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(54) **RADIO COMMUNICATION METHOD, AND RADIO COMMUNICATION SYSTEM**

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(57) **ABSTRACT**

In order to improve utilization efficiency of a wireless base station having high communication quality and smooth a difference in communication quality between wireless terminals, in a wireless communication method, a wireless base station performs setting processing of setting a threshold for determining a congestion degree of the wireless base station on a basis of an actual value of past communication, determination processing of determining a congestion degree of the wireless base station using the threshold, and change processing of changing a connection condition of the wireless base station on a basis of a congestion degree of the wireless base station.

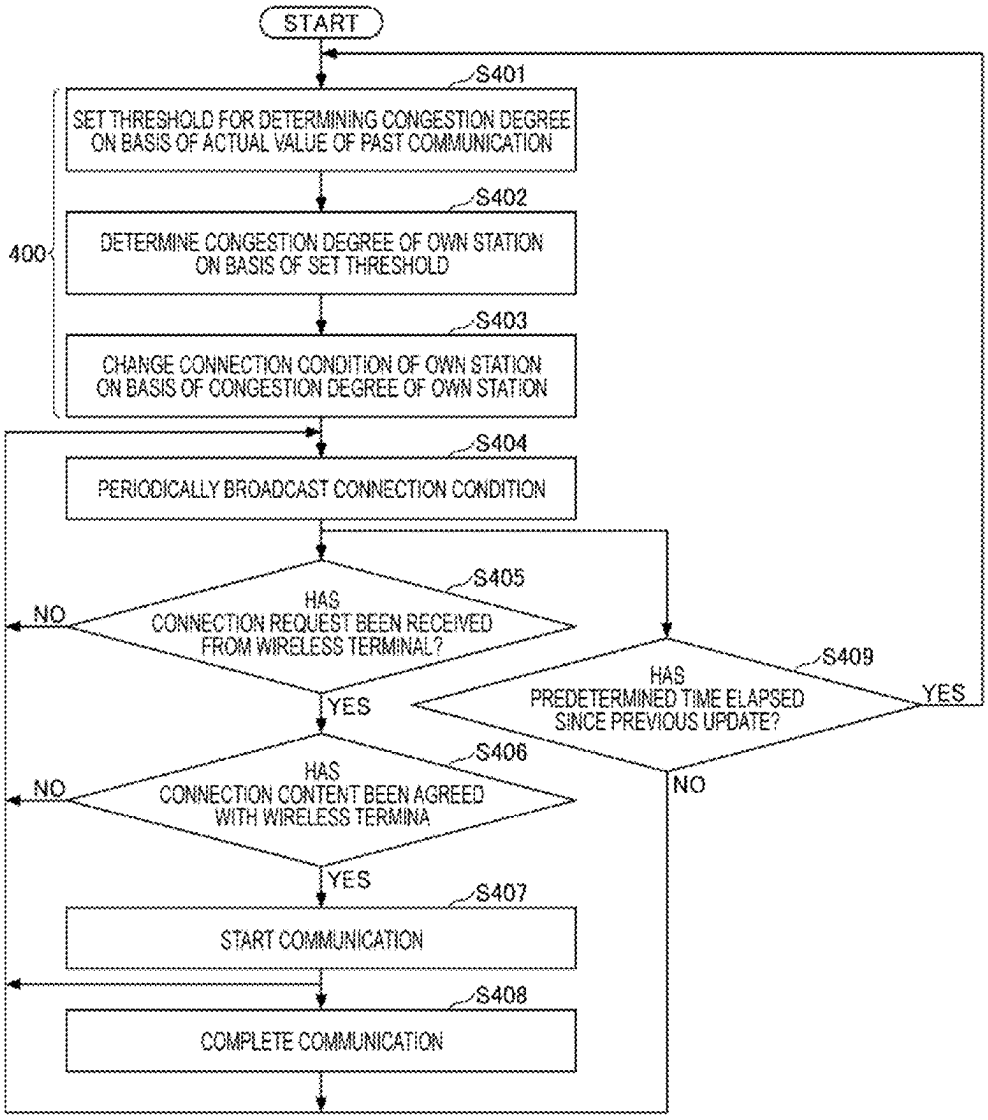
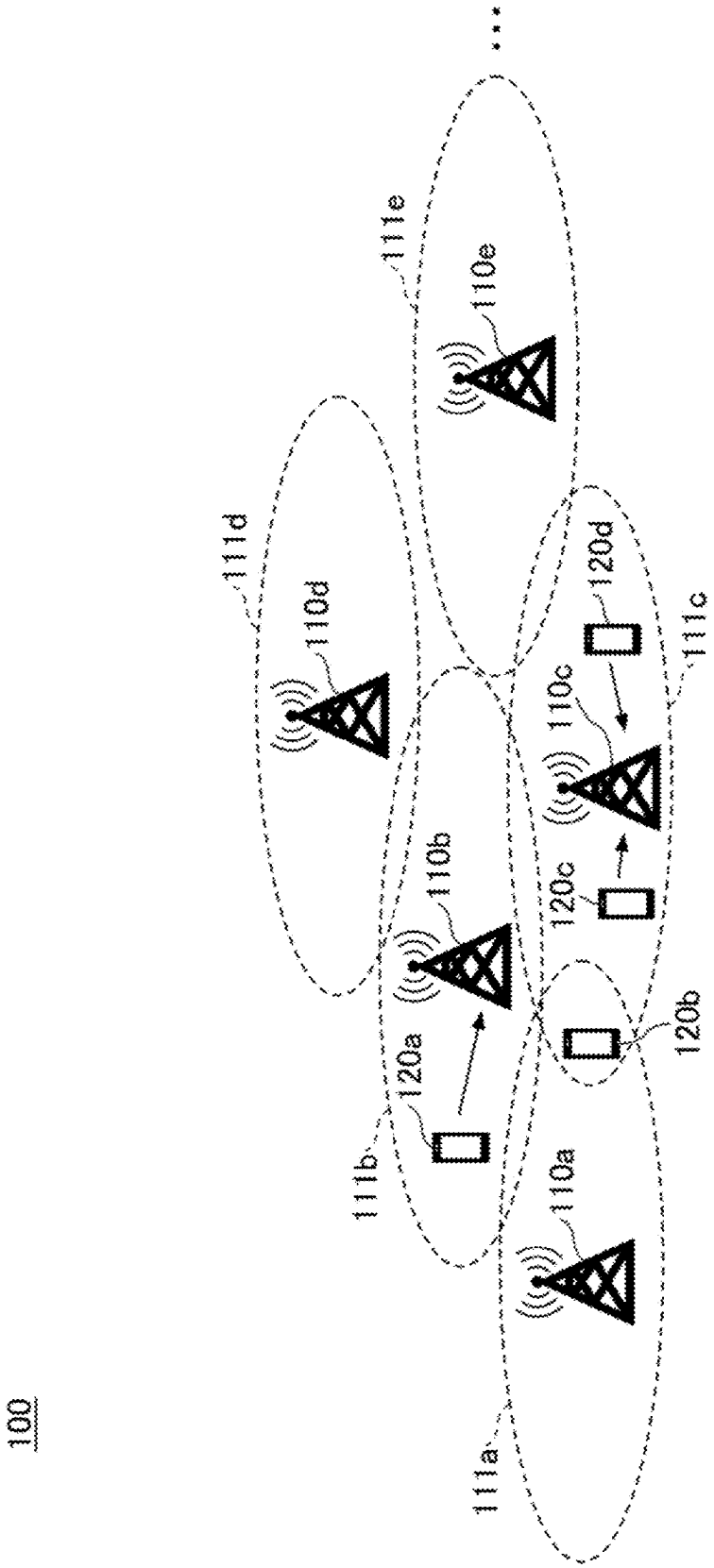


