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(54) Title of the Invention: Wireless communication system

(57) [Abstract]

[Problem] To provide a wireless communication system that can efficiently and flexibly assign wireless frequencies to terminal stations.

[Means of Solution] In a wireless communication system where a plurality of wireless base stations each having its own coverage area not only communicate with terminal stations in each coverage area but also use radio waves even for communication between the wireless base stations adjacent to each other, each wireless base station is provided with a relay processing means in order to enhance the function as a relaying device, and is provided with a frequency management information sharing means for sharing between the wireless base station the frequency management information related to the wireless frequency that is used in communication with the terminal station inside each coverage area and to the wireless frequency that is used in communication between the wireless base stations.

[insert figure]

[clockwise from upper center]

Router 2

Router 3

21... Server

20... Wireless LAN cable

Router 1

[Scope of Patent Claims]

[Claim 1] In a wireless communication system where a plurality of wireless base stations each having its own coverage area not only communicate with terminal stations in each coverage area but also use radio waves even for communication between the wireless base stations adjacent to each other, each wireless base station is provided with a relay processing means in order to enhance the function as a relaying device, and is provided with a frequency management information sharing means for sharing between the wireless base station the frequency management information related to the wireless frequency that is used in communication with the terminal station inside each coverage area and to the wireless frequency that is used in communication between the wireless base stations.

[Claim 2] In the wireless communication system in Claim 1, each wireless base station is provided with a non-directional antenna means for the purpose of wireless communicating with the terminal stations within each coverage area, and a directional antenna means for the purpose of communicating between wireless base stations, and has a use frequency management part that manages the use frequency such that the same wireless frequency is not used in the duplicated communication at least in the area while maintaining high frequency utilization efficiency, by employing the frequency management information.

[Claim 3] In the wireless communication system in Claim 2, the use frequency management part performs management of the use frequency that employs the frequency management information such that the same wireless frequency is not used in the duplicated communication in the area even if a dynamic event requiring a change in the use frequency occurs.

[Claim 4] In the wireless communication system in Claim 3, the use frequency management part is provided with an update processing means for the purpose of making the contents of the frequency management information consistent.

[Claim 5] In the wireless communication system in Claim 1, the wireless frequency for communication between wireless base stations and the wireless frequency for communication between the wireless base stations and terminal stations are selected from different frequency bands.

[Detailed Description of the Invention]

[Technical Field to Which the Invention Belongs]

[0001] The invention relates to a wireless communication system and is suitable for application to wireless LAN (local area network) systems, for example.

[0002]

[Prior Art] A conventional LAN is composed of wired lines such as Ethernet (registered trademark).

[0003] Whereas, in a wireless LAN, communication is performed with wireless lines. IEEE 802.11, IEEE 802.11a, IEEE 802.11b, and so on have been stipulated as the standards of this wireless LAN.

[0004]

[Problems That the Invention Attempts to Solve] In a wireless LAN employing radio waves, problems that did not exist in conventional Ethernet, such as interference due to neighboring frequencies and degradation due to interference waves, can occur. These points have not been clearly defined even in IEEE 802.11, IEEE 802.11a and IEEE 802.11b, and the placement of wireless routers and wireless switches, the frequency assignment method, and so are issues yet to be resolved.

[0005] In addition, if the routing procedures of a LAN composed by wired lines are applied as-is to a wireless LAN, the transition speed of the wireless LAN is generally slower than that of a wired LAN, so the speed of the wireless lines assigned by the routing may become extremely slow, and communication failures due to communication timeouts may occur depending on the terminal.

[0006]

[Means for Solving the Problems] In order to solve said problems, in the present invention, in a wireless communication system where a plurality of wireless base stations each having its own coverage area not only communicate with terminal stations in each coverage area but also use radio waves even for communication between the wireless base stations adjacent to each other, each wireless base station is provided with a relay processing means in order to enhance the function as a relaying device, and is provided with a frequency management information sharing means for sharing between the wireless base station the frequency management information related to the wireless frequency that is used in communication with the terminal station inside each coverage area and to the wireless frequency that is used in communication between the wireless base stations.

[0007]

[Mode of Embodiment of the Invention] (A) Embodiment

A description of an embodiment of the inventive wireless communication system is provided below, taking as an example a case in which it is applied to a wireless LAN system.

[0008] When a LAN that does not use cables or other wired lines as communication lines is a wireless LAN, such general wireless LANs can include those that use radio waves, infrared rays, laser beams, etc., but the description will be chiefly about a wireless LAN that uses radio waves in the following embodiment.

[0009] Wireless LANs like Ethernet are basically constructed based on the concept of distributed control, in which each node (including routers as well as terminals) on the LAN has an equal relationship with one another, and integrated CSMA is employed in the access to the transmission medium, however, in wireless LANs, there are cases in which distributed control is not necessarily appropriate, and the need to adopt a centralized control-type system configuration in which the relationship between the controlling node and the controlled node is clear may also arise.

[0010] (A-1) Composition of the first embodiment

Figure 1 shows an example of the overall configuration of the wireless LAN system 10 of the present embodiment.

[0011] In Figure 1, the wireless LAN system 10 comprises routers 1-3, stations 1S-3S, a wired LAN cable 20, and a server 21.

[0012] The figure includes three routers 1-3, but these routers 1-3 can be all of the routers in the system 10, or the figure can also be regarded as illustrating by extracting only a subset from among the many more routers in the system 10.

[0013] Each router 1-3 is a device that has the function as a base station for wireless communication in addition to the function as a router, and there are different service areas 1A-3A for each router 1-3, that is, router 1 has service area 1A, router 2 has service area 2A, and router 3 has service area 3A.

[0014] In the illustrated state, stations 1S and 1S1 are present in service area 1A, station 2A is present in service area 2A, and station 3S is present in service area 3A. Naturally, the number of

stations in the respective service areas 1A-3A does not have to be the same, and it can be more than one station.

[0015] Various communication devices can be used as stations 1S-3S and 1S1, and they may also have mobility as needed, but in many cases stationary personal computers or notebook computers loaded with a LAN card (LAN adapter) for wireless LAN are considered typical examples thereof.

[0016] Generally, the size of a service area is determined in accordance with the level of the transmission power of each router, and the two-dimensional shape of the service area is determined in accordance with the directivity pattern in the horizontal plane of the antennae used by each router for wireless transmission to each station. For example, for the entire geographical area of a certain size to be covered by any one service area, the neighboring service areas must overlap with one another, but this is not necessary if areas that are not covered by any one service area are present.

[0017] In the example shown in Figure 1, the shape of each service area 1A-3A is roughly circular, but service area 3A does not overlap with either 1A or 2A.

