terminal **20**E of the second terminal **20**E and the third terminal **20**E having a lower priority (step S**304** in FIG. **14**). Subsequently, the first terminal **20**E returns to step S**101** in FIG. **14**.

[0257] When, for example, the priority of the second terminal **20**E is higher than the priority of the third terminal **20**E, the first terminal **20**E synchronizes a communication timing with that of the second terminal **20**E based on the synchronization signal from the second terminal **20**E in step S**303**. Further, in this case, the first terminal **20**E notifies the third terminal **20**E of the presence of the second terminal **20**E in step S**304**. Thus, the third terminal **20**E stops transmitting synchronization signals at the third terminal **20**E. Consequently, it is possible to reduce in the first terminal **20**E an interference of synchronization signals from the third terminal **20**E with signals from the second terminal **20**E.

[0258] By contrast with this, when, for example, the priority of the third terminal **20**E is higher than the priority of the second terminal **20**E, the first terminal **20**E synchronizes a communication timing with that of the third terminal **20**E based on the synchronization signal from the third terminal **20**E in step S**303**. Further, in this case, the first terminal **20**E notifies the second terminal **20**E of the presence of the third terminal **20**E in step S**304**. Thus, in this case, the second terminal **20**E stops transmitting synchronization signals at the second terminal **20**E. Consequently, it is possible to reduce in the first terminal **20**E an interference of synchronization signals from the second terminal **20**E with signals from the third terminal **20**E.

[0259] As described above, in response to reception of synchronization signals from each of the second and third terminals **20**E of the different priorities, the first terminal **20**E according to Modified Example 1 sends a notification of the presence of the other one terminal **20**E to the one terminal **20**E of the second and third terminals **20**E having a lower priority.

[0260] Consequently, even when the one terminal **20**E fails to receive a synchronization signal from the other terminal **20**E, the one terminal **20**E can recognize the presence of the other terminal **20**E.

[0261] In addition, the terminal **20**E needs not to update the priority. Further, the terminal **20**E may use a priority received from the base station **10** as a priority of the local terminal **20**E without determining the priority of the local terminal **20**E.

[0262] Furthermore, the terminal **20**E may continue transmitting synchronization signals when receiving synchronization signals from the other terminals **20**E having higher priorities than the priority of the local terminal **20**E in the second operation mode.

Modified Example 2 of Second Embodiment

[0263] Next, a wireless communication system according to Modified Example 2 of the second embodiment of the present invention will be described. The wireless communication system according to Modified Example 2 of the second embodiment differs from the wireless communication system according to the second embodiment in transmitting synchronization signals when each terminal receives a synchronization signal from each of a plurality of terminals in the first operation mode. Such a difference will be mainly described below. In addition, in description of Modified Example 2 of the second embodiment, components assigned the same reference numerals as those used in the second embodiment will be identical or substantially same components.

[0264] (Function)

[0265] As illustrated in FIG. **15**, a terminal **20**F according to Modified Example 2 functionally includes a controller **206**F instead of the controller **206**D in FIG. **11**.

[0266] In this regard, for ease of description, the terminal **20**F of interest will be referred to as the first terminal **20**F or the local terminal **20**F, the terminal **20**F different from the first terminal **20**F will be referred to as the second terminal **20**F, and the terminal **20**F different from the first terminal **20**F and the second terminal **20**F will be referred to as the third terminal **20**F.

[0267] The controller **206**F includes the same functions as those of the controller **206**D except that the first terminal **20**F transmits synchronization signals when receiving a synchronization signal from each of the second terminal **20**F and the third terminal **20**F in the first operation mode.

[0268] In this example, the controller **206**F determines whether or not another synchronization signal has been detected, based on a detection result of the synchronization signal detector **204** in the first operation mode of the local terminal **20**F.

[0269] In this regard, the another synchronization signal is a synchronization signal transmitted by the third terminal **20**F different from the second terminal **20**F which has transmitted a synchronization signal based on which the first terminal **20**F determines to operate in the first operation mode. For example, a case where the first terminal **20**F receives a synchronization signal from the second terminal **20**F different from the local terminal **20**F, and determines to operate in the first operation mode in response to reception of the synchronization signal will be assumed. In this case, a case where the first terminal **20**F receives a synchronization signal from the third terminal **20**F, too, will be assumed. In this case, the above "another synchronization signal" is the synchronization signal transmitted by the third terminal **20**F.

[0270] When detecting the another synchronization signal, the controller **206**F performs control to synchronize a communication timing with that of the one terminal **20**F of the second terminal **20**F and the third terminal **20**F having a higher priority. Further, in this case, the controller **206**F controls the synchronization signal generator **209** to transmit synchronization signals.

[0271] In this example, the controller **206**F controls the synchronization signal generator **209** such that a synchronization signal transmission timing is a timing based on a timing at which a synchronization signal is received from the parent terminal **20**F. In this example, the parent terminal **20**F is the one terminal **20**F of the second terminal **20**F and the third terminal **20**F having a higher priority. For example, the timing based on the timing at which the synchronization signal is received from the parent terminal **20**F is a timing at which the synchronization signal is received from the parent terminal **20**F or a timing which is different by a certain time from the timing at which the synchronization signal is received from the parent terminal **20**F.

[0272] Thus, the controller **206**F transmits synchronization signals in response to reception of synchronization signals from each of the second terminal **20**F and the third terminal **20**F.

[0273] Consequently, even when the one terminal **20**F of the second terminal **20**F and the third terminal **20**F fails to receive a synchronization signal from the other one terminal **20**F of the second terminal **20**F and the third terminal **20**F, the one terminal **20**F can receive a synchronization signal from the first terminal **20**F.

[0274] (Function)

[0275] Next, an operation of the first terminal **20**F according to Modified Example 2 will be described with reference to FIG. **16**.

[0276] The first terminal **20**F according to Modified Example 2 executes a process in FIG. **16** instead of the process in FIG. **12**. The process in FIG. **16** additionally includes steps S**401** to S**403** in FIG. **16** subsequent to step S**105** in FIG. **12**.

[0277] Hereinafter, a case where the first terminal **20**F detects a synchronization signal from the second terminal **20**F having a higher priority than the priority of the local terminal **20**F in step S**202** in FIG. **16** will be assumed. In this case, the first terminal **20**F determines "Yes", and moves to step S**105** to synchronize a communication timing with that of the second terminal **20**F which has transmitted the synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **16**).