Fig. 1


100
111a
111b
111c
111d
111e
110a
110b
110c
110d
110e
120a
120b
120c
120d

# Fig. 2

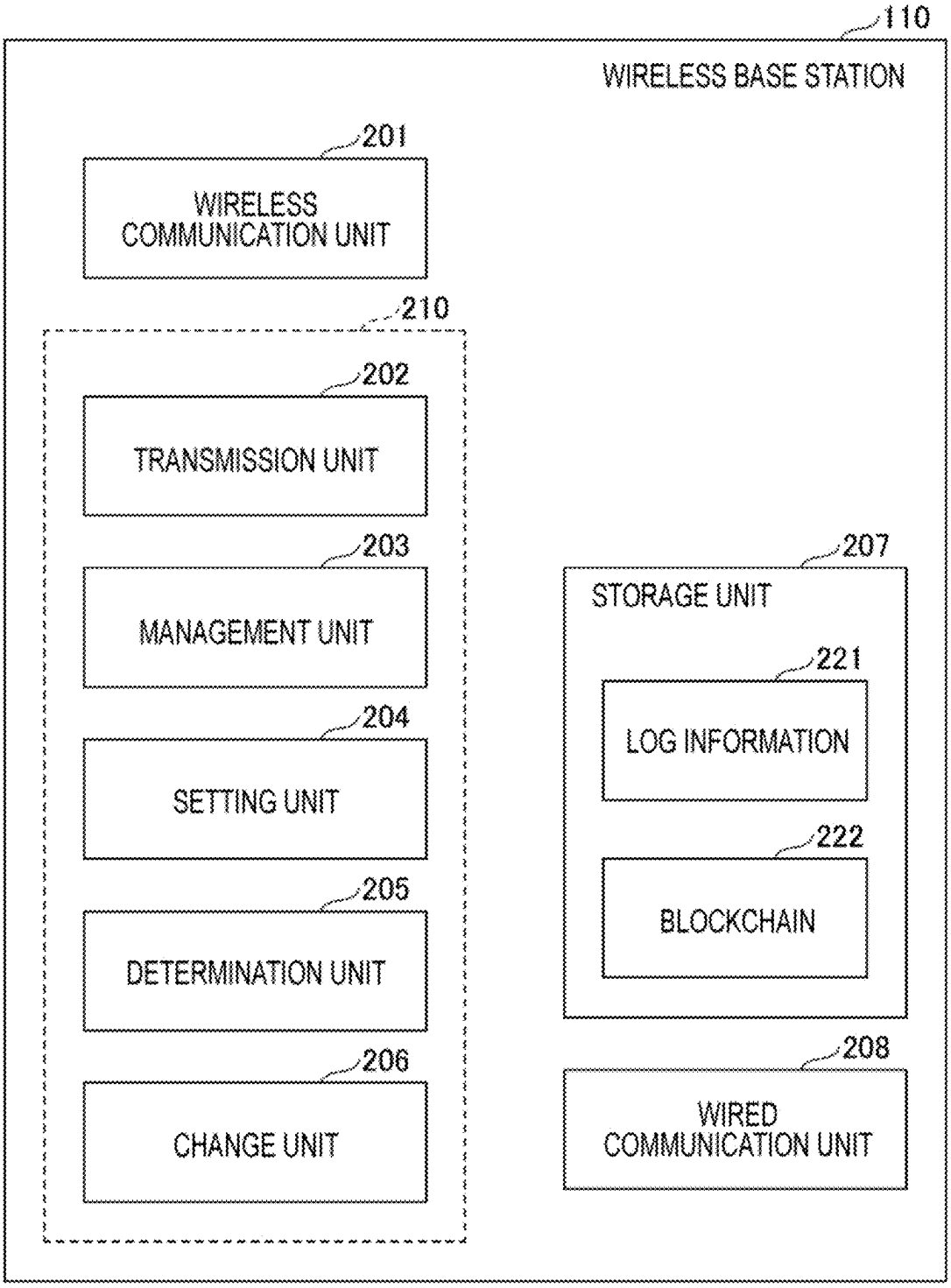

110
WIRELESS BASE STATION
201
WIRELESS COMMUNICATION UNIT
210
202
TRANSMISSION UNIT
203
MANAGEMENT UNIT
204
SETTING UNIT
205
DETERMINATION UNIT
206
CHANGE UNIT
207
STORAGE UNIT
221
LOG INFORMATION
222
BLOCKCHAIN
208
WIRED COMMUNICATION UNIT

Fig. 3

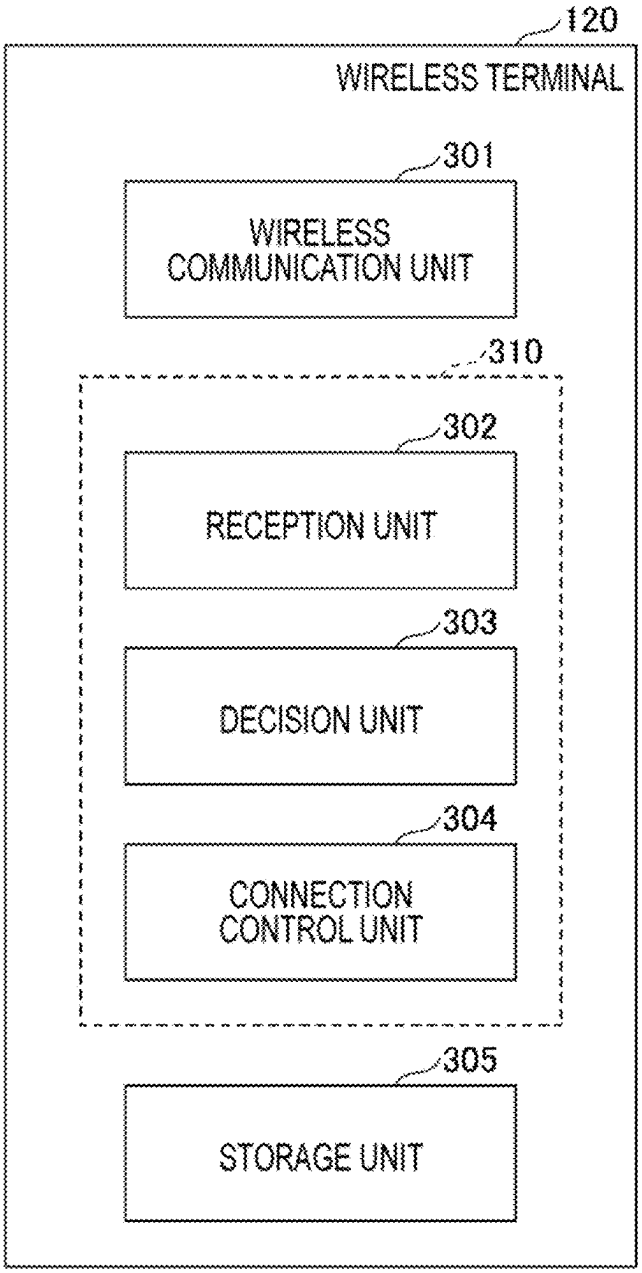

120
WIRELESS TERMINAL
301
WIRELESS COMMUNICATION UNIT
310
302
RECEPTION UNIT
303
DECISION UNIT
304
CONNECTION CONTROL UNIT
305
STORAGE UNIT

Fig. 4

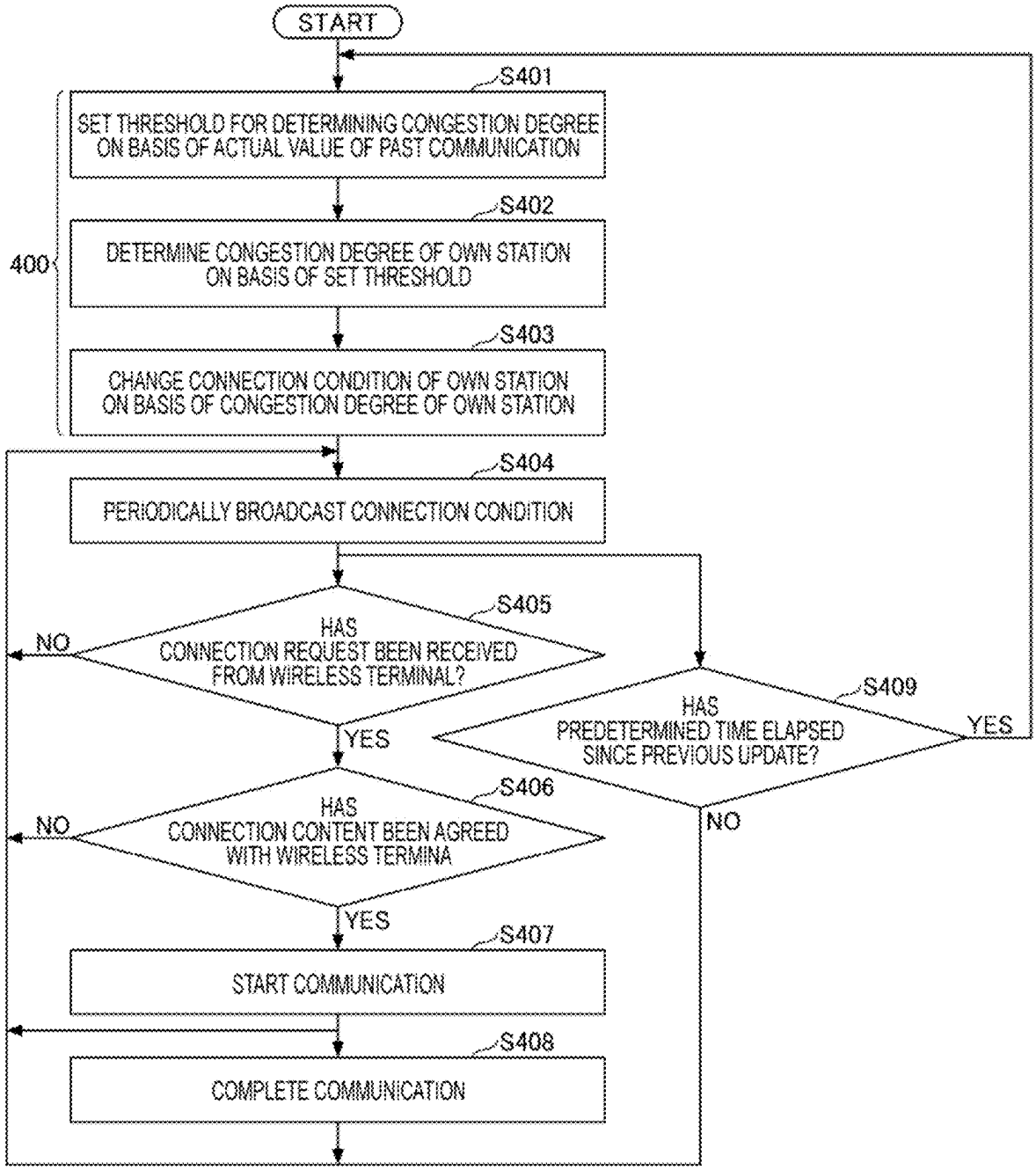

START
S401
SET THRESHOLD FOR DETERMINING CONGESTION DEGREE ON BASIS OF ACTUAL VALUE OF PAST COMMUNICATION
S402
DETERMINE CONGESTION DEGREE OF OWN STATION ON BASIS OF SET THRESHOLD
400
S403
CHANGE CONNECTION CONDITION OF OWN STATION ON BASIS OF CONGESTION DEGREE OF OWN STATION
S404
PERIODICALLY BROADCAST CONNECTION CONDITION
S405
HAS CONNECTION REQUEST BEEN RECEIVED FROM WIRELESS TERMINAL?
NO
YES
S409
HAS PREDETERMINED TIME ELAPSED SINCE PREVIOUS UPDATE?
YES
NO
S406
HAS CONNECTION CONTENT BEEN AGREED WITH WIRELESS TERMINA
NO
YES
S407
START COMMUNICATION
S408
COMPLETE COMMUNICATION