[0018] There may be various distances between the neighboring routers and various distances between the routers and the terminals, but in wireless LANs, as an example, the distance between neighboring base stations may be 1-2 kilometers and the distance between terminals and base stations may be several tens of meters. Applying this to the present embodiment, if the distance between a router and a station (for example, the distance between router 1 and station 1S) is set at 50 meters (the maximum value) and the distance between routers is set at 1 kilometer, it is easy to configure the system such that no overlap that might be observed between service areas 1A and 2A in Figure 1 occurs.

[0019] In addition, there is no need for the frequency that is used for the routers and stations (for example, router 1 and station 1S) to communicate inside each service area (intra-area communication) to necessarily be one frequency, and there may be a plurality of frequencies, but it is preferable that it be one frequency in order to conserve frequency resources. In the present embodiment it is assumed that a single frequency is used in for the purpose of communication inside said area. In other words, frequency f1 is used in the intra-area communication for service area 1A, frequency f2 is used in the intra-area communication for service area 2A, and frequency f3 is used in the intra-area communication for service area 3A.

[0020] As long as radio signals with a single frequency are used for intra-area communication, any one service area (for example, 1A) among the service areas 1A-3A corresponds to one segment (one collision domain) under each router (for example, 1). Therefore, in this case, when a plurality of devices (stations or routers) wirelessly transmit simultaneously inside one service area, a collision occurs. In the case of wireless communication, it is difficult to employ CSMA/CD (carrier sense multiple access with collision detection) like Ethernet, so in many instances CSMA/CA (CSMA with collision avoidance) is employed, so that collision is avoided.

[0021] Moreover, in the present embodiment routers 1-3 use wireless not only in the intra-area communication that is carried out between them and each station (1S, etc.) but also communication (inter-area communication) with other routers (for example, router 2 or 3 for router 1), so it is also necessary to pay due attention so that inter-area communication and intra-area communication do not interfere. Here, the routers 1-3 are connected with one another by said inter-area communication, and connection employing wired lines has not been undertaken.

[0022] An example of the composition of the chief parts of the routers 1-3 is shown in Figure 2.

[0023] Since the functions of routers 1-3 may be essentially the same, a description is provided with an item that shows chiefly router 1 in Figure 2. However, router 1, which is connected with a wired LAN (Ethernet) ET1 through a wired cable 20, has also been equipped with unique functions that are not present in the other routers 2 and 3.

[0024] (A-1-1) Example of the composition of the router

In Figure 2, said router 1 is provided with antennae AT0-AT6, wireless parts 30-36, a control part 37, and an Ethernet interface 38.

[0025] Among these the antenna AT0 is a non-directional antenna for performing intra-area communication, and has a non-directional directionality pattern inside the horizontal plane.

[0026] In addition, the antennae AT1-AT-6 are directional antennas for performing inter-area communication, and exhibit directionality inside the horizontal plane. As noted above, if routers 1-3 are all the routers inside the system 10, it is acceptable for router 1 to undertake inter-area communication with only two routers (2 and 3) at most, so it suffices to have only two directional antennae, but in a case that is an embodiment that illustrates by extracting only a subset from among an even larger plurality of router in which the routers 1-3 are included in the system 10, it is necessary to provide three or more directional antennae.

[0027] Since there is the problem that the question of with which router a given router undertakes inter-area communication depends on the network configuration, in general there is no need for router 1 to necessarily carry out inter-area communication with all neighboring routers (for example, routers 2 and 3 are neighboring routers for router 1) that have been disposed geographically adjacent to one another, but here a case in which inter-area communication is conducted with all neighboring routers is assumed.

[0028] In this case, the fact that it is equipped with six directional antennae AT1-AT6, corresponds to the case in which the router 1 has six neighboring routers and is carrying out inter-area communication with all of these. If router 1 is made the center and all directions in the horizontal plane are divided into six even parts, the arrangement of each directional antenna AT1-AT6 will be as shown in Figure 3, and the directional antennae AT1-AT6 will have a radiation angle of 60 degrees.

[0029] If the directional patterns of directional antennae AT1-AT6 are sharply narrowed down to a beam shape, higher precision is required for the positional relationship of each router, etc. that is installed and the direction adjustment of the directional antennae AT1-AT6, but it is possible to reduce or eliminate the range of the geographical impact of said inter-area communication on the intra-area communication that are carried out in the surrounding service area, so the frequency used by other routers for intra-area communication in other service area can be used for inter-area communication more easily, thereby improving the frequency utilization efficiency in the geographical area.

[0030] Although it depends on the circumstances of the overlap in each service area and so on, if there are a minimum of three frequencies they can compensate for all intra-area communication with the inter-area communication that is carried out for the six neighboring routers.

[0031] Figure 7 illustrates four of the six neighboring routers for router 1, and shows a configuration in which the routers RX1 and RX2 have been added in addition to the two routers 2 and 3 shown in Figure 1. As can be seen from Figure 7, there is no obstacle to using this for intra-area communication if it is a frequency other than the frequency that the router that is the interlocutor in inter-area communication with router 1 is using for intra-area communication and the frequency that router 1 itself is using in inter-area communication (here, f1).

[0032] Accordingly, [router 1] carries out inter-area communication using f3 with router R2, which is using f2 in intra-area communication, carries out inter-area communication using f2 with router R3, which is using f3 in intra-area communication, carries out inter-area communication using f2 (this f2 can be replaced by f3) with router RX1, which is using f1 in intra-area communication, and carries out inter-area communication using f3 with router RX2, which is using f2 in intra-area communication.

[0033] If the above-described overlap occurs between service areas, then operation in stations that are located on overlapped areas may become a problem. In addition, it is a problem in connection with the overlap that occurs between the service areas that are using the same frequency for intra-area communication (for example, the overlap of service areas 1A and 4A in Figure 7).

[0034] In response to this, it is effective for example to configure the system such that the frequency of the intra-area communication of any two service areas differs by utilizing the frequency repetition pattern (12-cell repetition pattern) of the small zone mode of car telephones, but in that case 12 kinds of frequency become necessary, and the frequency utilization efficiency declines.

[0035] The simplest way to solve this problem while conserving frequency resources is to not allow the occurrence itself of such overlaps. As noted above, if the size of each router's service area is sufficiently small compared to the distance between the routers that are carrying inter-area communication (for example, if service areas 1A and 4A are sufficiently small compared to the distance between router 1 and RX 1), said overlap will not occur.

[0036] Alternatively, even if the overlap itself is allowed, it can be addressed by executing operation such that stations (for example, 1S) are not disposed in the areas that are overlapping.

