

DESCRIPTION

Title of Invention

TYPE DETERMINATION APPARATUS OF WIRELESS COMMUNICATION

5 FAILURE AND HOME APPLIANCE CONTROL SYSTEM

Technical Field

The present invention relates to a type determination
apparatus of a wireless communication failure and a home
10 appliance control system. In particular, the present invention
relates to a type determination apparatus of a wireless
communication failure and a home appliance control system
which determine a type of a failure occurring in wireless
communications including Wi-Fi (Wireless Fidelity: registered
15 trademark), Bluetooth (registered trademark), and ZigBee
(registered trademark).

Background ART

Patent Literature 1 discloses a portable wireless system
20 that can, if wireless communication fails due to a change in
wireless communication quality, prevent a communication
failure by making effective use of automatic retry
(retransmission) of the wireless communication, thereby
suppressing an increase in communication time due to redoing
25 of communication. In the portable wireless system, if wireless

communication fails, a portable communication apparatus issues a notification of the failure of the wireless communication each time.

5 Citation List

Patent Literature

Patent Literature 1: JP-2006-279561A

Summary of Invention

10 Technical Problem

The portable wireless system disclosed in Patent Literature 1, if wireless communication fails, makes a notification of the failure of the wireless communication each time, but not of a cause of the failure.

15 There are several possible causes for a failure of wireless communication, including that a radio field intensity needed for the wireless communication is not available and that the wireless communication fails due to the effect of external radio noise. Even if a notification of a failure of
20 wireless communication is notified each time, it is therefore difficult for the user to determine the type of the cause and identify measures to take.

Consequently, even if the user obtains useful information that wireless communication fails, it has been difficult to
25 fully utilize the information.

It is thus an object of the present invention to not simply make a notification of a failure of wireless communication but also enable notification of the type of the cause thereof.

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Solution to Problem

To solve the foregoing problem, a type determination apparatus (for example, a type determination apparatus 500C shown in Fig. 3) of a wireless communication failure according to the present invention performs type determination of a wireless communication failure on the basis of:

a radio field intensity of communication between a first device (for example, a human detection sensor 600 shown in Fig. 1) and a second device (for example, a SGW 500A shown in Fig. 1) that perform wireless communication with each other;

presence or absence of transmission and reception (for example, step S5 of Fig. 3) of a success/failure signal (for example, an ACK/NACK signal) indicating a success or failure of the wireless communication performed between the first device and the second device; and

the number of occurrence of retries (for example, four as shown by steps S2-1 to S2-4 of Fig. 3) of signal transmission for establishing the wireless communication.

The type determination apparatus may perform the type determination of the wireless communication failure further on

the basis of a success or failure of wireless connection (for example, pairing) between the first device and the second device.

If the wireless communication between the devices is
5 ZigBee communication, the radio field intensity may be obtained from a physical layer of either one of the devices. The presence or absence of transmission and reception of the success/failure signal may be obtained from a media access control layer of either one of the devices. The number of
10 retries and the success or failure of the wireless connection may be obtained from a network layer of either one of the devices.

If the wireless communication between the devices is
Bluetooth communication or OSI communication, the radio field
15 intensity may be obtained from a physical layer of either one of the devices. The presence or absence of transmission and reception of the success/failure signal may be obtained from a media access control layer of either one of the devices. The number of retries and the success or failure of the wireless
20 connection may be obtained from a network layer of either one of the devices.

A type determination system according to the present invention includes:

the foregoing type determination apparatus;
25 the first device and the second device; and

a remote controller for transmitting an instruction for the first device to the second device.

The type determination system may include a notification apparatus for making a notification of a result of the type
5 determination, or a recording apparatus for recording the result of the type determination.

The type determination apparatus may be included in the second device or the recording apparatus. The processing performed by the type determination apparatus may be
10 implemented by a program to be executed by the second device or the recording apparatus.

Advantageous Effects of Invention

According to the present invention, not simply a
15 notification of a failure of wireless communication but also a notification of a type of a cause thereof can be made.

Brief Description of Drawings

Fig. 1 is a schematic explanatory diagram of a home
20 appliance control system including a type determination apparatus of a wireless communication failure according to an embodiment of the present invention.