Fig. 5

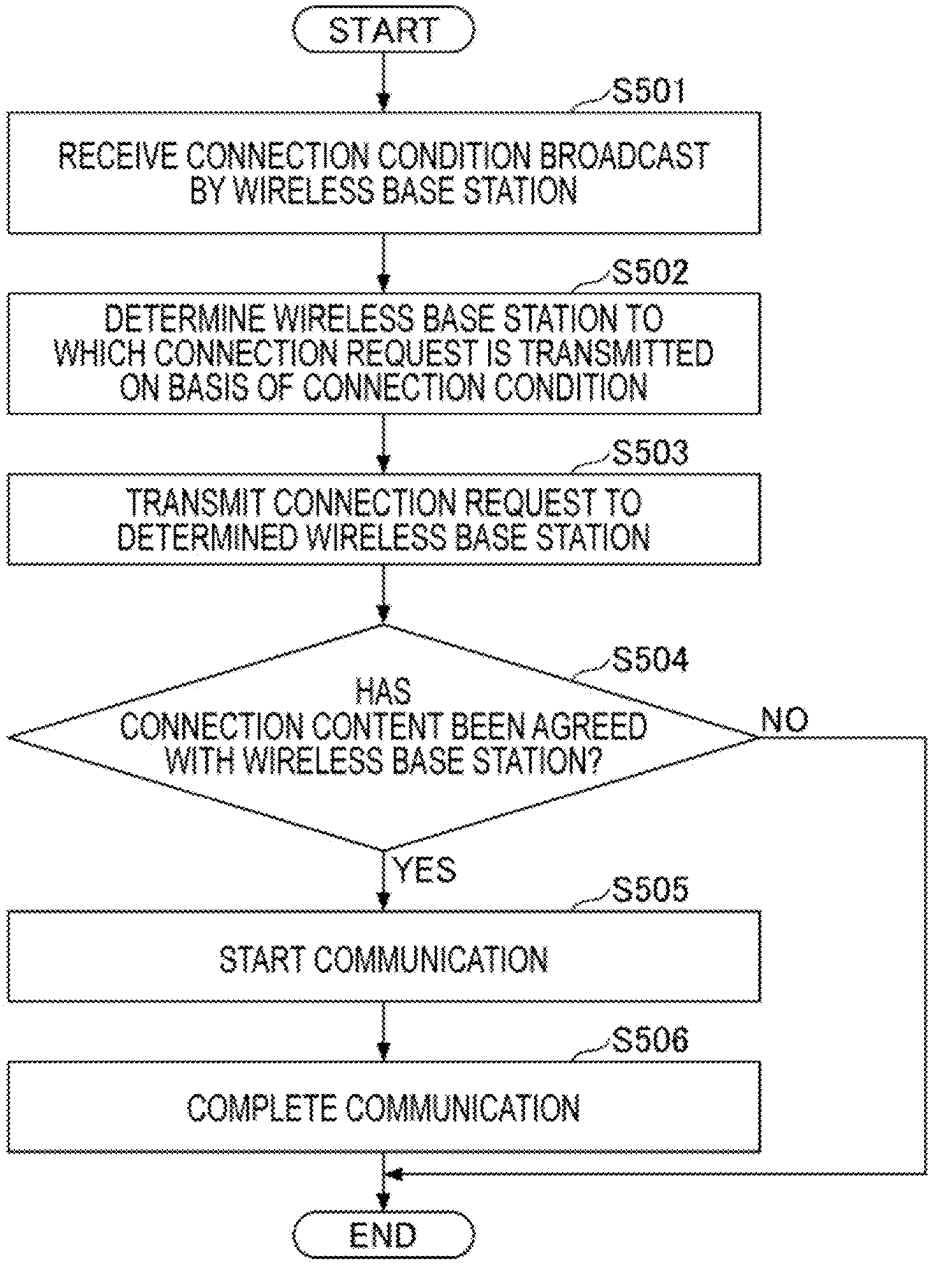

START
S501
RECEIVE CONNECTION CONDITION BROADCAST BY WIRELESS BASE STATION
S502
DETERMINE WIRELESS BASE STATION TO WHICH CONNECTION REQUEST IS TRANSMITTED ON BASIS OF CONNECTION CONDITION
S503
TRANSMIT CONNECTION REQUEST TO DETERMINED WIRELESS BASE STATION
S504
HAS CONNECTION CONTENT BEEN AGREED WITH WIRELESS BASE STATION?
NO
YES
S505
START COMMUNICATION
S506
COMPLETE COMMUNICATION
END

Fig. 6

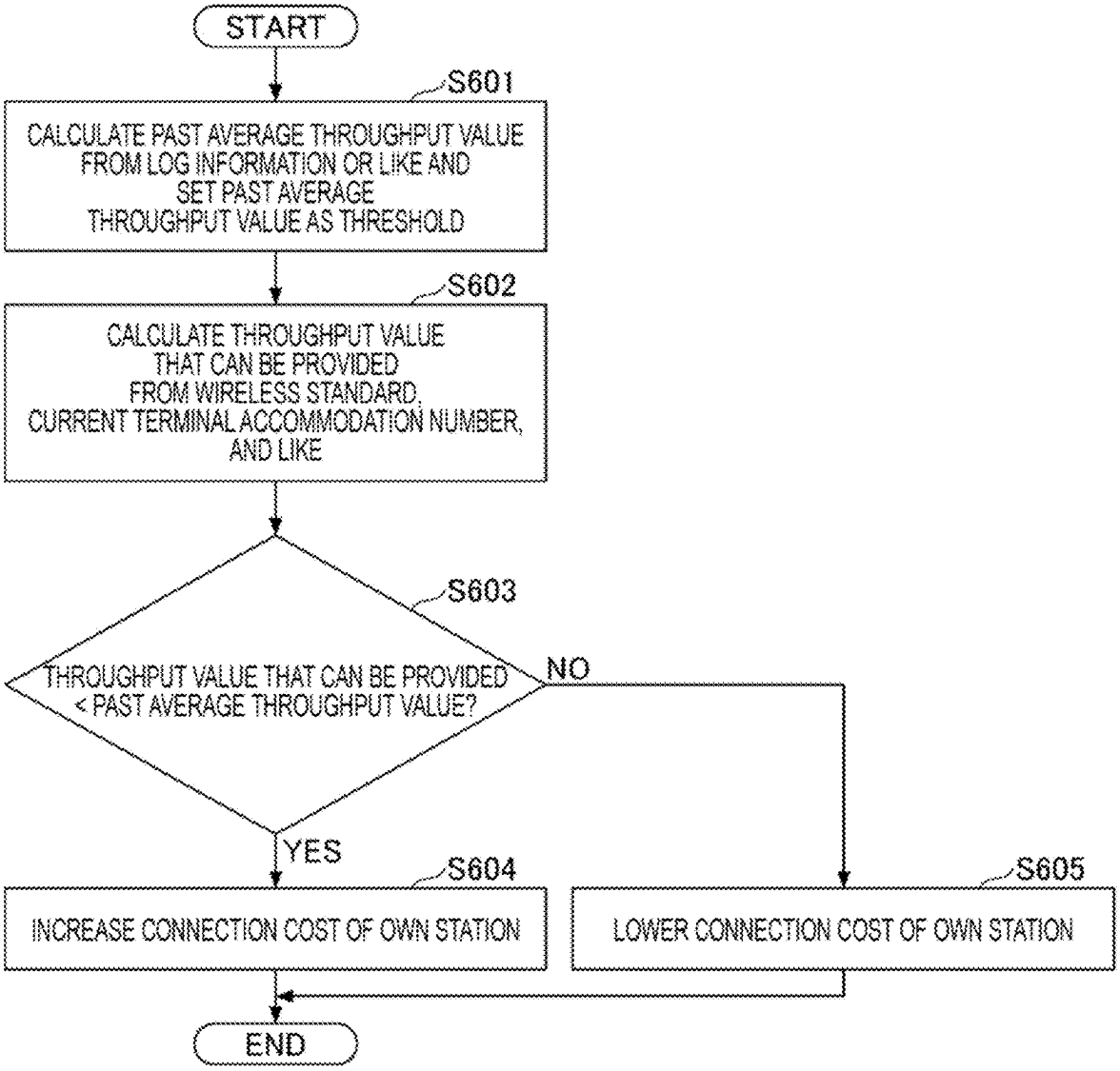

START
S601
CALCULATE PAST AVERAGE THROUGHPUT VALUE FROM LOG INFORMATION OR LIKE AND SET PAST AVERAGE THROUGHPUT VALUE AS THRESHOLD
S602
CALCULATE THROUGHPUT VALUE THAT CAN BE PROVIDED FROM WIRELESS STANDARD, CURRENT TERMINAL ACCOMMODATION NUMBER, AND LIKE
S603
THROUGHPUT VALUE THAT CAN BE PROVIDED < PAST AVERAGE THROUGHPUT VALUE?
NO
YES
S604
INCREASE CONNECTION COST OF OWN STATION
S605
LOWER CONNECTION COST OF OWN STATION
END