[0037] In Figure 2, wireless part 30-36 have been connected respectively one non-directional antenna AT0 and six directional antennae AT1-AT6 of router 1. The functions of wireless part 30-36 are essentially the same, and this a part wherein if wireless communication is performed from an antenna that has been connected modulation is executed and encoding, encryption, etc. are carried out as needed, and conversely if a wireless signal is received from the antenna demodulation is executed and decoding is carried out as needed.

[0038] The frequency at which each wireless part receives [signals] and performs demodulation is fixed at the specific frequency that has been assigned after the assignment of frequencies has been decided, and that frequency is maintained until said assignment is changed due to failure occurrence and the like, but in the initial state prior to the carrying out of assignment, reception is carried out for all frequencies that might be assigned. It is best to save in non-volatile memory (not shown in the figures) with a wireless part built in the specific values of all frequencies that might be assigned.

[0039] As long as each router is in its initial state, each router basically does not carry out inter-area communication, but after the assignment of the frequencies has been decided, wireless transmission is carried out at the specific frequencies that were assigned. The point that the frequency is maintained until said assignment is changed due to the occurrence of failure, etc. is the same in case of transmission. The frequency for wireless transmission and the frequency for reception for each router may be provided separately, it is assumed that the same frequency is employed in the present embodiment.

[0040] A function that detects and gives notification about failure occurrence has also been provided in said wireless part. An IP packet that outputs to the control part 37 is utilized for the notification of failure occurrence.

[0041] Given the configuration of the present embodiment, it is naturally necessarily that even if there are wireless nits inside the same router (for example, wireless part 30 and 31 inside router 1) these can operate independently of one another.

[0042] In addition, basically, one antenna and one wireless part that is connected to the former (for example, AT0 and 30) can be regarded as items corresponding to one port in a router for Ethernet.

[0043] Here, the processing in the layer beneath the MAC sublayer, which is in the data link layer of the OSI reference model, is assumed to be the item that is executed by said wireless part 30.

[0044] The control part 37 is the part that basically functions as the routing processing part 40 (see Figure 5), and it executes routing with a routing table (not shown in the figures) that has been prepared beforehand. Said control part 37 as the routing processing part 40 may be the same as the routing processing part that executes routing in an ordinary router for Ethernet.

[0045] Therefore, assuming that said routing processing part 40 corresponds to the IP (Internet protocol) as the network layer protocol of the OSI reference model, if it is learned from the MAC address table that a sender MAC address of the MAC (media access control) frame that is obtained inside the wireless part 30 based on the wireless signal WL1 that is wirelessly received by the station 1S is present inside service area 1A (for example, a case in which it is the MAC address of station 1S1 and so on), there is no need for inter-area communication, so the wireless part 30 does not output the IP packet BA1, and the control part 37 (routing processing part 40) does not carry out any processing at all, but if the sender MAC address is the MAC address of the LAN card in which the router 1 is itself loaded, the wireless part 30 extracts the IP packet from the MAC frame and supplies it to the control part 37, and the control part 37 refers to the routing table and outputs the sender IP address that the IP packet has to the wireless part.

[0046] For example, if said sender IP address is the IP address of station 3S, the control part 37 ends up outputting as the IP packet BA8 to the wireless part 33 to perform inter-area communication with the router 3.

[0047] Owing to the fact that the wireless part 33 that received this wirelessly transmits the wireless signal WL8 from the directional antenna AT3, it carries out inter-area communication towards the router 3.

[0048] If the sender MAC address of the MAC frame is present inside service area 1A, it is possible for example for stations 1S and 1S1 to carry out communication (this is also intra-area communication) employing frequency f1 without this being mediated by the router 1.

[0049] On the other hand, if Ethernet interface part 38 that is connected to the control part 37 is also viewed from the control part 37, it is one port that is like the wireless parts 31-36, but the substance of said Ethernet interface part 38 differs completely from the wireless part 31-36.

[0050] In other words, said Ethernet interface part 38 is the part that functions as the access point (AP) from the wireless LAN system 10 to the wired LAN system ET1, and it is the gateway that carries out interface conversion with the IEEE802.3 protocol, which is used in general Ethernet (here, wireless LAN system ET1), and the protocol that is used by the wireless LAN system 10 (for example, the IEEE 802.11 protocol).

[0051] This Ethernet interface part 38 is a unique function in the router 1, where the other routers that are not connected with the wired LAN system (for example, 2, 3) have not been provided.

[0052] The control part 37 has for example the internal configuration shown in Figure 5.

[0053] (A-1-2) Example of the internal composition of the control part

In Figure 5, said control part 37 is provided with a routing table processing part 40, a frequency assignment part 41, a list updating part 42, and a list storage part 43.

[0054] Among these, the function of the routing processing part 40 is the same as what has already been described, but the components where the routing processing part 40 interacts with the IP packet are not limited to the wireless parts 30-36 and Ethernet interface part 38, and the frequency assignment part 41 and the list updating part 42 are also included.

[0055] If for example a dynamic cause such as failure occurrence occurs, the frequency assignment part 41 is the part that changes the assignment of the frequencies that are used in intra-area communication and in inter-area communication.

[0056] In Ethernet, etc. that employs wired lines, excluding for example a case in which the wires have been doubled when the wired cable is physically damaged, the continuation of communication is impossible, but there are many cases where continuation of communication is possible by changing the frequency (channel) that is used when wireless lines are used. This is because the characteristics of the propagation path in wireless communication depends on the frequency it is normal for these to differ greatly, so if the quality of communication employing a certain frequency is extremely poor (for example, equivalent to a case in which a cable is cut in wired communication), communication employing another frequency can often be carried out well.

[0057] The list storage part 43 is one kind of database that stores a frequency list showing the assignment status of the frequencies that are being used in each intra-area communication and inter-area communication at the present point in time. In those cases where it is necessary to save the contents of the frequency list when the supply of power is cut off as well and so on, it is necessary for said list storage part 43 to be composed by a non-volatile memory means such as a hard disk.

[0058] Said frequency list is, as one example, generated based on the logical structure shown in Figure 6 (A) and (B). Here, the table in Figure 6(A) is used as the assignment table, and the table in Figure 6(B) is used as the order of priority table. The assignment table in Figure 6(A) contains three data items. These are the “assignee”, which shows the assignee of each frequency (channel), “failure occurrence”, which shows whether a failure has occurred at each assignee, and the “channel number”, which specifies uniquely each frequency.