Fig. 2 is a block diagram of a ZigBee protocol stack which can be employed in the home appliance control system
25 shown in Fig. 1.

Fig. 3 is a block diagram showing a schematic configuration of a type determination apparatus 500C arranged in a SGW 500A shown in Fig. 1.

Fig. 4 is a sequence diagram in which the SGW 500A and a human detection sensor 600 establish a wireless connection.

Fig. 5 is a flowchart showing an example of an operation of the type determination apparatus 500C shown in Fig. 3.

Description of Embodiments

An embodiment of the present invention will be described below with reference to the drawings.

Fig. 1 is a schematic explanatory diagram of a home appliance control system including a type determination apparatus of a wireless communication failure according to the embodiment of the present invention. Fig. 1 shows a smartphone 100, a modem router 200, a multi adapter 300, an air conditioner 400, a gateway unit 500, a human detection sensor 600, audio units 700, and the Internet 800 to be described below.

The smartphone 100 serves as a so-called remote controller to remotely control or monitor various devices, such as the air conditioner 400, the human detection sensor 600, and the audio units 700, via the modem router 200. The smartphone 100 is connected to the modem router 200 by wireless local area network (wireless LAN: W-LAN)

communication such as Wi-Fi.

The remote control or monitoring of the air conditioner 400 and the like does not necessarily need to be performed by using the smartphone 100, and may be performed by using a mobile phone, a tablet, a personal computer with a wireless function or so-called notebook PC, etc.

The modem router 200 connects the multi adapter 300 and the gateway unit 500 located downstream with the Internet 800 and the W-LAN located upstream. The modem router 200 is a modem having a router function, which mainly receives instructions transmitted from the smartphone 100 via the W-LAN and remotely controls or monitors the air conditioner 400, the human detection sensor 600, and the audio units 700 on the basis of the instructions by using the router function.

The modem router 200 not only can receive instructions from the smartphone 100 via the W-LAN, but also can receive instructions via the Internet 800. Instead of the modem router 200, separate pieces of hardware that are a modem and a router may be prepared. The modem and the router may be connected to each other and used to implement the foregoing operation.

The multi adapter 300 is arranged between the modem router 200 and the air conditioner 400. The multi adapter 300 is an interface for mainly receiving instructions directly transmitted from the smartphone 100 or instructions transmitted via the modem router 200 and outputting the

instructions to the air conditioner 400. The multi adapter 300 is wirelessly connected to the modem router 200 by the W-LAN and the like, and is connected to the air conditioner 400 in a wired manner via a connection cable and the like.

5 In the present embodiment, to support a wide variety of air conditioners of different manufacturers and models, the multi adapter 300 is configured to be able to issue instructions that can be given by remote controllers of main models of air conditioners of major manufacturers. Examples of
10 the instructions include power-on/off, operation switching, and air volume adjustment.

 An air conditioner and its remote controller are usually set to share information indicating various instruction contents and corresponding commands. For example, if a power
15 button of the remote controller is pressed, a command for a power-on/off instruction is transmitted to the air conditioner. Receiving the command, the air conditioner identifies that the instruction content corresponding to the command is power-on/off, and the air conditioner is actually controlled on/off.

20 In the present embodiment, the control of the air conditioner 400 via the multi adapter 300 is implemented in a manner similar to the foregoing. For that purpose, the multi adapter 300 stores information indicating various instruction contents and corresponding commands of major manufacturers and
25 main models. When the multi adapter 300 is connected to the

air conditioner 400, that the air conditioner to be controlled is the air conditioner 400 of a certain manufacturer and a certain model is set into the multi adapter 300.

In addition, application software for remotely
5 controlling an air conditioner, containing information indicating various instruction contents and corresponding commands of major manufacturers and main models, is installed on the smartphone 100. Like the setting of the multi adapter 300, that the air conditioner to be controlled is the air
10 conditioner 400 is set into the application software of the smartphone 100.

The application software displays virtual buttons corresponding to a power button and the like on the display of the smartphone 100. If the user touches a specific area of the
15 display with the virtual buttons displayed, information for giving an instruction to output a command corresponding to that area to the air conditioner 400 is transmitted from the smartphone 100 to the multi adapter 300. The multi adapter 300 may be configured to output the command to the air conditioner
20 400 when receiving the instruction.