Fig. 7

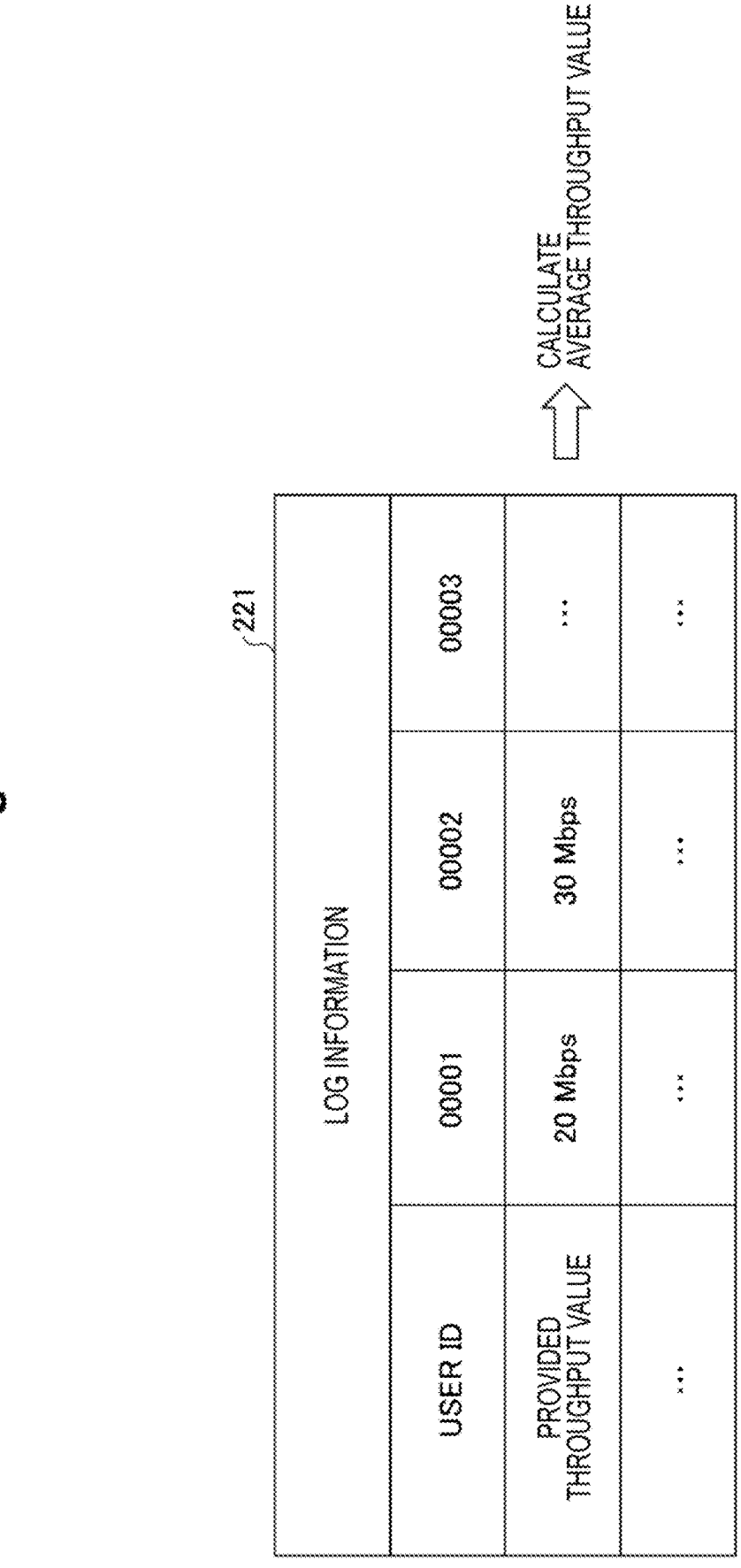

221
LOG INFORMATION
USER ID
00001
00002
00003
PROVIDED THROUGHPUT VALUE
20 Mbps
30 Mbps
CALCULATE AVERAGE THROUGHPUT VALUE

Fig. 8

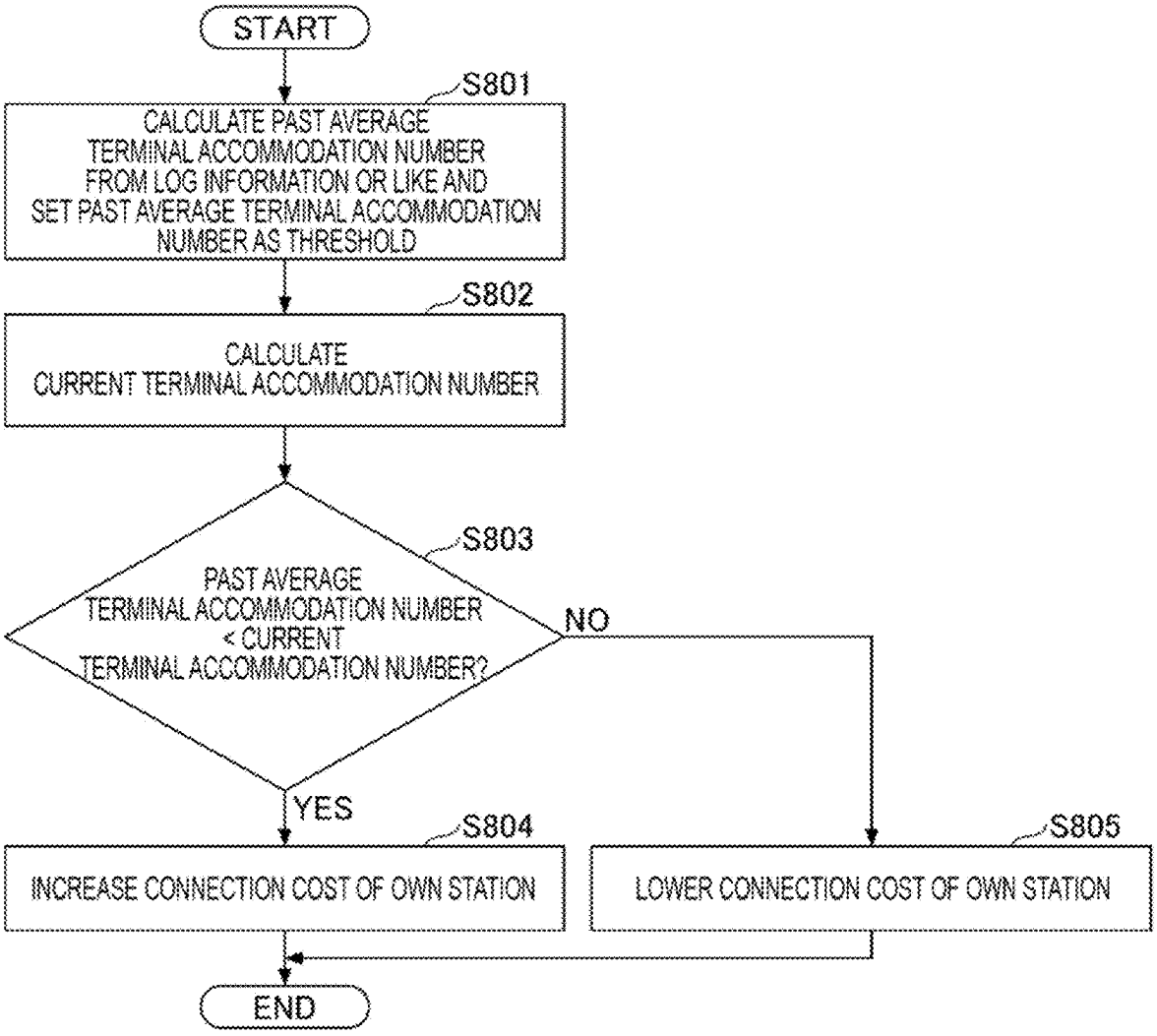
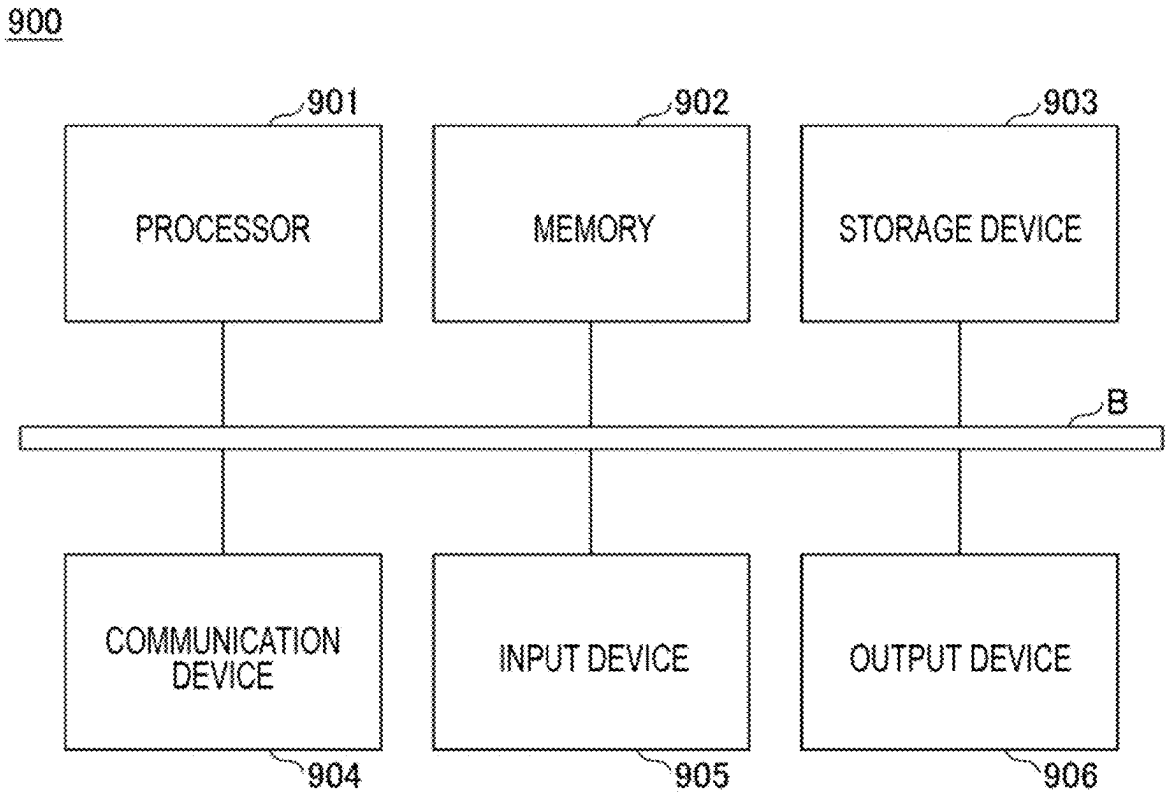