[0059] In addition, the order of priority table in Figure 6(B) is provided with an “order of priority”, which stipulates the order of use of each frequency, and the “channel number”, as data items. Since the channel numbers have been provided as common data items in the table in Figure 6(A) and the table in Figure 6(B), it is possible to naturally combine both tables with said channel numbers. Then, the table that is obtained by naturally combining both tables is used as the frequency list.

[0060] This frequency list is a table with a composition in which “order of priority”, which is the data item of the order of priority table, is added in addition to “assignee”, “failure occurrence” and “channel number”, which are the data items of the assignment table. In the example in Figure 6(A), the values of the order of priority of each tuple are the order of priority values (1), (2), (3), (2), (2), (2), (1), ... (4), (5), (6), which are noted inside the parentheses at the right end.

[0061] In the order of priority table shown in Figure 6(B), since the channel number of frequency f1 is CN (f1), the channel number of frequency f2 is CN (f2), the channel number of frequency f3 is CN (f3), the channel number of frequency f4 is CN (f4), the channel number of frequency f5 is CN (f5), and the channel number of frequency f6 is CN (f6), the frequencies that can be used by the wireless LAN system 10 overall are the six frequencies, f1-f6. However, ordinarily

the order of priority only uses up to the upper order three frequencies (f1, f3, f2), and the remaining three frequencies are backup frequencies that were prepared in case of failure and so on.

[0062] In addition, in the assignment table shown in Figure 6(A), for the assignee the code of the service area, which is the assignee if the communication that uses said frequency is intra-area communication, has been shown, and the code of both routers that communicates has been shown in the case of inter-area communication.

[0063] Accordingly, for the tuple that is disposed on the uppermost part of Figure 6(A), the frequency that is used in the intra-area communication of service area 1a is f1, which is specified by the channel number CN (f1), and it indicates that at that point in time failure occurrence has not been detected in said intra-area communication employing frequency f1. Similarly, the tuple that is disposed second from the top of Figure 6(A) is f3, for which the frequency used in the inter-area communication that is carried out between routers 1 and 2 is specified the channel number CN (f3), and it indicates that at that point in time failure occurrence has not been detected in said inter-area communication employing frequency f3.

[0064] The tuples disposed in the lower order in Table 6(A), for example in the lowest order tuple, it states that the assignee is "None", failure occurrence is "No", and the channel number is CN (f6), and this indicates that assignment of frequency F6 has not yet been undertaken, and owing to that it has not become the object of detection of failure occurrence.

[0065] One may configure the system in accordance with need such that the frequencies that are used in intra-area communication and the frequencies that are used in inter-area communication are clearly distinguished and defined beforehand in the order of priority table, but in Figure 6(B) such a distinction has not been provided. Accordingly, all of the frequencies f1-f6 can be used in both intra-area communication and inter-area communication.

[0066] The thing that is stored in the list storage part 43 is for example the frequency list shown in Figure 6(A), but this frequency list is generated dynamically in cooperation with routers 1-3, based on the order of priority table shown in Figure 6(B) that is supplied from the server 21 to the router 1.

[0067] The list updating part 42, which is connected by the signal MP to said list storage part 43, is the part that updates the contents of the frequency list. The updating of the frequency is carried out in accordance with the fact that assignment of frequencies for each intra-area communication and inter-area communication progresses in the initial phase of the start of operation, and in addition is executed from time to time if failure is detected during operation.

[0068] The occurrence of events that serve as the trigger for list updating and the contents of those events, such as an advance in the assignment of frequencies or failure occurrence, are transmitted from the applicable wireless part such as each router 1-3 to the list updating part 42 of said router 1 by the IP packet BAY that is supplied from the routing processing part 40 to the list updating part 42.

[0069] A change in the assignment of the frequency that is executed by the frequency assignment part 41 can be termed an operation for achieving physically the updated contents of the logical frequency list. A change in the frequency assignment that is conveyed by said frequency assignment part 41 to each wireless part (for example, 30 or 31, or the wireless part of another router) is transmitted by the IP packet that is supplied to the routing processing part 40 as the signal RE, and the question of whether or not a change thereof has been executed is conveyed to said frequency assignment part 41 by the responding IP packet BAH.

[0070] The server 21 provides the order of priority table in response to a request from the router 1.

[0071] A description is provided below about the operation of the present embodiment that has a composition like that described above. Here, basically a description of the operation is provided with the example being a case in which all inter-area communication and all intra-area communication inside the wireless LAN system 10 is performed with only three frequencies, f1-f3.

[0072] (A-2) Operation of the first embodiment

A description is first provided of the initial operation in a case where the wireless LAN system 10 is constituted.

[0073] (A-2-1) Initial operation

First of all, the power is turned on for the router 1, which is connected to the wired LAN system ET1, and the router 1 is booted up, and the router 1 receives the supply of an order of priority table like that shown for example in Figure 6(B) from the server 21, in accordance with the procedure that is executed on ordinary Ethernet.

[0074] The states of the other routers 2, 3 at the point in time when router 1 has booted up can be divided into two possible kinds of cases, one in which they have not yet booted up and another in which they have already booted up. Moreover, among those cases in which they have already booted up, there are included two further kinds of cases, cases in which each router that has booted up is already executing intra-area communication or inter-area communication and those kinds where they are not executing it.

[0075] However, here chiefly it is assumed that the other routers have not yet booted up when router 1 boots up, or even if they have booted up at least inter-area communication has not started yet, and here is assumed a case in which the item that starts inter-area communication initially is the router 1, and the other routers start these communications successively following router 1.

[0076] In other words, router 1 continues to generate for example a frequency list like that shown in Figure 6(A) in accordance with said received order of priority list, and the consistency between each frequency is ensured such that the frequency lists that are stored in the list storage part 43 of each router other than the router 1 have the same contents as the frequency lists that are stored in the list storage part 43 inside said router 1. The processing that is used to ensure the consistency of the updated contents with a distributed database can be used as is in the processing for this purpose.

[0077] Since assignment has not been determined for any of the frequencies f1-f6 at the point in time immediately after the router 1 boots up, the value of each data item in the frequency list are not valid.

[0078] Because at least inter-area communication has not yet been executed in any of the routers, the router 1 now is basically free to use whichever frequency in the order of priority table, but here it uses frequency f1 of channel number CN (f1), which has the highest order of priority.

[0079] In other words, router 1 uses said frequency f1 to send the information for control through the wireless part 30 and antenna AT0 to its own service area 1A. When there is data that terminal inside service area 1A that receives the information for control, for example station 1S, wants to send at that point in time, it returns by said frequency f1 a request signal to the effect that it will receive service at the service area 1A of router 1. When router 1 receives this request signal, it sends a permission signal by frequency f1, and the connection of the router 1 and the station 1S is terminated. This procedure may for example follow IEEE 802.11b or Bluetooth.