[0278] Next, the first terminal **20**F determines whether or not another synchronization signal (a synchronization signal from the third terminal **20**F in this example) is detected (step S**401** in FIG. **16**).

[0279] When not detecting the another synchronization signal, the first terminal **20**F determines "No", and returns to step S**101** in FIG. **16**. Meanwhile, when detecting the another synchronization signal, the first terminal **20**F determines "Yes", and moves to step S**402** in FIG. **16**.

[0280] Then, the first terminal **20**F synchronizes a communication timing with that of the one terminal **20**F of the second terminal **20**F and the third terminal **20**F which has a higher priority and has transmitted a synchronization signal based on the synchronization signal from the one terminal **20**F (step S**402** in FIG. **16**).

[0281] Next, the first terminal **20**F transmits a synchronization signal at a timing based on a timing at which a synchronization signal is received from the parent terminal **20**F which is synchronized with the communication timings in above step S**402** (step S**403** in FIG. **16**). Subsequently, the first terminal **20**F returns to step S**101** in FIG. **16**.

[0282] When, for example, the priority of the second terminal **20**F is higher than the priority of the third terminal **20**F, the first terminal **20**F synchronizes a communication timing with that of the second terminal **20**F based on the synchronization signal from the second terminal **20**F in step S**402**. Further, in this case, the first terminal **20**F transmits a synchronization signal at a timing based on the timing at which the synchronization signal is received from the second terminal **20**F in step S**403**.

[0283] In this case, a case where the priority of the first terminal **20**F is higher than the priority of the third terminal **20**F will be assumed. In this case, the third terminal **20**F switches an operation mode from the second operation mode to the first operation mode in response to reception of the synchronization signal from the first terminal **20**F. Thus, the third terminal **20**F stops transmitting synchronization signals at the third terminal **20**F. Consequently, it is possible to reduce in the first terminal **20**F an interference of synchronization signals from the third terminal **20**F with signals from the second terminal **20**F.

[0284] As described above, the first terminal **20**F according to Modified Example 2 transmits synchronization signals in response to reception of synchronization signals from each of the second terminal **20**F and the third terminal **20**F.

[0285] Consequently, even when the one terminal **20**F of the second and third terminals **20**F fails to receive a synchronization signal from the other one terminal **20**F of the second and third terminals **20**F, the one terminal **20**F can receive a synchronization signal from the first terminal **20**F.

[0286] In addition, the terminal **20**F needs not to update a priority. Further, the terminal **20**F may use a priority received from the base station **10** as the priority of the local terminal **20**F without determining the priority of the local terminal **20**F.

[0287] Furthermore, the terminal **20**F may continue transmitting synchronization signals when receiving synchronization signals from the other terminals **20**F having higher priorities than the priority of the local terminal **20**F in the second operation mode.

Third Embodiment

[0288] Next, a wireless communication system according to the third embodiment of the present invention will be described. The wireless communication system according to the third embodiment differs from the wireless communication system according to the second embodiment in notifying one terminal of a difference between timings at which synchronization signals are received from a plurality of terminals. Such a difference will be mainly described below. In addition, in description of the third embodiment, components assigned the same reference numerals as those used in the second embodiment will be identical or substantially same components.

[0289] (Function)

[0290] As illustrated in FIG. **17**, a terminal **20**G according to the third embodiment functionally includes an RA signal generator **217**G in addition functions of the terminal **20**D in FIG. **11**. The RA is an abbreviation of a Random Access.

[0291] The RA signal generator **217**G generates an RA signal for executing an RA procedure. For example, the RA procedure may be a competition-based or non-competition-based RA procedure. The RA signal generator **217**G outputs a generated RA signal to transmit the RA signal by using predetermined radio resources under control of a controller **206**G described below.

[0292] Further, the terminal **20**G according to the third embodiment functionally includes the controller **206**G instead of the controller **206**D in FIG. **11**.

[0293] In this regard, for ease of description, the terminal **20**G of interest will be referred to as the first terminal **20**G or the local terminal **20**G, the terminal **20**G different from the first terminal **20**G will be referred to as the second terminal **20**G, and the terminal **20**G different from the first terminal **20**G and the second terminal **20**G will be referred to as the third terminal **20**G.

[0294] The controller **206**G includes the same functions as those of the controller **206**D except for first and second differences. The first difference is that, when receiving synchronization signals from each of the second and third terminals **20**G, one of the second terminals **20**G and the third terminals **20**G is notified of a difference between a timing at which a synchronization signal is received from the second terminal **20**G and a timing at which a synchronization signal is received from the third terminal **20**G. The second difference is that a synchronization signal transmission timing at the local terminal **20**G is adjusted based on a notification from the terminal **20**G different from the local terminal **20**G.

[0295] In the present embodiment, the controller **206**G determines whether or not another synchronization signal has been detected, based on a detection result of the synchronization signal detector **204** in the first operation mode.

[0296] In this regard, the another synchronization signal is a synchronization signal transmitted by the third terminal **20**G different from the second terminal **20**G which has transmitted a synchronization signal based on which the first terminal **20**G determines to operate in the first operation mode. For example, a case where the first terminal **20**G receives a synchronization signal from the second terminal **20**G different from the local terminal **20**G, and determines to operate in the first operation mode in response to reception of the synchronization signal will be assumed. In this case, a case where the first terminal **20**G receives a synchronization signal from the third terminals **20**G, too, will be assumed. In this case, the above "another synchronization signal" is a synchronization signal transmitted by the third terminal **20**G.

[0297] When detecting the another synchronization signal, the controller **206**G performs control to synchronize a communication timing with that of the one terminal **20**G of the second terminal **20**G and the third terminal **20**G having a higher priority.

[0298] Further, in this case, the controller **206**G sends to the other one terminal **20**G of the second terminal **20**G and the third terminal **20**G having a lower priority a notification of a difference between a timing at which a synchronization signal is received from the second terminal **20**G and a timing at which a synchronization signal is received from the third terminal **20**G. In the present embodiment, the controller **206**G determines the notification destination terminal **20**G based on a priority associated with the detected synchronization signal. In addition, the difference between a timing at which a synchronization signal is received from the second terminal **20**G and a timing at which a synchronization signal is received from the third terminal **20**G is also referred to as a time difference between synchronization signals.