START
S801
CALCULATE PAST AVERAGE TERMINAL ACCOMMODATION NUMBER FROM LOG INFORMATION OR LIKE AND SET PAST AVERAGE TERMINAL ACCOMMODATION NUMBER AS THRESHOLD
S802
CALCULATE CURRENT TERMINAL ACCOMMODATION NUMBER
S803
PAST AVERAGE TERMINAL ACCOMMODATION NUMBER < CURRENT TERMINAL ACCOMMODATION NUMBER?
NO
YES
S804
INCREASE CONNECTION COST OF OWN STATION
S805
LOWER CONNECTION COST OF OWN STATION
END

Fig. 9


900
901
PROCESSOR
902
MEMORY
903
STORAGE DEVICE
B
COMMUNICATION DEVICE
904
INPUT DEVICE
905
OUTPUT DEVICE
906

# RADIO COMMUNICATION METHOD, AND RADIO COMMUNICATION SYSTEM

## TECHNICAL FIELD

**[0001]** The present invention relates to a wireless communication method and a wireless communication system.

## BACKGROUND ART

**[0002]** A wireless communication system that, in connection control between a wireless base station and a wireless terminal, performs distribution processing of connection control using a blockchain technology is known (see, for example, Non Patent Literature 1).

## CITATION LIST

### Non Patent Literature

**[0003]** Non Patent Literature 1: X. Ling, et al., "Blockchain Radio Access Network (B-RAN): Towards Decentralized Secure Radio Access Paradigm", IEEE Access, Volume: 7, 2019, p. 9714 9723

## SUMMARY OF INVENTION

### Technical Problem

**[0004]** In the conventional technology, in a situation in which a wireless terminal autonomously determines a wireless base station of a connection destination, a difference in performance for each wireless base station cannot be considered, and accordingly, there are issues that utilization efficiency of a wireless base station having high communication quality decreases, a difference in communication quality of a wireless terminal occurs, and the like.

**[0005]** The embodiment of the present invention has been made in view of the above issues, and provides a wireless communication method for improving utilization efficiency of a wireless base station having high communication quality and smoothing a difference in communication quality between wireless terminals.

### Solution to Problem

**[0006]** In order to solve the above issue, in a wireless communication method, a wireless base station performs setting processing of setting a threshold for determining a congestion degree of the wireless base station on a basis of an actual value of past communication, determination processing of determining a congestion degree of the wireless base station using the threshold, and change processing of changing a connection condition of the wireless base station on a basis of a congestion degree of the wireless base station.

### Advantageous Effects of Invention

**[0007]** According to the embodiment of the present invention, it is possible to provide a wireless communication method for improving utilization efficiency of a wireless base station having high communication quality and smoothing a difference in communication quality between wireless terminals.

## BRIEF DESCRIPTION OF DRAWINGS

**[0008]** FIG. **1** is a diagram illustrating an example of a system configuration of a wireless communication system according to the present embodiment.

**[0009]** FIG. **2** is a diagram illustrating an example of a functional configuration of a wireless base station according to the present embodiment.

**[0010]** FIG. **3** is a diagram illustrating an example of a functional configuration of a wireless terminal according to the present embodiment.

**[0011]** FIG. **4** is a flowchart illustrating an example of processing of the wireless base station according to the present embodiment.

**[0012]** FIG. **5** is a flowchart illustrating an example of processing of the wireless terminal according to the present embodiment.

**[0013]** FIG. **6** is a flowchart illustrating an example of connection condition change processing according to Example 1.

**[0014]** FIG. **7** is a diagram for describing the connection condition change processing according to Example 1.

**[0015]** FIG. **8** is a flowchart illustrating an example of connection condition change processing according to Example 2.

**[0016]** FIG. **9** is a diagram illustrating an example of a hardware configuration of the wireless base station and the wireless terminal according to the present embodiment.

## DESCRIPTION OF EMBODIMENTS

**[0017]** Hereinafter, an embodiment (present embodiment) of the present invention will be described with reference to the drawings. The embodiment to be described below is merely an example, and an embodiment to which the present invention is applied is not limited to the following embodiment.

<System Configuration>

**[0018]** FIG. **1** is a diagram illustrating an example of a system configuration of a wireless communication system according to the present embodiment. As illustrated in FIG. **1**, a wireless communication system **100** includes a plurality of wireless base stations **110***a*, **110***b*, **110***c*, **110***d*, **110***e*, . . . that form different network cells from each other. For example, the wireless base station **110***a* forms a network cell **111***a* and can communicate with a wireless terminal **120***b* in the network cell **111***a*. Furthermore, the wireless base station **110***b* forms a network cell **111***b* and can communicate with a wireless terminal **120***a* in the network cell **111***b*. Similarly, the wireless base station **110***c* forms a network cell **111***c* and can communicate with wireless terminals **120***b*, **120***c*, and **120***d* in the network cell **111***c*. Further, the wireless base station **110***d* forms a network cell **111***d*, and the wireless base station **110***e* forms a network cell **111***e*.

**[0019]** Note that, in the following description, in a case where any wireless base station among the wireless base stations **110***a*, **110***b*, **110***c*, **110***d*, **110***e*, . . . is indicated, "wireless base station **110**" is used. Similarly, in a case where any wireless terminal among the wireless terminals **120***a*, **120***b*, **120***c*, and **120***d* is indicated, "wireless terminal **120**" is used. Furthermore, the number of wireless base stations **110** and the number wireless terminals **120** illustrated in FIG. **1** are examples, and may be other numbers.

(Outline of Processing)

**[0020]** Here, referring back to FIG. **1**, an outline of processing of the wireless communication system **100** according to the present embodiment will be described.

**[0021]** Each wireless base station **110** broadcasts a connection condition for connecting to the own station to a wireless terminal **120** in a network cell **111** of the own station. The connection condition includes, for example, information of communication quality to be provided, a connection cost (connection fee) for connecting to the wireless base station **110**, and the like.

**[0022]** A wireless terminal **120** that starts communication receives a connection condition transmitted by a wireless base station **110** in the vicinity, and determines a wireless base station **110** of which connection is requested on the basis of the connection condition. For example, the wireless terminal **120** determines a wireless base station **110** that satisfies communication quality requested by the wireless terminal **120** and has the lowest connection cost among one or more wireless base stations **110** that have received the connection condition as the wireless base station **110** of which connection is requested. As described above, the wireless communication system **100** is a system in which the wireless terminal **120** autonomously determines the wireless base station **110** of a connection destination.

**[0023]** However, traffic may be concentrated on a specific wireless base station **110** if the method is used alone. For example, in FIG. **1**, the wireless terminal **120***a* is connected to the wireless base station **110***b*, and wireless terminals **120***c* and **120***d* are connected to the wireless base station **110***c*.

**[0024]** In the conventional technology, in a case where the wireless terminal **120***b* newly starts communication in this state, it is difficult to perform control such that the wireless terminal **120***b* is connected to the wireless base station **110***a* having a lower congestion degree in order to lower the congestion degree of the wireless base station **110***c*.

**[0025]** Furthermore, it is not realistic to control the optimum connection destination for all the wireless terminals **120** by centralized control by a control station that controls the wireless communication system **100** since the processing amount becomes enormous as the number of the wireless base stations **110** and the wireless terminals **120** increases.

**[0026]** Therefore, the wireless base station **110** according to the present embodiment includes a function of setting a threshold for determining the congestion degree of the own station (wireless base station **110**) on the basis of an actual value of past communication, and determining the current congestion degree of the own station using the threshold.