[0080] It is common for connectionless-type communication to be carried out inside the segments of a wired LAN such as Ethernet, but here connection-type communication is being carried out in this manner.

[0081] The receipt of the information for control is not limited to station 1S, and all terminals (for example, 1S1) inside the service area 1A can execute, so it is possible for each terminal to create with the router a common understanding that the frequency conveyed by said information for control (here f1) is used for the communication between the router 1 and the terminal (here 1S1 or 1S) and between terminals (between stations), out of the plurality of frequencies (here, f1-f6) that might be used in intra-area communications by the reception thereof.

[0082] If at this point in time the data that it wants to transmit to stations 1S and 1S1 is already present, it may return a request signal more or less simultaneously by the same frequency f1, and in addition f the router 1 transmits a permission signal by the same frequency f1 as the transmission of the request signal, a collision may occur between the request signal and permission signal and in that case a collision avoidance method such as the above-described CSMA/CA can be employed.

[0083] Even if the same frequency is used, the MAC addresses that were assigned to the LAN card of each station are unique, so the router 1 can grant permission by a permission signal to only one station, and it can specify unambiguously the station that can transmit the data. Owing to this, the occurrence of a collision during data transmission that can occur with Ethernet and the like can be prevented.

[0084] This is processing corresponding to the above-described concentrated control-type system configuration, in a case in which the node that is controlled is set as the station (for example, 1S, 1S1), and the node that controls is set as the router 1.

[0085] After the processing related to this intra-area communication, or in the simultaneous advance with the processing related to this intra-area communication, the router 1 wirelessly transmits the prescribed control signals for executing the processing to achieve a connection related to inter-area communication. The frequency list is included in this control signal.

[0086] Although the processing for the connection of inter-area communication that is carried out by the router 1 is carried out for each neighboring router of the router 1, the contents of that processing are essentially the same.

[0087] When the power is turned for example the router 2 among the neighboring routers that undergo this processing from the router 1, it executes the necessary processing in accordance with the processing procedure that were written into the non-volatile memory beforehand.

[0088] Owing to this, the operation of the router 2 differs in accordance with the contents of said processing procedure. For example, due to the cooperation with the router 1, it is possible to set it as a processing procedure that starts valid operation after the frequency that is used in inter-area communication in its own service area 2A and the frequency for inter-area communication with each neighboring router of itself are determined, but the necessity thereof is low at least as concerns intra-area communication if for example the service area 2A does not have the above-described overlap in the relationships with any of the service areas, and so on.

[0089] Therefore, whenever overlap is not present, the router 2 can execute intra-area communication with an optional frequency even if it is before when the frequency that is assigned for intra-area communication is determined, and communication can be carried out between each terminal inside the service area 2A such as the station 2S under control by the router 2.

[0090] In this case, like router 1, router 2 can also carry out exchanges of the information for control, request signals and permission signals between it and the stations (for example, 2S) inside service area 2A. This point is the same as concerns the neighboring routers (3, RX1, RX2, etc.) other than router 2 and the routers that are not adjacent to router 1, and each station can perform intra-area communication inside each service area.

[0091] In this manner, in a state in which each station inside the service area of each router is executing intra-area communication in each item under the control of each router, a control signal for realizing the connection related to inter-area communication is wirelessly transmitted from router 1 to router 2. The chief components of this control signal are the frequency list, but they are the frequency list and the order of priority table now, but the frequency list is not in the state shown in Figure 6(A) but rather in a state in which on the tuple positioned in the uppermost part in Figure 6(A) is present.

[0092] The router for which router 1 initially starts this processing may be any router provided that it is a router that is adjacent to the router 1, but here it is assumed to be an item that first selects router 2, and the frequency f3 that comes second from the top in the order of priority table shown in Figure 6(B) is used in inter-area communication between router 1 and router 2. The use of this f3 may be compelled from router 1 to router 2, and if necessary, it may be decided by arbitration between router 2 and router 1.

[0093] For example, if the router 2 is already using said f3 in intra-area communication, it is possible to hope for a frequency (for example, f2) other than f3 as the frequency for inter-area communication if one does not want to change the frequency of inter-area communication.

[0094] At the side of router 2, it receives the above-mentioned signals by continuing to carry out successive searches in accordance with the order of priority that has been stored beforehand in the non-volatile memory for all wireless channels (here f1-f6) that have been formally assigned in order to receive the wireless signals from the router 1. Then it uses the directional antennae and each wireless part 31-36 that is connected to these in this reception.

[0095] In addition, router 2 attempts the reception of the above-mentioned control signals from the router 1 for the frequency that is being used in intra-area communication in its own service area 2A. At this time, the router 2 either temporarily suspends intra-area communication or it becomes necessary for it to carry it out at a different frequency.

[0096] Whichever the case may be, when the frequency that is used in inter-area communication between the routers 1 and 2 is determined, that is reflected in the frequency list. If for example employing the frequency f3 in said inter-area communication is determined, the frequency list is in a state in which the second tuple from the top is added (a tuple for which the assignee is 1-2, failure occurrence is none, and the channel number is CN (f3)).

[0097] Accordingly the frequency list in this state is stored in the list storage parts 43 of both router 1 and router 2, and the consistency of the frequency lists is ensured. At this point in time, it is still not possible to carry out inter-area communication for those routers (for example, 3) other than router 1 and 2, so the consistency of the frequency list ends up being ensured only between routers 1 and 2.

[0098] Next, the frequency that is used for the intra-area communication that is executed by the router 2 inside the service area 2A is determined. For this determination, it is necessary to return to the router 1 the determination results in order to execute by the judgment of the router 2 itself. A variety of methods can be imagined when it comes to the question of how router 2 selects the use frequency of intra-area communication. For example, selecting the frequency that had been used in intra-area communication until then or ignoring this and selecting the frequency in

accordance with only the order of priority level are both possible, but at the very least it must be a frequency that is different from the frequency f_3 for which use in inter-area communication with router 1 was determined.

[0099] In addition, whenever it is necessary to pay due attention to the overlap between the service area 1A of router 1 and the service area 2A of router 2, it must be a frequency that differs from the frequency f_1 for which using the router 1 in intra-area communication was determined. In order to judge whether or not overlap has occurred, or with which service area has overlap occurred, it is natural that it is necessary for the router 2 to recognize the various information about the physical composition of the wireless LAN, such as the geographical position relationships and distance between it and each router that is adjacent to it, and the size and shape of the service area of each neighboring router.

[0100] If the router 2 selects a frequency that differs from the frequency that had been used in intra-area communication until then, before and after said determination the frequency that is used in intra-area communication is changed, and this change is conveyed to each station (for example, 2S) inside the service area 2A.