The air conditioner 400, the human detection sensor 600, and the audio units 700 are devices on which the smartphone 100 performs various types of remote control and monitoring. These devices are just a few examples. Other examples may
25 include various devices to be managed by a home energy

management system (HEMS), such as a lighting device, a surveillance camera device, a bed leaving sensor that can be attached to a nursing bed, a water leakage sensor, a gas leakage sensor, a smoke sensor, an opening/closing device of a window, door, or curtain, and a refrigerator and other electric appliances capable of variable temperature settings, as well as a charging system of a plug-in electric vehicle.

The gateway unit 500 connects the modem router 200 with the human detection sensor 600 and the audio units 700. The gateway unit 500 includes a service gateway (SGW) 500A and its slave unit 500B. If the audio units 700 are installed in an environment where wireless signals transmitted from the SGW 500 can be sufficiently received, the slave unit 500B does not necessarily need to be used.

The modem router 200 and the gateway unit 500 are often arranged in physically close positions. The modem router 200 and the gateway unit 500 can thus be connected in a wired manner, for example, by cable communication or wired LAN communication. The modem router 200 and the gateway unit 500 may be connected by wireless communication.

The gateway unit 500 and the human detection sensor 600 can be connected by ZigBee communication, sub-G communication, Bluetooth low energy (BLE) communication, and the like for the purpose of low power consumption. The gateway unit 500 and the human detection sensor 600 may be connected by Bluetooth

communication, Wi-Fi communication, and the like with relatively higher power consumption.

The gateway unit 500 and the audio units 700 can be connected by infrared communication which is already in widespread use. Bluetooth communication, Wi-Fi communication, and the like may be used so that the communication will not be interrupted by a physical obstruction, if any, on the communication path therebetween.

The Internet 800 is connected to the modem router. The Internet 800 is a network to serve mostly as a communication network if the smartphone 100 and the modem router 200 are not able to communicate with each other by W-LAN communication.

Next, a type determination apparatus according to the present embodiment will be described. In the present embodiment, the SGW 500A shown in Fig. 1 includes a type determination apparatus 500C (Fig. 3). Before a description of a configuration of the type determination apparatus 500C, a principle by which the type determination apparatus 500C determines a cause of a wireless communication failure will be described.

Fig. 2 is a configuration diagram of a ZigBee protocol stack which can be employed in the home appliance control system shown in Fig. 1. Fig. 2 shows a physical layer, a media access control (MAC) layer, a network layer, an application layer, information that the type determination apparatus 500C

can obtain from such layers, and causes of wireless communication failures according to the information.

For ease of understanding, an example of determining a failure type when a wireless communication failure occurs between the SGW 500A and the human detection sensor 600 will be described. As shown in Fig. 2, the radio field intensity of the communication between the SGW 500A and the human detection sensor 600 can be obtained from the physical layer. The presence or absence of reception of an ACK signal, which is transmitted from the human detection sensor 600 to the SGW 500A to indicate the reception of a discovery response to be described below etc., can be obtained from the MAC layer. Whether the number of retries of a request signal and the like from the human detection sensor 600 to the SGW 500A is large or small and the presence or absence of pairing can be obtained from the network layer. In the field of wireless communications, the communication radio field intensity is called received signal strength indicator (RSSI).

For example, if the radio field intensity is low, the human detection sensor 600 and the SGW 500A may be arranged far apart from each other. If the human detection sensor 600 and the SGW 500A fail to be paired despite high radio field intensity, the initial settings of the human detection sensor 600 may be erroneous. In such a manner, there may be observed phenomena corresponding to respective failures. In the present

embodiment, the type of a wireless communication failure is thus determined on the basis of various types of information obtainable from the communication layers.

The foregoing description has been given by using a ZigBee communication protocol as an example. Note that the description based on this communication protocol is just an example, since the foregoing information needed to determine the type of a wireless communication failure can also be obtained from layers of other communication protocols.