**[0027]** As an example, the wireless base station **110** may set an average value of past communication quality of the own station (hereinafter, referred to as average communication quality) as a threshold, and determine that the wireless base station **110** is congested in a case where the value of communication quality that can be provided by the own station is smaller than the threshold.

**[0028]** As another example, the wireless base station **110** may set an average value of the past terminal accommodation number of the own station (hereinafter, referred to as an average terminal accommodation number) as a threshold, and determine that the own station is congested in a case where the terminal accommodation number of the own station is larger than the past average terminal accommodation number.

**[0029]** As described above, the wireless base station **110** according to the present embodiment determines the congestion degree of the own station on the basis of an actual value of past communication, thereby being able to determine the congestion degree of the own station in consideration of a difference in performance for each wireless base station **110**.

**[0030]** Furthermore, the wireless base station **110** according to the present embodiment includes a function of changing the connection condition of the own station on the basis of the congestion degree of the own station. For example, in a case where the own station is congested, the wireless base station **110** increases the connection cost of the own station. Alternatively, in a case where the own station is not congested, the wireless base station **110** may lower the connection cost of the own station.

**[0031]** As described above, the wireless communication system **100** according to the present embodiment determines the congestion degree of each wireless base station **110** in consideration of a difference in performance of each wireless base station **110**, and changes the connection condition of each wireless base station **110** on the basis of the congestion degree of each wireless base station **110**. Therefore, according to the present embodiment, it is possible to provide the wireless communication system **100** and a wireless communication method for improving utilization efficiency of the wireless base station **110** having high communication quality and smoothing a difference in communication quality between the wireless terminals **120**.

<Functional Configuration>

**[0032]** Next, functional configurations of the wireless base station **110** and the wireless terminal **120** according to the present embodiment will be described.

(Functional Configuration of Wireless Base Station)

**[0033]** FIG. **2** is a diagram illustrating an example of a functional configuration of a wireless base station according to the present embodiment. The wireless base station **110** includes, for example, a configuration of a computer, and the computer implements a wireless communication unit **201**, a transmission unit **202**, a management unit **203**, a setting unit **204**, a determination unit **205**, a change unit **206**, a storage unit **207**, a wired communication unit **208**, and the like by executing a predetermined program. Note that at least some of the functional configurations described above may be implemented by hardware.

**[0034]** The wireless communication unit **201** forms the network cell **111** capable of performing wireless communication with the wireless base station **110**, and performs wireless communication processing of performing wireless communication with the wireless terminal **120** connected to the wireless base station **110**.

**[0035]** The transmission unit **202** performs transmission processing of broadcasting a connection condition for connecting to the wireless base station **110** to the wireless terminal **120** in the network cell **111** of the wireless base station **110**. The connection condition includes, for example, information of communication quality provided by the wireless base station **110**, a connection cost (connection fee) for connecting to the wireless base station **110**, and the like.

**[0036]** For example, the management unit **203** performs management processing of storing and managing log infor-

mation **221** including information of a wireless terminal **120** connected to the wireless base station **110** on the basis of the connection condition transmitted by the transmission unit **202** and information of the communication quality to be provided to the wireless terminal **120** and the like in the storage unit **207** or the like.

**[0037]** Note that the management unit **203** may record and manage information of a wireless terminal **120** connected to the wireless base station **110** and information of communication quality provided to the wireless terminal **120** and the like in a blockchain **222** as in the technology disclosed in Non Patent Literature 1, for example. Here, the following description will be given on the assumption that the management unit **203** stores and manages the log information **221** including information of a wireless terminal **120** connected to the wireless base station **110** and information of the communication quality to be provided to the wireless terminal **120** and the like in the storage unit **207**.

**[0038]** The setting unit **204** performs setting processing of setting a threshold for determining a congestion degree of a wireless base station **110** on the basis of an actual value of past communication of the wireless base station **110**. For example, the setting unit **204** may set past average communication quality of a wireless base station **110** as the threshold, or may set a past average terminal accommodation number of the own station as a threshold.

**[0039]** The determination unit **205** performs determination processing of determining a congestion degree of a wireless base station **110** using a threshold set by the setting unit **204**. For example, the determination unit **205** may determine that the wireless base station **110** is congested in a case where the value of communication quality that can be provided by the wireless base station **110** is smaller than the past average communication quality of the own station (example of the threshold). Alternatively, the determination unit **205** may determine that the own station is congested in a case where the number of wireless terminals **120** connected to the wireless base station **110** (terminal accommodation number) is larger than the past average terminal accommodation number (another example of the threshold).

**[0040]** The change unit **206** performs change processing of changing the connection condition of the wireless base station **110** on the basis of the congestion degree of the wireless base station **110**. For example, in a case where the own station (wireless base station **110**) is congested, the change unit **206** increases the connection cost of the own station. Furthermore, in a case where the own station is not congested, the change unit **206** may lower the connection cost of the own station.

**[0041]** Here, the connection cost is a cost for a wireless terminal **120** connecting to a wireless base station **110** (for example, connection fee), and the wireless terminal **120**, for example, preferentially connects to a wireless base station **110** having the lowest connection cost among wireless base stations **110** that satisfy required communication quality.

**[0042]** Note that, in a case where the distance between the wireless base station **110** and the wireless terminal **120** is short, the transmission power can be reduced, and in a case where the communication speed between the wireless base station **110** and the wireless terminal **120** is high, the communication time can be shortened. Therefore, the wireless terminal **120** may determine a wireless base station **110** to be connected on the basis of a received signal strength from the wireless base station **110**, the communication speed, or the like in addition to the connection cost.

**[0043]** Note that the transmission unit **202**, the management unit **203**, the setting unit **204**, the determination unit **205**, the change unit **206**, and the like are included in, for example, a communication control unit **310** that controls wireless communication by the wireless communication unit **201**.

**[0044]** The storage unit **207** performs storage processing of storing various types of data, information, programs, and the like including the log information **221**, the blockchain **222**, or the like in, for example, a storage device or the like included in the wireless base station **110**.

**[0045]** The wired communication unit **208** connects the wireless base station **110** to, for example, a wired communication network and communicates with other wireless base stations **110** and the like.

(Functional Configuration of Wireless Terminal)

**[0046]** FIG. **3** is a diagram illustrating an example of a functional configuration of a wireless terminal according to the present embodiment. The wireless terminal **120** includes, for example, a configuration of a computer, and the computer implements a wireless communication unit **301**, a reception unit **302**, a decision unit **303**, a connection control unit **304**, a storage unit **305**, and the like by executing a predetermined program. Note that at least some of the functional configurations described above may be implemented by hardware.

**[0047]** The wireless communication unit **301** is connected to the wireless base station **110** by wireless communication and performs wireless communication processing of transmitting and receiving data. The reception unit **302** performs reception processing of receiving a connection condition transmitted by the wireless base station **110** using the wireless communication unit **301**.

**[0048]** The decision unit **303** determines a wireless base station **110** of which the wireless terminal **120** requests connection on the basis of a connection condition received by the reception unit **302**. For example, the wireless terminal **120** preferentially connects to a wireless base station **110** having the lowest connection cost among wireless base stations **110** that satisfy the required communication quality. Note that, in a case where the distance between the wireless base station **110** and the wireless terminal **120** is short, the transmission power can be reduced, and in a case where the communication speed between the wireless base station **110** and the wireless terminal **120** is high, the communication time can be shortened. Therefore, the wireless terminal **120** desirably determines a wireless base station **110** of a connection destination on the basis of the communication quality of a wireless base station **110** and the connection cost.

**[0049]** The connection control unit **304** performs connection processing of connecting to a wireless base station **110** of a connection destination determined by the decision unit **303**. Note that the reception unit **302**, the decision unit **303**, the connection control unit **304**, and the like are included in, for example, a communication control unit **310** that controls wireless communication by the wireless communication unit **301**.

**[0050]** The storage unit **305** performs storage processing of storing various types of data, information, programs, and

the like necessary for wireless communication in, for example, a storage device or the like included in the wireless terminal **120**.

<Flow of Processing>

**[0051]** Next, a flow of processing of a wireless communication method according to the present embodiment will be described with a plurality of examples.

(Processing of Wireless Base Station) FIG. **4** is a flowchart illustrating an example of processing of the wireless base station according to the present embodiment. This processing illustrates the overall flow of processing performed by the wireless base station **110** described in FIG. **2**.

**[0052]** In step S**401**, the setting unit **204** sets a threshold for determining a congestion degree of the own station on the basis of an actual value of past communication of the own station (wireless base station **110**). For example, as described above, the setting unit **204** may set past average communication quality of the own station as a threshold, or may set past average terminal accommodation number of the own station as a threshold. Note that the setting unit **204** may use a value other than the past average communication quality and the average terminal accommodation number as a threshold for determining the congestion degree of the own station.

**[0053]** In step S**402**, the determination unit **205** performs determination processing of determining a congestion degree of a wireless base station **110** using a threshold set by the setting unit **204**. For example, the determination unit **205** may determine that the wireless base station **110** is congested in a case where the value of communication quality that can be provided by the wireless base station **110** is smaller than the past average communication quality of the own station (example of the threshold).

**[0054]** Alternatively, the determination unit **205** may determine that the own station is congested in a case where the number of wireless terminals **120** connected to the wireless base station **110** (terminal accommodation number) is larger than the past average terminal accommodation number (another example of the threshold).