[0299] In the present embodiment, the above notification is sent when the first terminal **20**G executes the RA procedure between the first terminal **20**G and the notification destination terminal **20**G. In the present embodiment, the controller **206**G controls the RA signal generator **217**G to execute the RA procedure between the first terminal **20**G and the notification destination terminal **20**G. When radio resources are allocated by the notification destination terminal **20**G, the controller **206**G controls the control signal generator **210** or the data signal generator **211** to send the notification by using allocated radio resources.

[0300] Further, the controller **206**G adjusts a synchronization signal transmission timing at the local terminal **20**G when receiving the above notification from the terminal **20**G different from the local terminal **20**G in the second operation mode.

[0301] In the present embodiment, the controller **206**G adjusts the synchronization signal transmission timing at the local terminal **20**G such that synchronization transmission timings synchronize between terminals **20**G which are transmission sources of the synchronization signals based on which this notification is sent synchronize based on the above notification.

[0302] Meanwhile, the controller **206**G does not adjust a synchronization signal transmission timing at the local terminal **20**G when not receiving the above notification from the terminal **20**G different from the local terminal **20**G in the second operation mode.

[0303] (Operation)

[0304] Next, an operation of the first terminal **20**G according to the third embodiment will be described with reference to FIG. **18**.

[0305] The first terminal **20**G according to the third embodiment executes a process in FIG. **18** instead of the process in FIG. **12**. The process in FIG. **18** is a process additionally including steps S**501** and S**502** in FIG. **18** in a No route in step S**202** in FIG. **12**, and additionally including steps S**503** to S**505** in FIG. **18** subsequent to step S**105** in FIG. **12**.

[0306] The first terminal **20**G determines that a synchronization signal associated with a higher priority than a priority of a local terminal **20**G has not been detected (the

No route in step S**202** in FIG. **18**), and then determines whether or not a notification from the another terminal **20**G has been received (step S**501** in FIG. **18**).

[0307] First, a case where the first terminal **20**G has not received the notification from the another terminal **20**G will be assumed. In this case, the first terminal **20**G determines "No", and returns to step S**104** in FIG. **18**.

[0308] Next, a case where the first terminal **20**G receives the notification from the another terminal **20**G will be assumed. In this case, the first terminal **20**G determines "Yes", and adjusts a synchronization signal transmission timing at the local terminal **20**G based on the notification (step S**502** in FIG. **18**). Further, the first terminal **20**G returns to step S**104** in FIG. **18**.

[0309] Hereinafter, a case where a synchronization signal from the second terminal **20**G having a higher priority than the priority of the local terminal **20**G has been detected will be assumed. In this case, the first terminal **20**G determines "Yes" in step S**202** in FIG. **18**, and moves to step S**105** in FIG. **18**.

[0310] Then, the first terminal **20**G synchronizes a communication timing with that of the second terminal **20**G which has transmitted the synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **18**). Next, the first terminal **20**G determines whether or not another synchronization signal (a synchronization signal from the third terminal **20**G in the present embodiment) is detected (step S**503** in FIG. **18**).

[0311] When not detecting the another synchronization signal, the first terminal **20**G determines "No", and returns to step S**101** in FIG. **18**. Meanwhile, when detecting the another synchronization signal, the first terminal **20**G determines "Yes", and moves to step S**504** in FIG. **18**.

[0312] Then, the first terminal **20**G synchronizes a communication timing with that of the one terminal **20**G of the second terminal **20**G and the third terminal **20**G which has a higher priority and has transmitted a synchronization signal, based on the synchronization signal from the one terminal **20**G (step S**504** in FIG. **18**).

[0313] Next, the first terminal **20**G sends to the other one terminal **20**G of the second and third terminals **20**G having a lower priority a notification of a difference between a timing at which a synchronization signal is received from the second terminal **20**G and a timing at which a synchronization signal is received from the third terminal **20**G (step S**505** in FIG. **18**). Subsequently, the first terminal **20**G returns to step S**101** in FIG. **18**.

[0314] When, for example, the priority of the second terminal **20**G is higher than the priority of the third terminal **20**G, the first terminal **20**G synchronizes a communication timing with that of the second terminal **20**G, based on the synchronization signal from the second terminal **20**G in step S**504**. Further, in this case, the first terminal **20**G notifies the third terminal **20**G of a time difference between the synchronization signals in step S**505**.

[0315] Thus, the third terminal **20**G synchronizes a synchronization signal transmission timing at the third terminal **20**G with a synchronization signal transmission timing at the second terminal **20**G based on the notification. Consequently, the first terminal **20**G can prevent an interference of signals from the third terminal **20**G with signals received from the second terminal **20**G. Hence, it is possible to increase quality of communication between the terminals **20**G. Consequently, it is possible to effectively use radio resources.

[0316] By contrast with this, when, for example, the priority of the third terminal **20**G is higher than the priority of the second terminal **20**G, the first terminal **20**G synchronizes a communication timing with that of the third terminal **20**G, based on a synchronization signal from the third terminal **20**G in step S**504**. Further, in this case, the first terminal **20**G notifies the second terminal **20**G of the time difference between the synchronization signals in step S**505**.

[0317] Thus, the second terminal **20**G synchronizes a synchronization signal transmission timing at the second terminal **20**G with a synchronization signal transmission timing at the third terminal **20**G based on the notification. Consequently, the first terminal **20**G can prevent an interference of signals from the second terminal **20**G with signals received from the third terminal **20**G. Consequently, it is possible to increase quality of communication between the terminals **20**G. Hence, it is possible to effectively use radio resources.

[0318] As described above, the first terminal **20**G according to the third embodiment notifies the one terminal **20**G of the second and third terminals **20**G of a time difference between synchronization signals in response to reception of the synchronization signals from each of the second and third terminals **20**G.

[0319] Consequently, it is possible to synchronize synchronization signal transmission timings between the second and third terminals **20**G. Thus, the first terminal **20**G can prevent an interference of signals from one of the second and third terminals **20**G with signals received from the other one of the second and third terminals **20**G. Consequently, it is possible to increase quality of communication between the terminals **20**G. Hence, it is possible to effectively use radio resources.

[0320] Further, the first terminal **20**G according to the third embodiment sends a notification of a time difference between synchronization signals to the one terminal **20**G of the second and third terminals **20**G having a lower priority related to transmission of a synchronization signal. Furthermore, the other one terminal **20**G of the second and third terminals **20**G synchronizes a timing at which a synchronization signal is to be transmitted with that of the one terminal **20**G based on the notification.