For example, in the case of Bluetooth, the communication radio field intensity can be obtained from a layer called baseband layer. The presence or absence of reception of the ACK signal, the number of retries, and the presence or absence of pairing can be obtained from a layer called host controller interface layer or a layer called link management layer.

In another example, in a protocol stack constructed on the basis of the Open Systems Interconnection (OSI) basic reference model, the communication radio field intensity can be obtained from a layer called physical layer or a layer called data link layer. The presence or absence of reception of the ACK signal, the number of retries, and the presence or absence of pairing can be obtained from the layer called data link layer or a layer called network layer.

Fig. 3 is a block diagram showing a schematic configuration of the type determination apparatus 500C

arranged in the SGW 500A shown in Fig. 1. Fig. 3 shows radio field intensity determination means 510, ACK signal reception determination means 520, retry counting means 530, and pairing success/failure determination means 540 to be described below.

5 The radio field intensity determination means 510 determines a radio field intensity between the SGW 500A and the human detection sensor 600 which perform wireless communication. In the case of the example shown in Fig. 2, the radio field intensity determination means 510 can perform the
10 determination on the basis of the radio field intensity obtained from the physical layer of the SGW 500A. Alternatively, the radio field intensity obtained from the physical layer of the human detection sensor 600 may be transmitted from the human detection sensor 600 to the SGW
15 500A, and the type determination apparatus 500C may perform the determination.

 The ACK signal reception determination means 520 determines whether the ACK signal is transmitted from the human detection sensor 600 to the SGW 500A. In the case of the
20 example shown in Fig. 2, the ACK signal reception determination means 520 can perform the determination on the basis of the presence or absence of reception of the ACK signal obtained from the MAC layer of the SGW 500A or the human detection sensor 600. Instead of the determination based
25 on the presence or absence of reception of the ACK signal, the

ACK signal reception determination means 520 may make a determination based on the presence or absence of reception of a NACK signal which indicates that a desired signal is not transmitted, etc.

5 The retry counting means 530 determines whether the number of retries of a discovery request and the like transmitted from the human detection sensor 600 is large or small. In other words, the retry counting means 530 determines the number of times the device discovery request and the like
10 are transmitted in performing pairing. In the case of the example shown in Fig. 2, the retry counting means 530 can perform the determination on the basis of the number of retries obtained from the network layer of the SGW 500A or the human detection sensor 600.

15 The pairing success/failure determination means 540 determines whether the SGW 500A and the human detection sensor 600 are successfully paired. In the case of the example shown in Fig. 2, the pairing success/failure determination means 540 can perform the determination on the basis of the number of
20 retries obtained from the network layer of the SGW 500A or the human detection sensor 600.

 The type determination apparatus 500C does not necessarily need to be provided to the SGW 500A. For example, the type determination apparatus 500C may be included in the
25 multi adapter 300. The type determination apparatus 500C may

be included in a not-shown cloud server or the like that is connected to the Internet 800.

At the time of initial installation of the human detection sensor 600, the audio units 700, and the like, or at
5 the time of initial installation of the multi adapter 300 itself, a wireless communication failure may occur between such devices and wireless connection targets. The provision of the type determination apparatus 500C in the SGW 500A or the multi adapter 300 allows early recognition of the cause of
10 such a wireless communication failure. This provides the advantage that the failure can be avoided in an early stage.

The provision of the type determination apparatus 500C in the cloud server has the advantage that if a wireless communication failure occurs, the cause of the wireless
15 communication failure can be found out by accessing the cloud server by using the smartphone 100 even away from home. There is another advantage that the presence or absence of a relatively large number of wireless communication failures and the causes of the wireless communication failures can be
20 recorded in the cloud server.

In particular, if the type determination apparatus 500C constantly performs the foregoing determination every few seconds to every few days, the type determination apparatus 500C can be provided in the cloud server to record the
25 determination results and pieces of real-time time information

in pairs. Such recording is useful because whether a wireless communication failure is a temporary one can be checked. If the installation position of the human detection sensor 600 or the like is changed, whether a wireless communication failure occurs due to the change can also be checked soon.