[0101] For example, if f_2 is determined as the frequency that is employed by router 2 in intra-area communication, the tuple that is third from uppermost part of Figure 6(A) is further added to the frequency list, and an indication to that effect is returned to router 1. However, if it is known that that the router invariably determines the frequency that is used in intra-area communication in accordance with the order of priority level, the determination results of the router 2 can be reliably predicted by router 1 as well, so there is no particular need to return the determination results to the router 1, but given the fact that wireless that is not limited to wireless with a good communication quality is used, at the very least the fact that the reception of the control signals that were transmitted by the router 1 was carried out normally must be conveyed from the router 2 to the router 1.

[0102] Processing for inter-area communication and intra-area communication similar to router 2 is repeated for the other routers that are adjacent to router 1, and each time this is done tuples continue to be added to the frequency list.

[0103] To explain the above processing with Figure 7, first of all the frequency f_1 that is used in intra-area communication of the router 1 is determined, and following on this the frequency f_3 of the inter-area communication between the routers 1 and 2 and the frequency f_2 of the intra-area communication of the router 2 are determined, and the frequency of the inter-area communication and intra-area communication are successively determined similarly for the other neighboring routers 3, RX1 and RX2. Owing to this basically as shown for example in Figure 4, it becomes possible for routers that are tied to one another by inter-area communication to carry out communication.

[0104] In Figure 4, the frequency of the inter-area communication that extends radially with the router as the center are distinguished by the triple line, the dotted line and the solid line. Here, for example, the triple line may indicate the frequency f_3 , the dotted line may indicate the frequency f_2 , and the solid line may indicate the frequency f_1 .

[0105] Regard all routers that are present and operate in the wireless LAN system 10, the frequencies of inter-area communication and intra-area communication are determined, and at the point in time when that determination is reflected in the frequency list, the above initial operation is terminated. Then after initial operation termination, it enters a steady operating state in which intra-area communication and inter-area communication are executed for each router in accordance with said frequency list.

[0106] At this time, in order that the signals that are wirelessly transmitted by each station (for example, 1S) bin intra-area communication are delivered to the station (for example, 2S) that becomes the addressee of the said wireless signals as needed, they are subjected to routing by the router (for example, 1), transmitted to the router (for example, 2) that has under it a station that serves as said address with the requisite inter-area communication, and moreover transmitted from said router to said addresses, and if it is the inside of the wireless LAN system 10, the data can be transmitted to an optional addresses within the areas and between the areas.

[0107] When such routing is being carried out normally by the wireless LAN system 10 overall, the failure occurrence of each assigned channel number shown in Figure 6(A) is nil.

[0108] However, if such a steady operating state is continuing, a situation where either inter-area communication or intra-area communication can no longer be executed normally in the wireless LAN system 10 can arise owing for example to internal or external noise generating sources of the system 10. In this case, failures in a variety of forms may occur in accordance with the intensity and frequency of the noise (interference waves), the location of the noise generating sources, etc.

[0109] For example, if a noise generating source is located at position N of Figure 7, the frequency of the noise is f3, and the intensity of the noise is not very strong, only inter-area communication between the routers 1 and 2 becomes impossible, and the intra-area communication and inter-area communication other than that can be carried out normally, but other inter-area communication (for example, inter-area communication between router 1 and RX2) and intra-area communication that employ the frequency f3 may also become impossible if this noise is strong, and if the frequency band of the noise is not only f3 but also extends to f1 or f2, effects may well be felt on inter-area communication and intra-area communication that employ f1 and f2.

[0110] However, as one example, a description is provided about the recovery operation with the example being a case in which a noise generating source is located at position N in Figure 7, the frequency of the noise is f3, and the intensity of the noise is not particularly strong, so only inter-area communication between the routers 1, 2 become an impossible (alternatively, even assuming that continuation of communication is possible a propagation path with an extremely high BER (bit error rate) is poor) state, and intra-area communication and inter-area communication other than that can be carried out normally.

[0111] The fact that inter-area communication between the routers 1, 2 cannot be carried out is detected by the router 1 or 2 and owing to that detection a failure occurrence of the second tuple from the top Figure 6 is updated from absent to present.

[0112] (A-2-2-) Recovery operation

As described above, in the wired LAN system, in such a case, router 1 abandons direct communication with the router 2, and for example this results in the carrying out of inter-area communication employing a roundabout route via the router 3, but in the case of wireless and unlike the case of wired, the inability to communicate is not limited to fatal failures of the wires as-is.

[0113] Since an inability to communicate due to the interference wages that are generated by some cause or another or interference with another system can occur frequently, recovery by changing the channel frequency that is used can be expected.

[0114] Naturally, as in the case of wired so in the case of wireless, utilizing a roundabout route is one of the recovery methods, for example, if the frequency band of the interference waves is extremely broad, and it extends to all the frequencies f1-f6, in wireless as well, the use of said

roundabout route can end up becoming the sole recovery method. However, when recovery is done with a roundabout route, large communication traffic ends up flowing from before recovery on the router that is present on the roundabout route, and a major load is exerted. Ordinarily, because the communication speed of a wireless LAN is slower than that of a wired LAN, the fact that a further lowering of the communication speed occurs due to such an increase in the load is not desirable on various scores, such as there being the possibility that a communication failure due to the above-described communication timeout might occur.

[0115] In order to avoid such a state of affairs, when the router 1 and the router 2 detect a communication failure originating in the noise generating source at position N, communication at a frequency with a high order of priority is attempted in accordance with the frequency list at that point in time (this is assumed to be something like what is shown in Figure 6(A) < excluding the second tuple from the top).

[0116] However, at this time router 1 cannot select the frequency f1 that is being employed in intra-area communication and router 2 cannot select the frequency f3 that is being employed in intra-area communication. When inter-area communication between routers 1, 2 is carried out by a directional antenna that has directionality with a sharp beam shape and when there is no overlap with the neighboring service area (for example, 4A, 3A) the frequency can be selected without being conscious of the frequency to be used in intra-area communication within neighboring service areas, but when that it is not the case it is necessary to select the frequency by excluding as the frequency that is used in intra-area communication inside the neighboring service area.

[0117] Assuming that the state of the frequency list at the time of failure detection is as shown in Figure 6(A) excluding the second tuple from the top, the backup frequencies are three in number, f4, which is specified by channel number CN (f4), f5, which is specified by channel number CN (f5), and f6, which is specified by channel number CN (f6), and among these the one with the highest order of priority is f4, so first of it attempts inter-area communication employing said frequency f4.