[0321] The terminal **20**G having a higher priority tends to have a larger number of cluster members connecting to the terminal **20**G. Consequently, it is possible to increase a probability that it is possible to reduce radio resources used to control synchronization signal transmission timings compared to a case where the terminal **20**G of a relatively high priority synchronizes a timing at which a synchronization signal is to be transmitted with that of the terminal **20**G of a relatively low priority.

[0322] In addition, the terminal **20**G needs not to update the priority. Further, the terminal **20**G may use a priority received from the base station **10** as the priority of the local terminal **20**G without determining the priority of the local terminal **20**G. Furthermore, the terminal **20**G may continue transmitting synchronization signals when receiving synchronization signals from the other terminals **20**G having higher priorities than the priority of the local terminal **20**G in the second operation mode.

[0323] Still further, the first terminal **20**G may notify both of the second and third terminals **20**G of a time difference between synchronization signals. In this case, the notification may include an identifier for identifying a wireless area or the terminal **20**G and a priority associated with the identifier. In this case, the second terminal **20**G may adjust a synchronization signal transmission timing when the priority of the local terminal **20**G is lower than the priority of the third terminal **20**G. Similarly, the third terminal **20**G may adjust a synchronization signal transmission timing when the priority of the local terminal **20**G is lower than the priority of the second terminal **20**G.

[0324] Further, when receiving synchronization signals from each of the second and third terminals **20**G, the first terminal **20**G may send a notification of a time difference between synchronization signals if a notification condition described below holds, and needs not to send a notification of the time difference between synchronization signals if the notification condition does not hold. Furthermore, when receiving synchronization signals from each of the second and third terminals **20**G, the first terminal **20**G may send a notification of a stop instruction to the one terminal **20**G of the second and third terminals **20**G having a lower priority if the notification condition does not hold. In the present embodiment, the stop instruction is information for instructing to stop transmitting synchronization signals. Hence, the terminal **20**G notified of the stop instruction stops transmitting synchronization signals.

[0325] The notification condition includes, for example, one of the following.

[0326] (1) Both of the priority of the second terminal **20**G and the priority of the third terminal **20**G are higher than a certain reference priority.

[0327] (2) A difference between the priority of the second terminal **20**G and the priority of the third terminal **20**G is smaller than a certain reference difference.

[0328] (3) Both of the number of cluster members whose connection destinations are the second terminal **20**G and the number of cluster members whose connection destinations are the third terminal **20**G are larger than a certain reference number.

[0329] (4) A difference between the number of cluster members whose connection destinations are the second terminal **20**G and the number of cluster members whose connection destinations are the third terminal **20**G is smaller than a certain reference difference.

[0330] (5) Both of a time from starting transmitting synchronization signals by the second terminal **20**G and a time from starting transmitting synchronization signals by the third terminal **20**G are longer than a certain reference time.

[0331] (6) A difference between a time from starting transmitting synchronization signals by the second terminal **20**G and a time from starting transmitting synchronization signals by the third terminal **20**G is smaller than a certain reference difference.

[0332] Further, a notification destination of a time difference between synchronization signals may be the one terminal **20**G of the second and third terminals **20**G whose a number of the connecting cluster members **20**G is smaller. Furthermore, a notification destination of a time difference between synchronization signals may be the one terminal **20**G of the second and third terminals **20**G whose a time from starting transmitting synchronization signals is shorter.

Fourth Embodiment

[0333] Next, a wireless communication system according to the fourth embodiment of the present invention will be described. The wireless communication system according to the fourth embodiment differs from the wireless communication system according to the second embodiment in instructing another terminal to switch to a cluster head before a terminal switches from a cluster head to a cluster member. Such a difference will be mainly described below. In addition, in description of the fourth embodiment, components assigned the same reference numerals as those used in the second embodiment will be identical or substantially same components.

[0334] (Function)

[0335] As illustrated in FIG. **19**, a wireless communication system **1**H according to the fourth embodiment includes terminals **20**H-**1** to **20**H-**10** instead of terminals **20-1** to **20-10** illustrated in FIG. **1**.

[0336] As illustrated in FIG. **20**, a terminal **20**H according to the fourth embodiment functionally includes a controller **206**H instead of the controller **206**D in FIG. **11**. The controller **206**H has the same functions as those of the controller **206**D except for first and second differences.

[0337] The first difference is that the controller **206**H controls the control signal generator **210** to transmit a head switch instruction when an operation mode of the terminal **20**H switches from the second operation mode to the first operation mode.

[0338] As described above, when an operation mode of the terminal **20**H is the second operation mode, a communication state of the terminal **20**H is the third communication state where the terminal **20**H is used as a cluster head. Further, when the operation mode of the terminal **20**H is the first operation mode, the communication state of the terminal **20**H is one of the second communication state where the terminal **20**H is used as a cluster member, and the first communication state where the terminal **20**H communicates with the base station **10**.

[0339] That the terminal **20**H is used as a cluster head may represent that the terminal **20**H is a cluster head. Further, that the terminal **20**H is used as a cluster member may represent that the terminal **20**H is a cluster member.

[0340] In the present embodiment, it is assumed that, for ease of description, when the operation mode of the terminal **20**H is the first operation mode, the communication state of the terminal **20**H is the second communication state. Hence, in the present embodiment, that the operation mode of the terminal **20**H switches from the second operation mode to the first operation mode represents that the terminal **20**H is changed from a cluster head to a cluster member. The change from a cluster head to a cluster member may represent switching from a cluster head to a cluster member.

[0341] In the present embodiment, a case where, as illustrated in FIG. **19**, the terminal **20**H-**1** which is a cluster head comes close to the terminal **20**H-**2** which is a cluster head to receive a synchronization signal transmitted by the terminal **20**H-**2** will be assumed. In addition, in this case, the terminal **20**H-**2**, too, receives a synchronization signal transmitted by the terminal **20**H-**1** likewise.

[0342] In the present embodiment, the head switch instruction is information for instructing to switch a connection destination cluster head. The head switch instruction is an example of information indicating integration of a plurality of clusters. In the present embodiment, the head switch instruction is included in a control signal.

[0343] By transmitting a head switch instruction by the controller **206**H, the cluster head **20**H sends a notification of integration of a plurality of clusters to cluster members which are the other terminals **20**H forming a cluster together with the cluster head **20**H. In this regard, the cluster includes a plurality of terminals **20**H, and is formed to enable direct communication between the plurality of terminals **20**H in response to synchronization signals to be transmitted by the cluster head **20**H.