If network congestion is not taken into account, an area for recording such determination results and the like may be provided in the SGW 500A and the like. Determination results and the like then may be recorded in the SGW 500A and the like, and transmitted to the cloud server on a regular or irregular basis.

The type determination unit 500C may be implemented by hardware. The type determination unit 500C may be implemented as software for causing any of the pieces of hardware shown in Fig. 1 to execute the processing to be executed by the respective means shown in Fig. 3.

Next, to describe an operation of the type determination apparatus 500C, a sequence when the SGW 500A and the human detection sensor 600 establish a desired wireless connection therebetween will initially be described.

Fig. 4 is a sequence diagram in which the SGW 500A and the human detection sensor 600 establish the wireless connection. Fig. 4 shows a sequence compliant with RF4CE (Radio Frequency for Consumer Electronics). The RF4CE communication protocol is just an example, and communication

based on other communication protocols may be performed.

Initially, the human detection sensor 600 searches for the SGW 500A. The application layer of the human detection sensor 600 outputs an instruction to a communication unit of the human detection sensor 600 to transmit a discovery request (step S1).

The communication unit of the human detection sensor 600 inputs the instruction, and transmits a discovery request with the SGW 500A as a target (step S2-1).

10 In the SGW 500A, a search request time for making a search response usually comes on a regular basis. If a discovery request is transmitted other than in a search response time, a communication unit of the SGW 500A receives the discovery request but does not perform processing for pairing. The human detection sensor 600 retries the discovery request (steps S2-2 to S2-4) until a discovery response shown in step S4 to be described below is made with respect to the discovery request.

20 In the example shown in Fig. 4, the discovery requests shown in steps S2-1 and S2-2 are the ones transmitted other than in a search response time of the SGW 500A. Since no discovery response is made with respect to the discovery requests, the human detection sensor 600 retries the discovery request.

25 For the convenience of description, an ACK signal is

shown only in step S5 to be described below. In fact, an ACK signal (or NACK signal; the same applies to the following) is returned if any signal such as a discovery request is transmitted from the human detection sensor 600 to the SGW

5 500A.

If a search response time arrives, the application layer of the SGW 500A transmits an automatic discovery request indicating the arrival to the communication unit of the SGW 500A (step S3).

10 If a discovery request is transmitted from the human detection sensor 600 within the search response time, the communication unit of the SGW 500A receives the discovery request (Rx1 and Rx2). The communication unit of the SGW 500A then transmits a discovery response to the communication unit
15 of the human detection sensor 600 (step S4).

In the example shown in Fig. 4, the discovery requests shown in steps S2-3 and S2-4 are the ones transmitted within the search response time of the SGW 500A. As has been described, the network layer of the human detection sensor 600
20 and the network layer of the SGW 500A store the number of retries of the discovery request. Since the retries are made not because of a communication failure, the number of such retries does not need to be used for determination.

Now, if, for example, the ACK signal is not found to be
25 sent back from the SGW 500A within a predetermined time since

the transmission of the discovery request from the human detection sensor 600, the discovery request will be retried. The number of such retries is used for determination. If a pairing response and a seed of an encryption key in exchanging an encryption key in steps S11 and S12 are also retried, the number of such retries is also used for determination.

Receiving the discovery response from the communication unit of the SGW 500A, the communication unit of the human detection sensor 600 stops retrying the discovery request, and transmits an ACK signal to notify the communication unit of the SGW 500A of the reception of the discovery response (step S5). More specifically, the communication unit of the human detection sensor 600 transmits the ACK signal that indicates whether wireless communication performed between the SGW 500A and the human detection sensor 600 prior to wireless communication to be performed after the completion of steps S15 and S16, like the reception of the discovery response shown in step S4 with respect to the transmission of the discovery request shown in steps S2-1 to S2-4, succeeds or fails.

In the determination processing by the ACK signal reception determination means 520 shown in Fig. 3, the ACK signal transmitted from the SGW 500A to the human detection sensor 600 in step S5 does not necessarily need to be used. For example, an ACK signal with respect to the discovery

request in step S2-1 may be used.

The communication unit of the SGW 500A and the communication unit of the human detection sensor 600 then output an automatic discovery confirm and a discovery confirm
5 to the application layer of the SGW 500A and the application layer of the human detection sensor 600, respectively (steps S6-1 and S6-2).