**[0055]** In step S**403**, the change unit **206** performs change processing of changing the connection condition of the own station on the basis of the congestion degree of the own station (wireless base station **110**). For example, as described above, in a case where the own station is congested, the change unit **206** increases the connection cost of the own station. Furthermore, in a case where the own station is not congested, the change unit **206** may lower the connection cost of the own station.

**[0056]** In step S**404**, the transmission unit **202** broadcasts the connection condition using the wireless communication unit **201**. For example, the transmission unit **202** periodically transmits a notification message including the connection condition including information of the communication quality of wireless communication provided by the own station (wireless base station **110**), the connection cost, and the like by wireless communication.

**[0057]** In step S**405**, the communication control unit **210** determines whether the wireless communication unit **201** has received a connection request from a wireless terminal **120**, and performs processing in and after step S**406** in a case where the connection request has been received. On the other hand, in a case where the connection request has not been received, the communication control unit **210** returns the processing to step S**404**.

**[0058]** In a case where the processing proceeds to step S**406**, the communication control unit **210** determines whether the connection content is agreed with the wireless terminal **120**, and in a case where the connection content is agreed with the wireless terminal **120**, the processing proceeds to step S**407**. On the other hand, in a case where the connection content is not agreed with the wireless terminal **120**, the communication control unit **210** returns the processing to step S**404**.

**[0059]** In a case where the processing proceeds to step S**407**, the wireless base station **110** starts communication with the wireless terminal **120** that has transmitted the connection request, and returns the processing to step S**404**. In step S**408**, in a case where the communication is completed, the wireless base station **110** returns the processing to step S**404**.

**[0060]** Note that the setting unit **204** performs processing of step S**409** in parallel with processing of steps S**404** to S**408**, for example.

**[0061]** In step S**409**, the setting unit **204** determines whether a predetermined time has elapsed since the previous performing of processing **400** of steps S**401** to S**403**. Here, the predetermined time is a preset connection cost update interval. In a case where the predetermined time has elapsed, the setting unit **204** performs the processing **400** of steps S**401** to S**403** again. In a case where the predetermined time has not elapsed, the setting unit **204** returns processing to step S**404** and waits until the predetermined time elapses.

**[0062]** Through the above processing, the wireless base station **110** changes the connection condition of the wireless base station **110** on the basis of an actual value of past communication of the own station. Furthermore, by each wireless base station **110** included in the wireless communication system **100** performing the processing of FIG. **4**, the wireless communication system **100** according to the present embodiment can set the connection condition of each wireless base station **110** in consideration of a difference in performance (communication quality) for each wireless base station **110**.

(Processing of Wireless Terminal)

**[0063]** FIG. **5** is a flowchart illustrating a flow of processing of the wireless terminal according to the present embodiment. This processing is an example of processing performed in a case where the wireless terminal **120** described with reference to FIG. **3** starts wireless communication.

**[0064]** In step S**501**, the reception unit **302** receives a connection condition broadcast by the wireless base station **110**. As described above, the connection condition includes information of communication quality of the wireless communication provided by the wireless base station **110**, a connection cost, and the like.

**[0065]** In step S**502**, the decision unit **303** determines a wireless base station **110** of which the wireless terminal **120** requests connection on the basis of the connection condition received by the reception unit **302**. For example, the decision unit **303** may determine a wireless base station **110** having the lowest connection cost among wireless base stations **110** that satisfy the required communication quality as the wireless base station **110** of which connection is required. Furthermore, in a case where there is a plurality of

wireless base stations **110** having the same connection cost, the decision unit **303** may determine a wireless base station **110** having the highest communication quality (for example, throughput, received power, or the like) as the wireless base station **110** of which connection is required.

**[0066]** In step S**503**, the connection control unit **304** transmits a connection request for requesting connection of wireless communication to the wireless base station **110** determined by the decision unit **303**.

**[0067]** In step S**504**, the connection control unit **304** determines whether the connection content is agreed with the wireless base station **110**, and proceeds the processing to step S**505** in a case where the connection content is agreed. On the other hand, in a case where the connection content is not agreed, the wireless terminal **120** ends the processing of FIG. **5**.

**[0068]** In a case where the processing proceeds to step S**505**, the wireless terminal **120** starts communication with the wireless base station **110** of the connection destination, and in a case where the communication is completed in step S**506**, the processing of FIG. **5** ends.

**[0069]** Through the above processing, the wireless terminal **120** preferentially connects to a wireless base station **110** having a lower connection cost among wireless base stations **110** in the vicinity.

**[0070]** Note that, in a case where the communication quality deteriorates during communication, the wireless terminal **120** may perform the processing of FIG. **5** again and switch the connection destination to a new wireless base station **110**. Furthermore, in a case where the communication cost of the wireless base station **110** increases during communication, the wireless terminal **120** may perform the processing of FIG. **5** again and switch the connection destination to a new wireless base station **110**.

<Connection Condition Change Processing>

**[0071]** Next, connection condition change processing performed by the wireless base station **110** will be described with specific examples.

Example 1

**[0072]** FIG. **6** is a flowchart illustrating an example of connection condition change processing according to Example 1. This processing illustrates, for example, a specific example of the processing **400** of steps $401 to S**403** in FIG. **4**.

**[0073]** In step S**601**, the setting unit **204** of the wireless base station **110** calculates the past average throughput value of the wireless base station **110** from, for example, the log information **221** stored in the storage unit **207**. For example, as illustrated in FIG. **7**, the log information **221** stores throughput values of wireless communication provided to each wireless terminal **120** (provided throughput values) in past communication with the wireless terminal **120**. For example, the setting unit **204** calculates the past average throughput value by averaging provided throughput values in a predetermined period or the entire period. Furthermore, the setting unit **204** sets the calculated past average throughput value as a threshold for determining the congestion degree of the wireless base station **110**.

**[0074]** In step S**602**, the determination unit **205** of the wireless base station **110** calculates a throughput value that can be provided to the wireless terminal **120** from, for example, the wireless standard, the current terminal accommodation number, and the like. Here, the current terminal accommodation number is the number of wireless terminals **120** currently connected to the wireless base station **110**.

**[0075]** In step S**603**, the determination unit **205** compares the throughput value that can be provided by the wireless base station **110** with the set threshold (past average throughput value) and determines the congestion degree of the wireless base station **110**. For example, the determination unit **205** determines that the wireless base station **110** is congested in a case where the throughput value (example of communication quality) that can be provided by the wireless base station **110** is smaller than the past average throughput value (threshold). On the other hand, the determination unit **205** determines that the wireless base station **110** is not congested in a case where the throughput value that can be provided by the wireless base station **110** is equal to or larger than the past average throughput value (threshold).

**[0076]** In a case where the throughput value that can be provided by the wireless base station **110** is smaller than the past average throughput value (threshold), that is, a case where the wireless base station **110** is congested, the determination unit **205** proceeds the processing to step S**604**. On the other hand, in a case where the throughput value that can be provided by the wireless base station **110** is equal to or larger than the past average throughput value (threshold), that is, a case where the wireless base station **110** is not congested, the determination unit **205** proceeds the processing to step S**605**.

**[0077]** In a case where the processing proceeds to step S**604**, the change unit **206** of the wireless base station **110** increases the connection cost of the own station (wireless base station **110**). On the other hand, in a case where the processing proceeds to step S**605**, the change unit **206** lowers the connection cost of the own station. Note that a constant value may be used as the increase/decrease width of the connection cost, or the increase/decrease width may be set to be larger as the difference between the throughput value that can be provided and the past throughput value is larger.

**[0078]** Note that, in the above description, the threshold is the average value of the past throughputs, but the threshold may be, for example, a representative value other than the average value, such as a median value of the past throughputs. Furthermore, the period referred to in a case of calculating the representative value may be, for example, a predetermined period such as the past 24 hours, the past one week, or the past one month, or may be, for example, a predetermined period classified into a day of the week, a time zone, or the like.

Example 2

**[0079]** FIG. **8** is a flowchart illustrating an example of connection condition change processing according to Example 2. This processing illustrates, for example, a specific example of the processing **400** of steps S**401** to S**403** in FIG. **4**.

**[0080]** In step S**801**, the setting unit **204** of the wireless base station **110** calculates the past average terminal accommodation number of the wireless base station **110** from, for example, the log information **221** stored in the storage unit **207**. Here, the past average terminal accommodation number is an average value of terminal accommodation numbers of the wireless base station **110** stored in the log information

221 or the like. Furthermore, the terminal accommodation number of the wireless base station 110 is the number of wireless terminals 120 connected to the wireless base station 110. Furthermore, the setting unit 204 sets the calculated past average terminal accommodation number of the wireless base station 110 as a threshold for determining the congestion degree of the wireless base station 110.

[0081] In step S802, the determination unit 205 of the wireless base station 110 calculates the current terminal accommodation number of the wireless base station 110.

[0082] In step S803, the determination unit 205 compares the current terminal accommodation number of the wireless base station 110 with the threshold (past average terminal accommodation number) and determines the congestion degree of the wireless base station 110. For example, in a case where the current terminal accommodation number of the wireless base station 110 is larger than the past average terminal accommodation number (threshold), the determination unit 205 determines that the wireless base station 110 is congested. On the other hand, in a case where the current terminal accommodation number of the wireless base station 110 is equal to or smaller than the past average terminal accommodation number (threshold), the determination unit 205 determines that the wireless base station 110 is not congested.