[0344] The second difference is that, when the terminal **20**H is used as a cluster member and receives the head switch instruction, the controller **206**H controls the synchronization signal detector **204** to perform a process of detecting a synchronization signal transmitted from the terminal **20**H different from a connection destination cluster head.

[0345] Consequently, the cluster members **20**H which form a cluster together with the cluster head **20**H can quickly detect synchronization signals to be transmitted by the other cluster heads **20**H. As a result, the cluster members **20**H can quickly switch the cluster head **20**H which is to be a destination of connection.

[0346] Similar to the controller **206**D in FIG. **11**, the controller **206**H changes the local terminal **20**H from a cluster head to a cluster member when a priority associated with the detected synchronization signal is higher than a priority of the local terminal **20**H. Hence, in this case, the controller **206**H stops transmitting synchronization signals at the local terminal **20**H.

[0347] Meanwhile, when the priority associated with the detected synchronization signal is lower than the priority of the local terminal **20**H, the controller **206**H maintains a state where the local terminal **20**H is used as a cluster head similar to the controller **206**D in FIG. **11**. Hence, in this case, the controller **206**H continues transmitting synchronization signals at the local terminal **20**H.

[0348] That the cluster head **20**H receives synchronization signals transmitted by the other cluster heads **20**H is an example where a plurality of cluster heads **20**H exist at positions at which the plurality of cluster heads **20**H can communicate with each other.

[0349] Hence, in the wireless communication system **1**H, the first cluster head **20**H among a plurality of cluster heads **20**H existing at positions at which the plurality of cluster heads **20**H can communicate with each other continues transmitting synchronization signals, and the second cluster head **20**H stops transmitting synchronization signals. In this regard, a priority of the first cluster head **20**H is higher than that of the second cluster head **20**H.

[0350] Consequently, the terminal **20**H having a higher priority can increase a probability that the terminal **20**H is used as a cluster head. Further, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0351] In other words, the wireless communication system **1**H integrates a plurality of clusters to be formed by synchronization signals to be transmitted by a plurality of cluster heads **20**H existing at positions at which the plurality of cluster heads **20**H communicate with each other, based on a priority of each of the plurality of cluster heads **20**H.

[0352] Consequently, it is possible to reduce the number of cluster heads. Thus, it is possible to reduce radio resources used to perform communication between cluster heads and control cluster heads, for example. Further, it is possible to appropriately reflect each priority in cluster integration. In the present embodiment, the terminal **20**H having a higher priority can increase a probability that the terminal **20**H is continuously used as a cluster head.

[0353] In addition, the head switch instruction may include synchronization signal information related to a detected control signal. For example, the synchronization signal information may include at least one of information for identifying a synchronization signal, and information indicating a transmission timing which is a timing at which a synchronization signal is to be transmitted.

[0354] In the present embodiment, the information for identifying a synchronization signal is an identifier for identifying a Zadoff-Chu sequence. In addition, when a synchronization signal is associated with a priority, a priority may be used as information for identifying the synchronization signal. For example, the information indicating the timing at which a synchronization signal is to be transmitted may include information for identifying a subframe in which the synchronization signal is to be transmitted. Further, for example, the information indicating the timing at which a synchronization signal is to be transmitted may include information indicating a difference between a timing at which a cluster head which is not yet switched transmits a synchronization signal, and a timing at which the switched cluster head transmits a synchronization signal.

[0355] The information for identifying a synchronization signal and the information indicating a synchronization signal transmission timing are used to, for example, detect synchronization signals. Hence, the synchronization signal information is also referred to as information used to detect a synchronization signal.

[0356] In this case, the cluster member **20**H having received the head switch instruction performs a process of detecting a synchronization signal transmitted by the terminal **20**H different from the cluster head **20**H which is a transmission source of the head switch instruction based on the synchronization signal information included in the head switch instruction.

[0357] Consequently, the cluster members **20**H forming a cluster together with the cluster head **20**H can quickly detect synchronization signals to be transmitted by the other cluster heads **20**H. As a result, the cluster members **20**H can quickly switch the cluster head **20**H which is to be a destination of connection.

[0358] (Operation)

[0359] Next, an operation of the terminal **20**H according to the fourth embodiment will be described with reference to FIG. **21**.

[0360] The terminal **20**H according to the fourth embodiment executes a process additionally including step S**601** in FIG. **21** in a "Yes" route in step S**202** in FIG. **12** instead of the process in FIG. **12**, and additionally including steps S**602** and S**603** in FIG. **21** subsequent to step S**105** in FIG. **12**.

[0361] In the present embodiment, a case where, as illustrated in FIG. **19**, in response to a synchronization signal transmitted by the terminal **20**H-**1** which is a cluster head, the terminals **20**H-**3** to **20**H-**6** which are cluster members form a first cluster together with the terminal **20**H-**1** will be assumed. Further, a case where, in response to a synchronization signal transmitted by the terminal **20**H-**2** which is a cluster head, the terminals **20**H-**7** to **20**H-**10** which are cluster members form a second cluster together with the terminal **20**H-**2** will be assumed.

[0362] In addition, a case where the cluster head **20**H-**1** comes close to the cluster head **20**H-**2** to receive a synchronization signal transmitted by the cluster head **20**H-**2** will be assumed. Further, in the present embodiment, a case where a priority of the cluster head **20**H-**1** is lower than a priority of the cluster head **20**H-**2** will be assumed.

[0363] First, an operation of the terminal **20**H-**1** will be described. In this case, when moving to step S**202** in FIG. **21**, the terminal **20**H-**1** determines "Yes", and transmits the head switch instruction to the cluster members **20**H-**3** to **20**H-**6** (step S**601** in FIG. **21**).

[0364] Next, the terminal **20**H-**1** moves to step S**105** in FIG. **21**. In the present embodiment, that the terminal **20**H-**1** determines "Yes" in step S**202** in FIG. **21** represents that the local terminal **20**H-**1** is changed from a cluster head to a cluster member. Hence, in this case, the terminal **20**H-**1** stops transmitting synchronization signals.

[0365] In this case, the terminal **20**H-**1** synchronizes a communication timing with that of the terminal **20**H-**2** which has transmitted a synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **21**). Further, the terminal **20**H-**1** determines whether or not the head switch instruction has been received (step S**602** in FIG. **21**). At this point of time, the terminal **20**H-**1** determines "No", and returns to step S**101**.