To make a pairing request, the application layer of the human detection sensor 600 then outputs an instruction to the
10 communication unit of the human detection sensor 600 to transmit a pairing request (step S7).

The communication unit of the human detection sensor 600 inputs the instruction, and transmits a pairing request with the SGW 500A as a target (step S8).

15 The communication unit of the SGW 500A receives the pairing request from the communication unit of the human detection sensor 600, and outputs a pairing instruction to the application layer of the SGW 500A (step S9).

The application layer of the SGW 500A inputs the pairing
20 instruction, and determines whether the pairing processing can be continued. In this case, the application layer of the SGW 500A outputs a transmission instruction for a pairing response to the communication unit of the SGW 500A (step S10).

The communication unit of the SGW 500A inputs the
25 transmission instruction for a pairing response, and transmits

a pairing response to the communication unit of the human detection sensor 600 (step S11). If the communication unit of the human detection sensor 600 and the communication unit of the SGW 500A use an encryption key for actual communication therebetween, the communication unit of the human detection sensor 600 and the communication unit of the SGW 500A then exchange seeds of the encryption key and generate link keys. Finally, the communication unit of the human detection sensor 600 and the communication unit of the SGW 500A perform ping transactions to check whether the encryption key is exchanged (step S12).

Next, the communication unit of the human detection sensor 600 and the communication unit of the SGW 500A output a pairing confirm and a confirm status instruction to the application layer of the human detection sensor 600 and the application layer of the SGW 500A, respectively (steps S13 and S14). The communication unit of the human detection sensor 600 and the communication unit of the SGW 500A input the instructions, and update respective flash memories (steps S15 and S16) to complete the pairing processing.

Fig. 5 is a flowchart showing an example of the operation of the type determination apparatus 500C shown in Fig. 3. As has been described, the radio field intensity determination means 510 of the type determination apparatus 500C obtains the radio field intensity between the SGW 500A and the human

detection sensor 600 from the physical layer of the SGW 500A, and determines whether the radio field intensity is lower than or equal to a certain threshold (step S21).

If, as a result of the determination in step S21, the
5 radio field intensity is lower than or equal to the certain threshold, there is likely to be a wireless communication failure because the SGW 500A and the human detection sensor 600 are located at physically separated positions. The type determination apparatus 500C then notifies the user of
10 information indicating this (step S22).

A specific method for such notification may include transmitting the information from the type determination apparatus 500C to the smartphone 100 via the modem router 200 or the cloud server, and making the smartphone 100 display the
15 information on its display or output the information from a speaker. Alternatively, a television set of the audio units 700 may externally input the information, and display the information on its screen or output the information from its speaker.

20 On the other hand, if, as a result of the determination in step S21, the radio field intensity is not lower than or equal to the certain threshold, the ACK signal reception determination means 520 obtains the presence or absence of reception of the ACK signal transmitted from the human
25 detection sensor 600 from the MAC layer, and determines

whether the ACK signal is received (step S23).

If, as a result of the determination in step S23, the ACK signal is not received, the type determination apparatus 500c notifies the user of information indicating that the human
5 detection sensor 600 is likely to have an abnormality, such as a failure, by using the foregoing notification method and the like (step S24).

On the other hand, if, as a result of the determination in step S23, the ACK signal is received, the retry counting
10 means 530 obtains the number of retries of the request signal and the like from the network layer of the SGW 500A, and determines whether the number of retries of the request signal and the like is greater than or equal to a predetermined threshold (step S25).

15 If, as a result of the determination in step S25, the number of retries of the request signal and the like is greater than or equal to the predetermined threshold, the type determination apparatus 500c notifies the user of information indicating that the wireless communication between the SGW
20 500A and the human detection sensor 600 is likely to be undergoing radio interference from other wireless communication (step S26).

On the other hand, if, as a result of the determination in step S25, the number of retries of the request signal and
25 the like is not greater than or equal to the predetermined

threshold, the pairing success/failure determination means 540 obtains the success or failure of pairing between the SGW 500A and the human detection sensor 600 from the network layer of the SGW 500A, and determines whether the pairing between the
5 SGW 500A and the human detection sensor 600 is successful (step S27).