[0083] In a case where the current terminal accommodation number of the wireless base station 110 is larger than the past average terminal accommodation number (threshold), that is, a case where the wireless base station 110 is congested, the determination unit 205 proceeds the processing to step S804. On the other hand, in a case where the current terminal accommodation number of the wireless base station 110 is equal to or smaller than the past average terminal accommodation number (threshold), that is, a case where the wireless base station 110 is not congested, the determination unit 205 proceeds the processing to step S805.

[0084] In a case where the processing proceeds to step S804, the change unit 206 of the wireless base station 110 increases the connection cost of the own station (wireless base station 110). On the other hand, in a case where the processing proceeds to step S805, the change unit 206 lowers the connection cost of the own station. Note that a constant value may be used as the increase/decrease width of the connection cost, or the increase/decrease width may be set to be larger as the difference between the current terminal accommodation number of the wireless base station 110 and the past average terminal accommodation number is larger.

[0085] Note that, in the above description, the threshold is the average value of the past terminal accommodation numbers, but the threshold may be, for example, a representative value other than the average value, such as a median value of the past terminal accommodation numbers. Furthermore, the period referred to in a case of calculating the representative value may be, for example, a predetermined period such as the past 24 hours, the past one week, or the past one month, or may be, for example, a predetermined period classified into a day of the week, a time zone, or the like.

<Hardware Configuration Example>

[0086] FIG. 9 is a diagram illustrating an example of a hardware configuration of the wireless base station and the wireless terminal according to the present embodiment. The wireless base station 110 and the wireless terminal 120 include, for example, a configuration of a computer 900 as illustrated in FIG. 9. In the example of FIG. 9, the computer 900 includes a processor 901, a memory 902, a storage device 903, a communication device 904, an input device 905, an output device 906, and a bus B.

[0087] The processor 901 is, for example, an arithmetic device such as a central processing unit (CPU) that implements various functions by executing a predetermined program. The memory 902 is a storage medium readable by the computer 900, and includes, for example, a random access memory (RAM) or a read only memory (ROM). The storage device 903 is a computer-readable storage medium, and can include, for example, a hard disk drive (HDD), a solid state drive (SSD), various optical disks, and a magneto-optical disk.

[0088] The communication device 904 includes one or more pieces of hardware (communication device) for communicating with other devices via a wireless or wired network. For example, the communication device 904 of the computer 900 included in the wireless base station 110 includes a communication device for performing wireless communication and a communication device for performing wired communication. Furthermore, the communication device 904 of the computer 900 included in the wireless terminal 120 includes a communication device for performing wireless communication.

[0089] The input device 905 is an input device (e.g., a keyboard, a mouse, a microphone, a switch, a button, or a sensor) that receives an input from the outside. The output device 906 is an output device (e.g., a display, a speaker, or an LED lamp) that performs output to the outside. The input device 905 and the output device 906 may be integrated (e.g., an input/output device such as a touch panel display).

[0090] The bus B is commonly connected to the above-described components, and transmits, for example, an address signal, a data signal, and various control signals. The processor 901 is not limited to a CPU, and may be, for example, a digital signal processor (DSP), a programmable logic device (PLD), or a field programmable gate array (FPGA).

(Supplement)

[0091] The wireless base station 110 and the wireless terminal 120 in the present embodiment are not necessarily implemented by dedicated devices, but may be implemented by general-purpose computers. In that case, a program for implementing the functions may be recorded in a computer-readable recording medium, and the functions may be implemented by loading the program recorded in this recording medium to a computer system, and executing the program. Note that the "computer system" mentioned herein includes an OS and hardware such as peripheral devices.

[0092] The "computer-readable recording medium" includes various storage devices such as a portable medium such as a flexible disk, a magneto-optical disk, a ROM, and a CD-ROM, and a hard disk built in the computer system. Furthermore, the "computer-readable recording medium" may include a medium that dynamically holds the program for a short time, such as a communication line in a case where the program is transmitted via a network such as the Internet or a communication line such as a telephone line, and a medium that holds the program for a certain period of time, such as a volatile memory inside a computer system serving as a server or a client in that case.

**[0093]** In addition, the program may be for implementing some of the above-described functions, may be capable of implementing the above-described functions in combination with a program already recorded in a computer system, or may be implemented by using hardware such as a programmable logic device (PLD) or a field programmable gate array (FPGA).

Effects of the Embodiments

**[0094]** As described above, according to the present embodiment, it is possible to provide a wireless communication method for improving utilization efficiency of a wireless base station having high communication quality and smoothing a difference in communication quality between wireless terminals. Furthermore, according to the present embodiment, the wireless base station **110** can obtain the above effect even in a wireless communication system **100** that cannot acquire information of other wireless base stations **110** from a blockchain **222**.

Summary of Embodiment

**[0095]** The present specification discloses at least the wireless communication method and the wireless communication system in the following clauses.

(Clause 1)

**[0096]** A wireless communication method, in which

**[0097]** a wireless base station performs:

**[0098]** setting processing of setting a threshold for determining a congestion degree of the wireless base station on a basis of an actual value of past communication;

**[0099]** determination processing of determining a congestion degree of the wireless base station using the threshold; and

**[0100]** change processing of changing a connection condition of the wireless base station on a basis of a congestion degree of the wireless base station.

(Clause 2)

**[0101]** The wireless communication method according to Clause 1, in which,

**[0102]** in the setting processing, an actual value of past communication quality of the wireless base station is set as the threshold, and,

**[0103]** in the determination processing, the wireless base station is determined to be congested in a case where a value of communication quality that can be provided by the wireless base station is smaller than the threshold.

(Clause 3)

**[0104]** The wireless communication method according to Clause 1, in which,

**[0105]** in the setting processing, an actual value of past terminal accommodation number of the wireless base station is set as the threshold, and,

**[0106]** in the determination processing, the wireless base station is determined to be congested in a case where a current terminal accommodation number of the wireless base station is larger than the threshold.

(Clause 4)

**[0107]** The wireless communication method according to any one of Clauses 1 to 3, in which, in the change processing, a connection cost of the wireless base station is increased in a case where the wireless base station is congested.

(Clause 5)

**[0108]** The wireless communication method according to any one of Clauses 1 to 3, in which, in the change processing, a connection cost of the wireless base station is lowered in a case where the wireless base station is not congested.

(Clause 6)

**[0109]** A wireless communication system including a plurality of wireless base stations and a wireless terminal, in which

**[0110]** a wireless base station includes:

**[0111]** a setting unit that sets a threshold for determining a congestion degree of the wireless base station on a basis of an actual value of past communication;

**[0112]** a determination unit that determines a congestion degree of the wireless base station using the threshold; and

**[0113]** a change unit that changes a connection condition of the wireless base station on a basis of a congestion degree of the wireless base station, and

**[0114]** the wireless terminal includes:

**[0115]** a reception unit that receives the connection condition; and

**[0116]** a decision unit that determines the wireless base station of which the wireless terminal requests connection on a basis of the connection condition.

**[0117]** While the present embodiment has been described above, the present invention is not limited to such a specific embodiment, and various modifications and changes can be made within the scope of the present invention described in the claims.

REFERENCE SIGNS LIST

**[0118]** **100** Wireless communication system

**[0119]** **110**, **110***a* to **110***e* Wireless base station

**[0120]** **120**, **120***a* to **120***d* Wireless terminal

**[0121]** **204** Setting unit

**[0122]** **205** Determination unit

**[0123]** **206** Change unit

**[0124]** **221** Log information

**[0125]** **302** Reception unit

**[0126]** **303** Decision unit

**1**. A wireless communication method comprising:

setting, by a wireless base station, a threshold for determining a congestion degree of the wireless base station on a basis of an actual value of past communication;

determining, by the wireless base station, a congestion degree of the wireless base station using the threshold; and

changing, by the wireless base station, a connection condition of the wireless base station on a basis of a congestion degree of the wireless base station.

**2**. The wireless communication method according to claim **1**, wherein,

in the setting, an actual value of past communication quality of the wireless base station is set as the threshold, and,

in the determining, the wireless base station is determined to be congested in a case where a value of communication quality that can be provided by the wireless base station is smaller than the threshold.

**3**. The wireless communication method according to claim **1**, wherein,

in the setting, an actual value of past terminal accommodation number of the wireless base station is set as the threshold, and,

in the determining, the wireless base station is determined to be congested in a case where a current terminal accommodation number of the wireless base station is larger than the threshold.

**4**. The wireless communication method according to claim **1**, wherein, in the changing, a connection cost of the wireless base station is increased in a case where the wireless base station is congested.

**5**. The wireless communication method according to claim **1**, wherein, in the changing, a connection cost of the wireless base station is lowered in a case where the wireless base station is not congested.

**6**. A wireless communication system comprising a plurality of wireless base stations and a wireless terminal, wherein

among the plurality of wireless base stations, each wireless base station includes:

a memory; and

a processor coupled to the memory and configured to:

set a threshold for determining a congestion degree of the each wireless base station on a basis of an actual value of past communication;

determine a congestion degree of the each wireless base station using the threshold; and

change a connection condition of the each wireless base station on a basis of a congestion degree of the each wireless base station, and

the wireless terminal includes:

a memory; and

a processor coupled to the memory and configured to:

receive the connection condition; and

determine a wireless base station, among the plurality of wireless base stations, of which the wireless terminal requests connection, on a basis of the connection condition.

* * * * *