[0366] Next, an operation of the terminal **20**H-**2** will be described. The terminal **20**H-**2** detects a synchronization signal transmitted by the terminal **20**H-**1**. Hence, when moving to step S**202** in FIG. **21**, the terminal **20**H-**2** determines "No", and returns to step S**104** in FIG. **21**. In this case, the terminal **20**H-**2** maintains a state where the terminal **20**H-**2** is used as a cluster head. Hence, the terminal **20**H-**2** continues transmitting synchronization signals.

[0367] Next, an operation of the terminal **20**H-**3** will be described. According to the above assumption, when the terminal **20**H-**1** transmits a synchronization signal, the terminal **20**H-**3** detects the synchronization signal transmitted by the terminal **20**H-**1**. Hence, when moving to step S**101** in FIG. **21**, the terminal **20**H-**3** determines "Yes", and synchronizes a communication timing with that of the terminal **20**H-**1** which has transmitted the synchronization signal, based on the detected synchronization signal (step S**105** in FIG. **21**).

[0368] Then, the terminal **20**H-**3** determines whether or not the head switch instruction has been received (step S**602** in FIG. **21**). In this case, the terminal **20**H-**3** determines "No", and returns to step S**101**.

[0369] When moving to step S**602** after the terminal **20**H-**1** transmits the head switch instruction, the terminal **20**H-**3** determines "Yes", and executes a process of detecting a synchronization signal transmitted by the terminal **20**H different from the terminal **20**H-**1**. In the present embodiment, a case where the terminal **20**H-**3** detects a synchronization signal transmitted by the terminal **20**H-**2** will be assumed.

[0370] In this case, the terminal **20**H-**3** synchronizes a communication timing with that of the terminal **20**H-**2** which has transmitted a synchronization signal, based on the detected synchronization signal (step S**603** in FIG. **21**). Subsequently, the terminal **20**H-**3** returns to step S**101**.

[0371] The terminals **20**H-**4** to **20**H-**6** may also operate similar to the terminal **20**H-**3**. Thus, the first cluster and the second cluster are integrated.

[0372] In addition, when it is not possible to detect a synchronization signal transmitted from the cluster head **20**H-**1** which is a destination of connection in step S**101** in FIG. **21**, the terminal **20**H-**3** may perform a process of detecting synchronization signals from the other cluster heads **20**H.

[0373] Consequently, the cluster member **20**H-**3** can quickly detect the synchronization signals transmitted by the other cluster heads **20**H. As a result, the cluster member **20**H-**3** can quickly switch the cluster head **20**H which is to be a destination of connection.

[0374] In this example, processes in steps S**601** to S**603** in FIG. **21** may be skipped. In this case, it is possible to reduce radio resources used to control clusters compared to a case where the head switch instruction is transmitted. Hence, it is possible to effectively use radio resources.

[0375] As described above, the wireless communication system **1**H according to the fourth embodiment integrates a plurality of clusters based on a priority of each of a plurality of cluster heads **20**H.

[0376] Consequently, it is possible to reduce the number of cluster heads **20**H. Thus, it is possible to reduce radio resources used to, for example, perform communication between the cluster heads **20**H and control the cluster head **20**H. Further, it is possible to appropriately reflect each priority in cluster integration. For example, the terminal **20**H having a higher priority can increase a probability that the terminal **20**H is continuously used as a cluster head.

[0377] Further, in the wireless communication system **1**H according to the fourth embodiment, integration of a plurality of clusters includes continuing transmitting synchronization signals by the cluster head **20**H-**2** having a higher priority than that of the cluster head **20**H-**1** among a plurality of cluster heads **20**H. Furthermore, integration of a plurality of clusters includes stopping transmitting synchronization signals by the cluster head **20**H-**1**.

[0378] Consequently, it is possible to increase a probability that the terminal **20**H-**2** having a higher priority can be continuously used as a cluster head. Further, it is possible to prevent synchronization signals from being unnecessarily transmitted.

[0379] In addition, in the wireless communication system **1**H according to the fourth embodiment, the cluster head **20**H-**1** sends a notification of integration of a plurality of clusters to the cluster members **20**H-**3** to **20**H-**6** forming a cluster together with the cluster head **20**H-**1**. Further, the cluster members **20**H-**3** to **20**H-**6** perform a process of detecting a synchronization signal transmitted from the cluster head **20**H-**2** in response to the notification from the cluster head **20**H-**1** (the head switch instruction in the present embodiment).

[0380] Consequently, the cluster members **20**H-**3** to **20**H-**6** can quickly detect a synchronization signal to be transmitted by the cluster head **20**H-**2**. As a result, the cluster members **20**H-**3** to **20**H-**6** can quickly switch the cluster head **20**H which is to be a destination of connection.

[0381] In addition, when detecting a synchronization signal associated with a priority lower than that of the local terminal **20**H-**2**, the cluster head **20**H-**2** may change a synchronization signal and a synchronization signal transmission timing. In the present embodiment, the cluster head

20H-**2** changes the synchronization signal transmission timing to the same timing as a timing at which the cluster head **20**H-**1** which is a transmission sources of the detected synchronization signal transmits the synchronization signal.

[0382] Consequently, the cluster members **20**H-**3** to **20**H-**6** forming a cluster together with the cluster head **20**H-**1** can detect a synchronization signal transmitted by the cluster head **20**H-**2** without changing a timing at which the synchronization signal is received. As a result, the cluster members **20**H-**3** to **20**H-**6** can quickly switch the cluster head **20**H which is to be a destination of connection.

[0383] Further, in the present embodiment, the cluster head **20**H-**2** changes the synchronization signal to the same signal as the detected synchronization signal. In addition, when a synchronization signal is associated with a priority as in the present embodiment, the cluster head **20**H-**2** may change the synchronization signal by changing a priority to the same priority as that of the cluster head **20**H-**1**.

[0384] Consequently, the cluster members **20**H-**3** to **20**H-**6** forming a cluster together with the cluster head **20**H-**1** can quickly detect a synchronization signal transmitted by the cluster head **20**H-**2**. As a result, the cluster members **20**H-**3** to **20**H-**6** can quickly switch the cluster head **20**H which is to be a destination of connection.