[0118] When the fact that this inter-area communication can be carried out normally is confirmed between routers 1, 2, the channel number of the second tuple from the top is updated from CN (f3) to CN (f4), and the tuple of the third channel number CN (f4) from the bottom is deleted and the recovery operation is terminated. If the fact that the frequency f3 had been used before recovery is only the inter-area communication between router 1, 2, due to this recovery a new tuple in which the assignee is none, failure occurrence is none, and the channel number is CN (f3) ends up being added to the lowermost part of the frequency list, but since the frequency f3 is being used in inter-area communication between routers 1, 3 and so on in Figure 6(A), such an addition is not carried out, and ultimately the number of backup frequencies decreases by one and it becomes two such frequencies.

[0119] If necessary, an update may be made to change said frequency f3 to frequency f4 for all inter-area and intra-area communications using frequency f3 prior to restoration. If such updating is carried out, it is possible to maintain the three frequencies as backup frequencies.

[0120] For the contents of this updating, consistency is ensured in the list storage part 43 of all routers inside the wireless LAN system 10.

[0121] The noise from the noise generating source at position N that resulted in this failure may dissipate naturally, and in addition it may also be eliminated by conscious work, so it will not remain permanently, and therefore it is possible to reuse the frequency f3 that had become a backup frequency after the dissipation of the noise. In addition, even if it is before the noise

dissipates, is the noise in question is not strong, said frequency f3 can be reused at a place other than between routers 1, 2 (for example, the intra-area communication that is carried out within service area 4A).

[0122] If it was confirmed that inter-area communication employing the frequency f4 cannot be carried out normally, inter-area communication employing frequencies f5, f6 ends up being tried successively in accordance with the order of priority.

[0123] Even in the case of a test that employed frequency f6, whose order of priority is the lowest order, if normal inter-area communication cannot be carried out, the system may be configured such that the roundabout route is utilized.

[0124] However, even in this case, because the frequencies f1 and f2 have still not been tried, the system may also try the frequencies f1 and f2, which are already being used. Naturally using the frequency f1 in said inter-area communication means changing the frequency of the intra-area communication that is being carried out inside the service area 1A of router 1, and using the frequency f2 in said inter-area communication means changing the frequency of the intra-area communication that is being carried out inside the service area 2A of router 2. In addition, since the impact due to this change extends to other intra-area communication and inter-area communication as well, it exerts a rather large effect on the wireless LAN system 10 overall, but it is advantageous from the standpoint of the communication speed compared to a case in which a roundabout route is employed.

[0125] If necessary, the system may be configured such that not only does it attempt inter-region communication with each frequency (for example, f4) simply in succession, but also decides the frequency that is used in inter-area communication in accordance with said measures results. It might be possible to shorten the time required for the recovery operation by this.

[0126] In addition, if a roundabout route is set, selecting a route in which the number of routers (number of hops) that are present on the roundabout route becomes smaller, or selecting the route with a high probability of being able to transmit at high speed the new communication traffic out of consideration of the free bandwidth amount of each router, is desirable.

[0127] In the selection of this roundabout route, in addition to the order of priority table, a routing list that shows the route where the connection is being carried out normally during failure occurrence (the relationship between the MAC address of each router and the MAC address of router that has been connected respectively has been described in this, and the information about the frequency (channel number, etc.) that has been used in the connection between each router is also described therein), etc.) etc. is utilized. Said routing list can be given a configuration in which the MAC addresses of each router is noted on the frequency list.

[0128] After the recovery operation is terminated, it reverts to a steady operation state, and the intra-area communication and the inter-area communication are executed for each router in accordance with the frequency list.

[0129] A recovery operation like the above is the same as well when a failure occurs in the inter-area communication other than between routers 1, 2 (for example, inter-area communication between routers 2, 3, etc.), or when a failure occurs in the intra-area communication. Router 1 plays a special role in the initial operation, but this is because in a steady operation state, each router (1-3, RX1, RX2, etc.) inside said wireless LAN system 10 are in an equal relationship, and it becomes a system configuration that falls within the range of distributed control in the

[0130] Regarding the turning on of the power for each router inside the wireless LAN system 10 that is carried out during initial operation, it is possible to compose separately a network for turning the power on more or less simultaneously as needed.

[0131] (A-3) Effects of the first embodiment

As noted above, according to the present embodiment, in the wireless LAN system, efficient placement of routers and frequency assignment can be achieved.

[0132] In addition, in the present embodiment, a large-scale wireless LAN system can be constituted by employing the frequency list, the routing list, etc., and in addition the wireless frequencies can be utilized effectively, and high speed, stable communication and high speed routing is enabled.

[0133] Moreover, in the dynamic causes of failure occurrence, etc. as well, a decline in the communication speed is inhibited, and in addition it is possible to respond flexibly while maintaining consistency overall.

[0134] (B) Second embodiment

A description is provided below about only the points on which this embodiment differs from the first embodiment.

[0135]

In the first embodiment, the same frequencies were utilized in both inter-area communication and intra-area communication in the wireless LAN system 10, but these shall be clearly distinguished in the present embodiment.

[0136] It is advantageous to not distinguish the two as regards the frequency utilization efficiency, but in a method that does not distinguish the two, the need for the router to be aware of the various information related to the physical composition of the wireless LAN is high, and if any of the various information (for example, the distance between routers 1 and 3) changes, it is highly likely that the need to change the frequencies used in each inter-area communication and intra-area communication in response to this will occur, but in a method where the two are distinguished, the need for the router to be aware of the various information about the physical composition of the wireless LAN is low, and if any of the various information (for example, the distance between routers 1 and 3) changes, the need to change the frequencies used in each inter-area communication and intra-area communication in response to this is low. In addition, even if it is necessary to change these, intra-area communication and inter-area communication have been clearly distinguished, so the scope of their impact is limited.

[0137]

Composition and operation of the second embodiment

In the present embodiment, the 2.4 GHz band, which is the mode of IEEE 802.11b, shall be employed in intra-area communication, while the 5 GHz band, which is the standard of IEEE 802.11a, shall be employed in inter-area communication.

[0138] In the present mode of embodiment, the routing list and the frequency list are basically used as is, but they differ from the first embodiment only insofar as the matching to each channel inside the routing list or frequency list, and moreover the type of frequency band to which the frequency specified by each channel number is noted thereon.

[0139] The points other than that may be the same as the first embodiment.

[0140] (B-2) Effects of the second embodiment

According to the present embodiment, it is possible to obtain effects equivalent to the effects of the first embodiment.