If, as a result of the determination in step S27, the pairing between the SGW 500A and the human detection sensor 600 is not successful, the type determination apparatus 500C
10 notifies the user of information indicating that the human detection sensor 600 is likely to have an erroneous initial setting (step S28).

On the other hand, if, as a result of the determination in step S27, the pairing between the SGW 500A and the human
15 detection sensor 600 is successful, desired communication is successfully being held without a wireless communication failure.

If desired communication fails to be made, there is a wireless communication failure due to some cause or causes. If
20 the occurrence of a wireless communication failure is predicated, step S27 does not necessarily need to be performed. That is, if the radio field intensity is determined to not be lower than or equal to the certain threshold (step S21), the ACK signal is determined to be received (step S23), and the
25 number of retries is determined to not be greater than or

equal to the predetermined threshold (step S25), then the type determination apparatus 500C may make a notification that there is likely to be an erroneous initial setting (step S28), without determining the success or failure of the pairing in
5 step S27.

Up to this point, the present embodiment has been described by using an example of determining the presence or absence of a wireless communication failure between the SGW 500A and the human detection sensor 600, and if there is the
10 failure, determining the failure type of the failure. The presence or absence of a wireless communication failure and the like between other devices, such as between the SGW 500A and the slave unit 500B and between the modem router 200 and the multi adapter 300, can also be determined by similar
15 methods.

In the present embodiment, if step S22 has not been performed before and is then performed a predetermined number of times in succession, like twice in succession, i.e., if there is determined to be a failure continuously in step S21,
20 the installation position of the human detection sensor 600 is expected to have been moved for room rearrangement and the like. In such a case, the type determination apparatus 500C may notify the user, when performing step S22, that it is preferable that the installation position of the human
25 detection sensor 600 be restored. The type determination

apparatus 500C may also stop determining the failure type until a time considered to be sufficient for the failure to be resolved (for example, one hour) elapses.

In the present embodiment, if step S24 has not been performed before and is then performed a predetermined number of times in succession, like twice in succession, i.e., if there is determined to be a failure consistently in step S23, there is expected to be a failure such as that of a communication device. In such a case, the type determination apparatus 500C may notify the user, when performing step S24, a message such as "power on the type determination apparatus 500C again after repair or replacement of the human detection sensor 600 completes." Here, the determination of the failure type can be stopped until the user powers on the type determination apparatus 500C again.

In the present embodiment, step S26 may be performed a predetermined number of times in succession, like twice in succession, in only a certain time of day, i.e., there may be determined to be a failure consistently in step S25 in a certain time of day. If, for example, such a failure occurs frequently at dinnertime, there is likely to be radio interference from the use of a microwave. In such a case, the type determination apparatus 500C can notify the user of an instruction to separate the microwave and other radio wave-emitting devices, if any, from the human detection sensor 600

and the like.

In the present embodiment, if step S28 is performed a predetermined number of times in succession, like twice in succession, i.e., if there is determined to be a failure consistently in step S27, the human detection sensor 600 and the like are likely to have an erroneous initial setting. In such a case, the type determination apparatus 500C can stop determining the failure type until the lapse of time considered to be sufficient for the failure to be resolved by correcting the erroneous initial setting (for example, three to five minutes).

If there is determined to not be a failure, for example, ten times in succession, the frequency of execution of the processing for determining a failure type may be reduced. On the other hand, if, for example, there is determined to be a failure ten times in succession, the type determination apparatus 500C may notify the cloud server of it regardless of the type of the failure. The reason is that such a failure is considered to be difficult for the user to resolve. Then, the administrator and the like of the cloud server can take measures such as advising the user on how to resolve the failure.

As has been described, the type determination apparatus 500C continuously performs the determination. However, depending on the failure type, the execution of useless

determinations can be cancelled before the failure state is resolved. For example, if the determination result of the type determination apparatus 500C is transmitted to the cloud server, the cancellation can reduce useless network traffic to the cloud server. The cancellation also reduces the congestion of the network, and provides an advantage of reduced power consumption because of reduced traffic. This suitably falls in line with the low power consumption of ZigBee communication and the like.