[0385] For example, as illustrated in FIG. **22**, the cluster head **20**H-**2** may execute a process additionally including steps S**701** and S**702** in the No route of step S**202** in FIG. **21**.

[0386] When determining No in step S**202** in FIG. **22**, the cluster head **20**H-**2** determines whether or not a synchronization signal associated with a priority lower than the priority of the local terminal **20**H-**2** has been detected (step S**701** in FIG. **22**).

[0387] Hereinafter, a case where a synchronization signal associated with a priority lower than the priority of the cluster head **20**H-**2** and transmitted by the cluster head **20**H-**1** has been detected will be assumed. In this case, the cluster head **20**H-**2** determines "Yes", and moves to step S**702** in FIG. **22**.

[0388] Then, the cluster head **20**H-**2** changes a synchronization signal transmission timing to the same timing as a timing at which the cluster head **20**H-**1** which is a transmission source of the detected synchronization signal transmits the synchronization signal. Furthermore, the cluster head **20**H-**2** changes the synchronization signal to the same signal as the detected synchronization signal (step S**702** in FIG. **22**). Subsequently, the cluster head **20**H-**2** returns to step S**104**.

[0389] Consequently, the cluster members **20**H-**3** to **20**H-**6** forming a cluster together with the cluster head **20**H-**1** can quickly switch the cluster head **20**H which is to be a destination of connection.

[0390] In addition, in case where the synchronization signal associated with the priority lower than the priority of the cluster head **20**H-**2** and transmitted by the cluster head **20**H-**1** has not been detected, the cluster head **20**H-**2** determines No in step S**701** in FIG. **22**. Then, the cluster head **20**H-**2** returns to step S**104** without executing a process in step S**702**.

[0391] Further, the cluster head **20**H-**2** may send a notification of synchronization signal information related to the changed synchronization signal to be transmitted by the cluster head **20**H-**2**, to the cluster members **20**H-**7** to **20**H-**10** forming a cluster together with the cluster head **20**H-**2**.

[0392] Consequently, even when a synchronization signal transmission timing and a synchronization signal are changed, the cluster members **20**H-**7** to **20**H-**10** can quickly detect the changed synchronization signal to be transmitted by the cluster head **20**H-**2**.

[0393] For example, the cluster head **20**H-**2** may execute a process additionally including step S**801** subsequent to step S**702** in FIG. **22** as illustrated in FIG. **23**.

[0394] When changing the synchronization signal and the synchronization signal transmission timing in step S**702** in FIG. **23**, the cluster head **20**H-**2** moves to step S**801** in FIG. **23**.

[0395] Further, the cluster head **20**H-**2** transmits the synchronization signal information to the cluster members **20**H-**7** to **20**H-**10** (step S**801** in FIG. **23**). Each of the cluster members **20**H-**7** to **20**H-**10** detects the synchronization signal to be transmitted by the cluster head **20**H-**2** based on the received synchronization signal information. Subsequently, the cluster head **20**H-**2** returns to step S**104**.

[0396] Consequently, the cluster members **20**H-**7** to **20**H-**10** can quickly detect changed synchronization signal.

[0397] In addition, when a synchronization signal is not associated with a priority, and a synchronization signal from the another terminal **20**H is detected, the terminal **20**H may notify the other terminals **20**H of priorities each other.

Fifth Embodiment

[0398] Next, a wireless communication system according to the fifth embodiment of the present invention will be described. The wireless communication system according to the fifth embodiment differs from the wireless communication system according to the second embodiment in stopping transmitting synchronization signals at certain timings. Such a difference will be mainly described below. In addition, in description of the fifth embodiment, components assigned the same reference numerals as those used in the second embodiment will be identical or substantially same components.

[0399] (Function)

[0400] As illustrated in FIG. **24**, a terminal **20**I according to the fifth embodiment functionally includes a controller **206**I instead of the controller **206**D in FIG. **11**. The controller **206**I includes the same functions as those of the controller **206**D except that the controller **206**I controls the synchronization signal generator **209** so as not to transmit synchronization signals at part of timings of a plurality of timings determined in advance as timings to transmit synchronization signals.

[0401] In the present embodiment, synchronization signals are transmitted at a plurality of timings determined in advance in the wireless communication system. For example, a synchronization signal may be transmitted in a predetermined subframe. In the present embodiment, timings determined in advance as timings to transmit synchronization signals in the wireless communication system will be also referred to as temporary transmission timings.

[0402] The controller **206**I controls the synchronization signal generator **209** so as not to transmit synchronization signals at part of a plurality of temporary transmission timings. In the present embodiment, timings of a plurality of temporary transmission timings at which synchronization signals are not transmitted will be also referred to as transmission stop timings.

[0403] The controller **206**I controls the synchronization signal detector **204** to execute a process of detecting synchronization signals transmitted by the terminals **20**I different from the local terminal **20**I at the transmission stop timings.

[0404] Consequently, it is possible to increase a probability that synchronization signals to be transmitted from the other terminals **20**I are detected.

[0405] In the present embodiment, each transmission stop timing is provided every time the temporary transmission timings come a certain number of times. For example, each transmission stop timing may be provided every time the five temporary transmission timings come. Further, each transmission stop timing may be a timing selected at random from the temporary transmission timings.

[0406] (Operation)

[0407] Next, an operation of the terminal **20**I according to the fifth embodiment will be described with reference to FIG. **25**.

[0408] The terminal **20**I according to the fifth embodiment executes a process additionally including steps S**901** and S**902** in a No route of step S**103** in FIG. **12** instead of the process in FIG. **12**.

[0409] When determining No in step S**103** in FIG. **25**, the terminal **20**I stands by until a temporary transmission timing comes (a No route in step S**901** in FIG. **25**). When the temporary transmission timing comes, the terminal **20**I determines "Yes" in step S**901**, and determines whether or not the transmission stop timing has come (step S**902** in FIG. **25**).

[0410] In case where the transmission stop timing has not come, the terminal **20**I determines No in step S**902**, moves to step S**104** and transmits a synchronization signal corresponding to a priority (step S**104** in FIG. **25**). Subsequently, the terminal **20**I executes the processes subsequent to step S**201** similar to the terminal **20**D according to the second embodiment.

[0411] Meanwhile, in case where the transmission stop timing has come, the terminal **20**I determines "Yes" in step S**902**, and moves to step S**201** without transmitting a synchronization signal. In this case, the terminal **20**I executes a process of detecting a synchronization signal transmitted at the transmission stop timing by the other terminals **20**I. Further, the terminal **20**I executes the processes subsequent to step S**201** similar to the terminal **20**D according to the second embodiment.