[0141] In addition, in the present embodiment, by making the use frequency bands of intra-area communication and inter-area communication differ, the number of channels that can be used respectively increases, and it becomes possible to increase the number terminals (stations) that

can be accommodated in the system overall, and in addition it is possible to ensure transmission efficiency inside each service area.

[0142] In addition, as noted above, since the need for the router to be aware of the various information about the physical composition of the wireless LAN is low, the setting of the router, etc. is simple.

[0143] Moreover, even if any of the various information (for example, the distance between routers 1 and 3) changes, the need to change the frequencies used in each inter-area communication and intra-area communication in response to this is low, so control when changing the frequency that is used in any intra-area communication or inter-area communication becomes simple.

[0144] Furthermore, even if it is necessary to change these, intra-area communication and inter-area communication are clearly distinguished, so the scope of the impact thereof is limited, and it can be anticipated that control will become simple on this score as well.

[0145] (C) Other embodiments

In the first embodiment, it was made a system in which the frequency list shown in Figure 6(A) is generated dynamically as the results that routers 1-3 operate cooperatively based on the order of priority table shown in Table 6(B) that is supplied from the server 21 to router 1, but at the very least it is possible to decide beforehand statically the contents of the frequency list at the outset of the start of operation. Accordingly, the frequency list itself that was decided statically is supplied from the server 21 to router 1, and router 1 and the other routers may be configured such that the frequency used in each intra-area communication and inter-area communication in accordance with said frequency list.

[0146]

In addition, in the first and second embodiments, the wireless mode inside service area and the wireless mode between routers shall be made similar items (IEEE 802.11 related). However, since there is no need for these two to be similar, it is possible to configure these by different communication modes.

[0147] For example, the item shown in Figure 8 can be utilized as a combination of modes related to between routers (inter-area communication) and within service areas (intra-area communication).

[0148] In Figure 8, the first combination uses IEEE 802.11a (5 GHz) between routers and Bluetooth (2.4 GHz) within service areas, respectively, the second combination uses Bluetooth between routers and PHS (1.9 GHz) within service areas, respectively, the third combination uses IEEE 802.11b (2.4 GHz) between routers and PHS within service areas, respectively, the fourth combination uses IEEE 802.11a between routers and PHS within service areas, respectively, and the fifth combination uses 802.11b (2.4 GHz) between routers and Bluetooth (2.4 GHz) within service areas, respectively.

[0149] In addition, a combination that replaces the mode between routers and the mode within service areas in the first-fifth combinations can also be used as needed.

[0150] Owing to such first-fifth combinations and their replacements, when it comes to the frequency design of the wireless LAN system ten kinds of various can be provided, but the question of which one of these to use can be decided in accordance with the circumstances of the traffic inside each system.

[0151] In addition, it goes without saying that wireless systems that differ for each service area may be used.

[0152] IEEE 802.11b and Bluetooth are the same frequency band, but communicating with the minimum possible impact is made possible by distinguishing the type of antenna.

[0153] Moreover, in the above description, one wireless router (router 1) that is connected with the wireless LAN was present, but it is also possible to provide two or more wireless routers that are connected with a wired LAN, or to not provide one and instead to make it a LAN system that is closed with only wireless.

[0154] Moreover, in the above description, a description was provided using as an example a router that carries out relay process that belongs to the network layer of the OSI reference model, but the present invention can be applied to things other than routers as well. For example, it can also be applied to wireless communication devices corresponding to the layer 2 switch (switching hub) that carries out the relay processing that belongs to the data link layer of the OSI reference model.

[0155]

[Effects of the Invention] As described above, according to the present invention, it is possible to execute the placement of wireless base stations, assign efficiently the wireless frequencies that are used in communications inside of the coverage area and between the wireless base stations, and re-assign the wireless frequencies by responding flexibly to dynamic causes like failure occurrence.

[Brief Description of the Figures]

[Figure 1] This is a schematic diagram showing an example of the overall composition of the wireless LAN system pertaining to the first and second embodiments.

[Figure 2] This is a schematic diagram showing an example of the composition of the chief parts of the router that is used in the first and second embodiments.

[Figure 3] This is a schematic diagram showing an example of the composition of the antenna placement of the router that is used in the first and second embodiments.

[Figure 4] This is a schematic diagram showing an example of the frequency assignments in the wireless LAN system of the first and second embodiments.

[Figure 5] This is a schematic diagram showing an example of the composition of the chief parts inside the control part in the router of the first and second embodiments.

[Figure 6] This is a schematic diagram of the configuration of the table that is used in the first embodiment.

[Figure 7] This is a schematic diagram for explaining in more detail the example of the frequency assignments in the wireless LAN system of the first embodiment.

[Figure 8] This is a schematic diagram showing an example of a combination of modes related to between routers (communication between areas) and within a service area (communication within an area) in another mode of embodiment.

[Explanation of the Numbers and Symbols of the Key]

1-3, RX1, RX2... Routers

1A-5A... Service area

1S-3S... Stations

30-36... Wireless parts

37... Control part

38... Ethernet interface part

40... Routing processing part

41... Frequency assignment part

42... List updating part

43... List storage part

[Figure 1]

[insert figure]

[clockwise from upper center]

Router 2

Router 3

21... Server

20... Wireless LAN cable

Router 1

[Figure 2]

[insert figure]

[left column, top to bottom]

Antenna AT0

Antenna AT1

Antenna AT2

Antenna AT3

Antenna AT6

[center column, top to bottom]

30... Wireless part

For station communication

31... Wireless part

(for router communication)

32... Wireless part

(for router 2 communication)

33... Wireless part

(for router 33 communication)

36... Wireless part

(for router communication)

[right side of diagram]

37... Control part

38... Ethernet interface part (only router 1)

[Figure 3]

[insert figure]

[center of circle] Router

[caption below] This shows a directional antenna

[Figure 4]

[insert figure]

1... Wireless router

2... Wireless router

[Figure 5]

[insert figure]

40... Routing processing part

41... Frequency assignment part

42... List updating part

43... List storage part

[Figure 6]

(A)

Assignee	Failure occurrence	Channel number	
1A	None	CN (f1)	(1)
1-2	None	CN (f3)	(2)
2	None	CN (f2)	(3)
1-3	None	CN (f3)	(2)
3A	None	CN (f3)	(2)
1 RX1	None	CN (f2)	(3)
4A	None	CN (f1)	(1)
...	...	...	...
Not yet	Not yet	CN(14)	(4)
Not yet	Not yet	CN(15)	(5)
Not yet	Not yet	CN(16)	(6)

(B)

Order of priority	Channel number
[see source for remainder]	

[Figure 7]

[insert figure]

[Figure 8]

Between routers	Within service areas
[see source for remainder]	