Note that that the type determination apparatus 500C cancels the execution of the foregoing determination for a predetermined time is equivalent to that the number of times of execution of the determination is adjusted.

Two or more types of wireless communication failures may occur between the SGW 500A and the human detection sensor 600 etc. in the same period of time. In such a case, the user convenience improves if the user executes processing for resolving both the failures in the same period of time, rather than the user executing the processing for resolving the failures not in the same period of time but twice separately. The type determination apparatus 500C may thus notify the user that there are likely to be a plurality of types of failures.

To achieve such a notification, for example, if there is determined to be any failure after a state where there has been determined to be no failure, the type determination

apparatus 500C may make determinations about the other failure types. For example, suppose that the radio field intensity has so far been higher than the certain threshold, and the type determination apparatus 500C performs the determination

5 processing of step S21 at a timing and determines that the radio field intensity is lower than or equal to the certain threshold. In such a case, after the execution of the notification processing of step S22, the type determination apparatus 500C may proceed to step S23 instead of ending the
10 processing shown in Fig. 5.

Consequently, the type determination apparatus 500C can notify the user in the same period of time that there are likely to be two or more types of wireless communication failures. As a specific notification method, the type
15 determination apparatus 500C may issue all the notifications in the same period of time. The type determination apparatus 500C may issue notifications according to predetermined order of priorities. The type determination apparatus 500C may issue the notifications of types first determined to be notified
20 first.

When issuing notifications according to predetermined order of priorities, for example, the type determination apparatus 500C may issue the notifications in the same order as the order of determinations shown in Fig. 5. Specifically,
25 the type determination apparatus 500C may issue the

notification that there is likely to be a wireless communication failure (step S22), the notification that there is likely to be an abnormality such as a device failure (step S24), the notification that there is likely to be radio interference from other wireless communication (step S26), and the notification that there is likely to be an erroneous initial setting (step S28) in such order.

Reference Signs List

10	100	smartphone
	200	modem router
	300	multi adapter
	400	air conditioner
	500	gateway unit
15	500A	service gateway (SGW)
	500B	slave unit
	500C	type determination apparatus
	510	radio field intensity determination means
	520	ACK signal reception determination means
20	530	retry counting means
	540	pairing success/failure determination means
	600	human detection sensor
	700	audio unit
	800	the Internet

25

Claims

[Claim 1]

A type determination apparatus of a wireless communication failure for performing type determination of a wireless communication failure on a basis of:

a radio field intensity of communication between a first device and a second device that perform wireless communication with each other;

presence or absence of transmission and reception of a success/failure signal indicating a success or failure of the wireless communication performed between the first device and the second device; and

a number of occurrence of retries of signal transmission for establishing the wireless communication.

[Claim 2]

The type determination apparatus according to claim 1, wherein the type determination apparatus performs the type determination of the wireless communication failure further on a basis of a success or failure of wireless connection between the first device and the second device.

[Claim 3]

The type determination apparatus according to claim 1, wherein:

the radio field intensity is obtained from a physical layer of either one of the devices;

the presence or absence of transmission and reception of the success/failure signal is obtained from a media access control layer of either one of the devices; and

the number of retries is obtained from a network layer of
5 either one of the devices.

[Claim 4]

The type determination apparatus according to claim 1, wherein:

the radio field intensity is obtained from a physical
10 layer or a baseband layer of either one of the devices; and

the presence or absence of transmission and reception of the success/failure signal and the number of retries are obtained from a host controller interface layer, a link management layer, a data link layer, or a network layer of
15 either one of the devices.

[Claim 5]

A type determination system comprising:

the type determination apparatus according to claim 1;

the first device and the second device; and

20 a remote controller for transmitting an instruction for the first device to the second device.

[Claim 6]

The type determination system according to claim 4, comprising a notification apparatus for making a notification
25 of a result of the type determination.

[Claim 7]

The type determination system according to claim 4,
comprising a recording apparatus for recording a result of the
type determination.

5 [Claim 8]

The type determination system according to claim 4,
wherein the type determination apparatus is included in any of
the second device and the recording apparatus.