[0412] As described above, the terminal **20**I according to the fifth embodiment executes a process of detecting synchronization signals transmitted by the other terminals **20**I without transmitting synchronization signals at part of timings (transmission stop timings in the present embodiment) of a plurality of temporary transmission timings.

[0413] Consequently, it is possible to increase a probability that synchronization signals to be transmitted from the other terminals **20**I are detected.

[0414] In addition, the terminal **20**I may skip the process in step S**902**.

[0415] Further, the terminal **20**I according to the fifth embodiment includes the function in addition to the functions of the terminal **20**D according to the second embodiment yet may include the above function in addition to those of each of the terminal **20**, or **20**A to **20**H according to the first, third or fourth embodiment instead of the terminal **20**D according to the second embodiment.

[0416] In addition, in each of the above embodiments, when a time from starting transmitting synchronization signals is longer than a certain threshold, the terminal **20** may set the priority of the local terminal **20** to a maximum value among priorities used in a wireless communication system **1**.

[0417] For example, as described above, in case where a priority which is higher as a value is smaller and whose takes an integer value equal to or more than 0 is used in the wireless communication system **1**, the maximum value among the priorities used in the wireless communication system **1** is 0. Hence, in this case, when a time from starting transmitting a synchronization signal is longer than a certain threshold, the terminal **20** may set the priority of the local terminal **20** to **0**.

[0418] Consequently, it is possible to reduce a probability that the terminal **20** which has passed a sufficiently long time from starting transmitting the synchronization signal is changed from a cluster head to a cluster member. Thus, a terminal **20** serving as a cluster head is hardly frequently changed. Consequently, it is thus possible to reduce the number of the terminals **20** which change operation modes and the number of cluster members which change the terminal **20** which is to be a destination of connection. As a result, it is possible to reduce radio resources used by the cluster members to change the terminal **20** which is to be a destination of connection. Hence, it is possible to effectively use radio resources.

[0419] Further, in each of the above embodiments, a certain signal may be a known signal. For example, the known signal is a signal which the terminal **20** knows in advance.

[0420] Further, in each of the above embodiments, communication which a plurality of terminals **20** directly performs with each other may be referred to as direct communication or device to device (D2D) communication. Furthermore, in each of the above embodiments, communication which a plurality of terminals **20** performs via the base station **10** may be referred to as indirect communication.

[0421] In addition, in each of the above embodiments, the wireless communication system **1** may use a broadcast signal or a reference signal as a certain signal instead of a synchronization signal.

[0422] The broadcast signal indicates information broadcast to the terminal **20** positioned in a wireless area. This information is also referred to as broadcast information. For example, the broadcast information includes an MIB (Master Information Block). For example, the MIB includes a frame number (SFN: System Frame Number) of a radio frame and a system bandwidth. Further, when the terminal **20** transmits a broadcast signal, the broadcast signal may include an identifier (ID) for identifying the terminal **20**.

[0423] The reference signal is used to measure at least one of reception power of radio signals, communication quality of radio signals and a state of a channel in which radio signals propagate.

[0424] It is possible to effectively use radio resources.

[0425] All examples and conditional language provided herein are intended for pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A wireless communication system comprising:

a plurality of terminals; and

a wireless base station,

wherein each of the plurality of terminals determines a priority of a local terminal related to transmission of a certain signal according to a certain rule when the certain signal is not received from the wireless base station.

2. The wireless communication system according to claim **1**, wherein each of the plurality of terminals starts transmitting the certain signal when the certain signal is not received until a time corresponding to the determined priority passes.

3. The wireless communication system according to claim **1**, wherein the rule defines that the priority is determined based on information related to the terminal.

4. The wireless communication system according to claim **3**, wherein the information related to the terminal includes at least one of a type of a user who possesses the terminal, a position of the terminal, whether the terminal is positioned indoor or outdoor, whether or not power is supplied to the terminal, a remaining amount of a battery of the terminal, a speed at which the terminal moves, performance of an antenna of the terminal, transmission power of the terminal, a number of usable communication schemes by the terminal, availability of a GPS (Global Positioning System) function of the terminal, and a billing state of the terminal.

5. The wireless communication system according to claim **3**, wherein the rule defines that each of the plurality of terminals holds in advance a relationship, and determines the priority based on the held relationship, the relationship being a relationship between the information related to the terminal and the priority.

6. The wireless communication system according to claim **3**, wherein

the information related to the terminal includes a plurality of pieces of element information, and

the rule defines that each of the plurality of terminals holds in advance a relationship, calculates a total sum based on the held relationship and determines the priority based on the calculated total sum, the relationship being a relationship between information contents and points for the plurality of pieces of element information, the total sum being a total sum of the points for the plurality of pieces of element information.

7. The wireless communication system according to claim **1**, wherein the rule defines that each of the plurality of terminals generates a pseudo random number, and determines the priority based on the generated pseudo random number.

8. The wireless communication system according to claim **1**, wherein the rule defines that each of the plurality of terminals executes a process of detecting other terminals, and determines the priority based on a number of the other terminals detected by the process.

9. The wireless communication system according to claim **8**, wherein the rule defines that each of the plurality of terminals determines the priority such that, as the number of other terminals detected by the local terminal is larger, the priority is higher.

10. The wireless communication system according to claim **8**, wherein the rule defines that each of the plurality of terminals determines the priority such that, as a number of other terminals which have detected the local terminal is larger, the priority is higher.

11. The wireless communication system according to claim **1**, wherein the rule defines that the priority is determined based on input information.

12. The wireless communication system according to claim **2**, wherein each of the plurality of terminals makes the priority of the local terminal higher as a time from starting the transmission of the certain signal is longer.

13. The wireless communication system according to claim **2**, wherein a first terminal of the plurality of terminals stops the transmission of the certain signal at the first terminal in response to reception of the certain signal from a second terminal of the plurality of terminals having a higher priority than a priority of the first terminal.

14. A terminal, wherein the terminal determines a priority according to a certain rule when the certain signal is not received from a wireless base station, the priority being related to transmission of the certain signal at the terminal.

15. A processing method of a terminal, wherein the terminal determines a priority according to a certain rule when a certain signal is not received from a wireless base station, the priority being related to transmission of the certain signal at the terminal.

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