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(54) **WIRELESS ACCESS SYSTEM**

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(57) **ABSTRACT**

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A wireless access system, including plural wireless control stations; a wireless terminal device to transmit and receive data to and from the plural wireless control stations, wherein the wireless control stations adjust with each other to reserve data transmission periods so as not to overlap with those of the other wireless control stations and transmit data in the reserved periods, and the wireless terminal device transmits data to at least one of the wireless control stations through space-division multiple access communication.

(30) **Foreign Application Priority Data**

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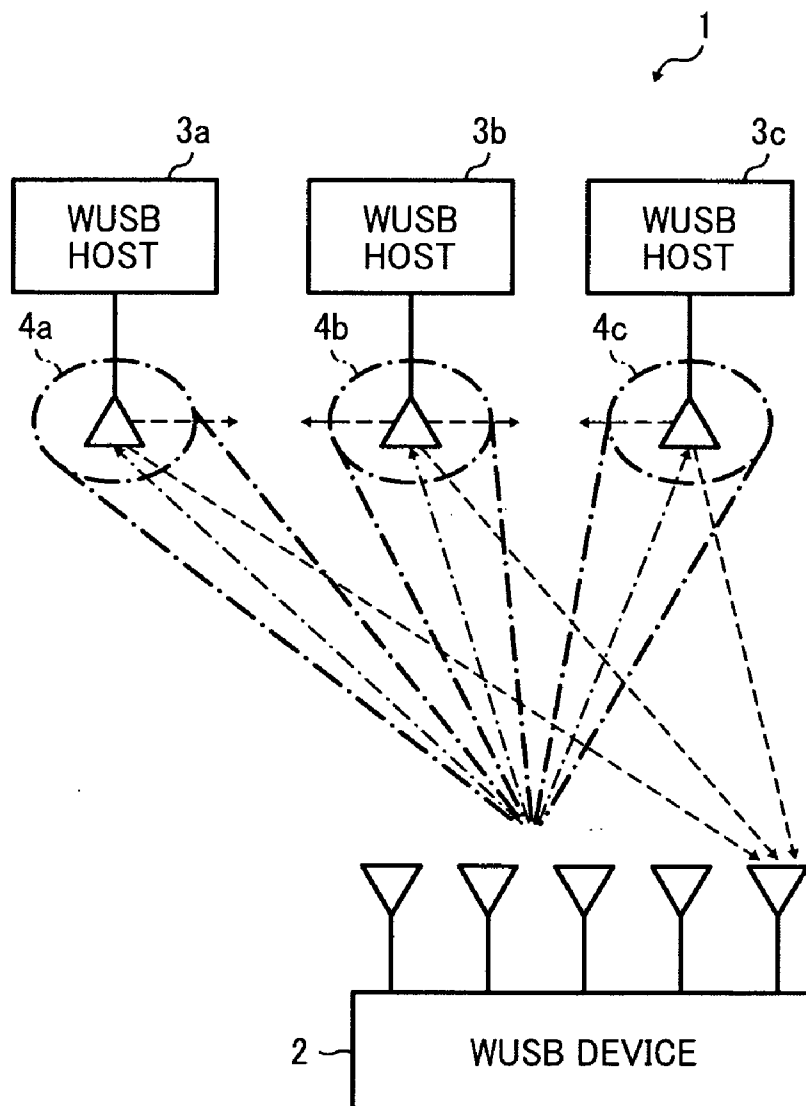


FIG. 1

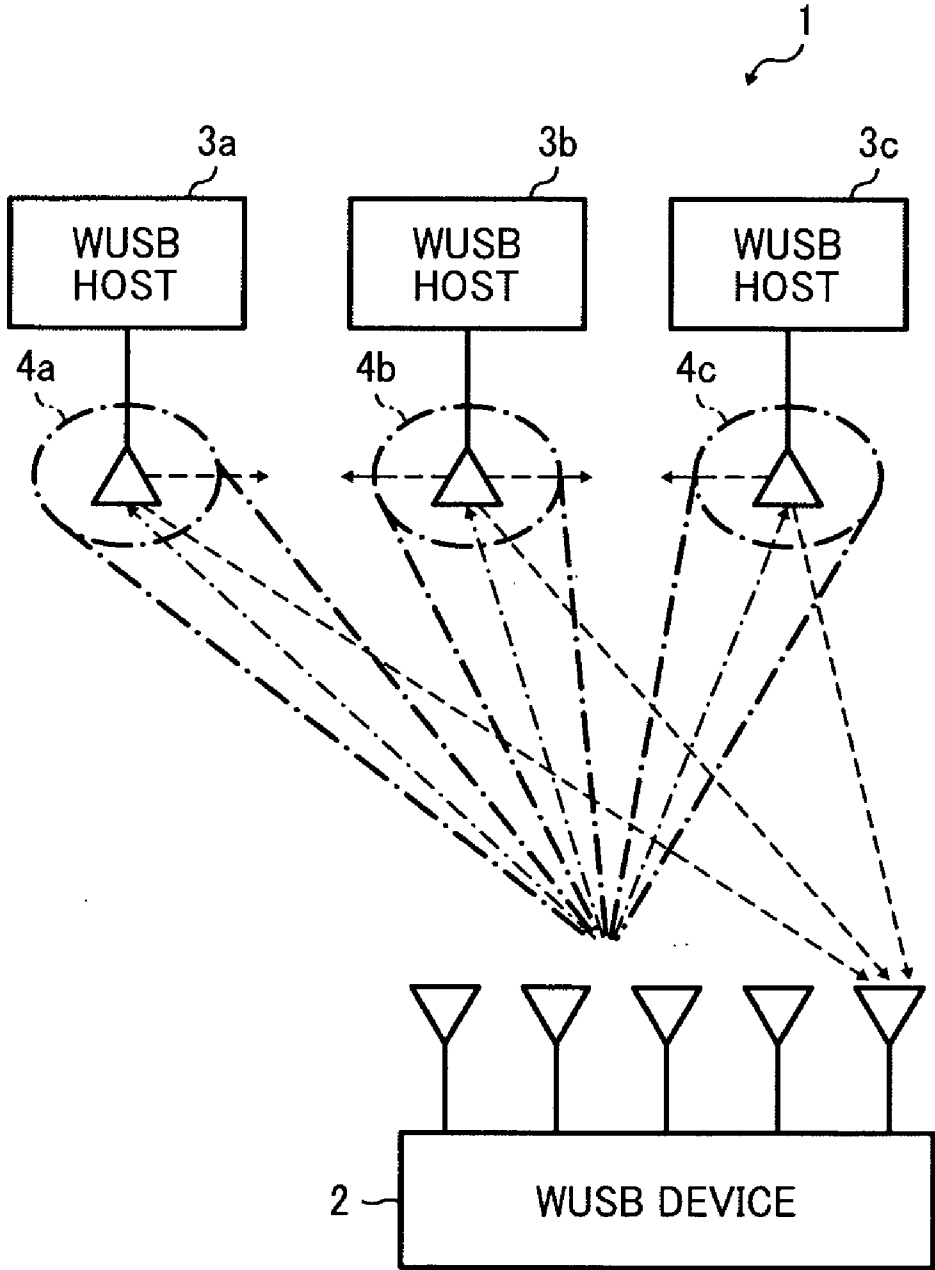


FIG. 2

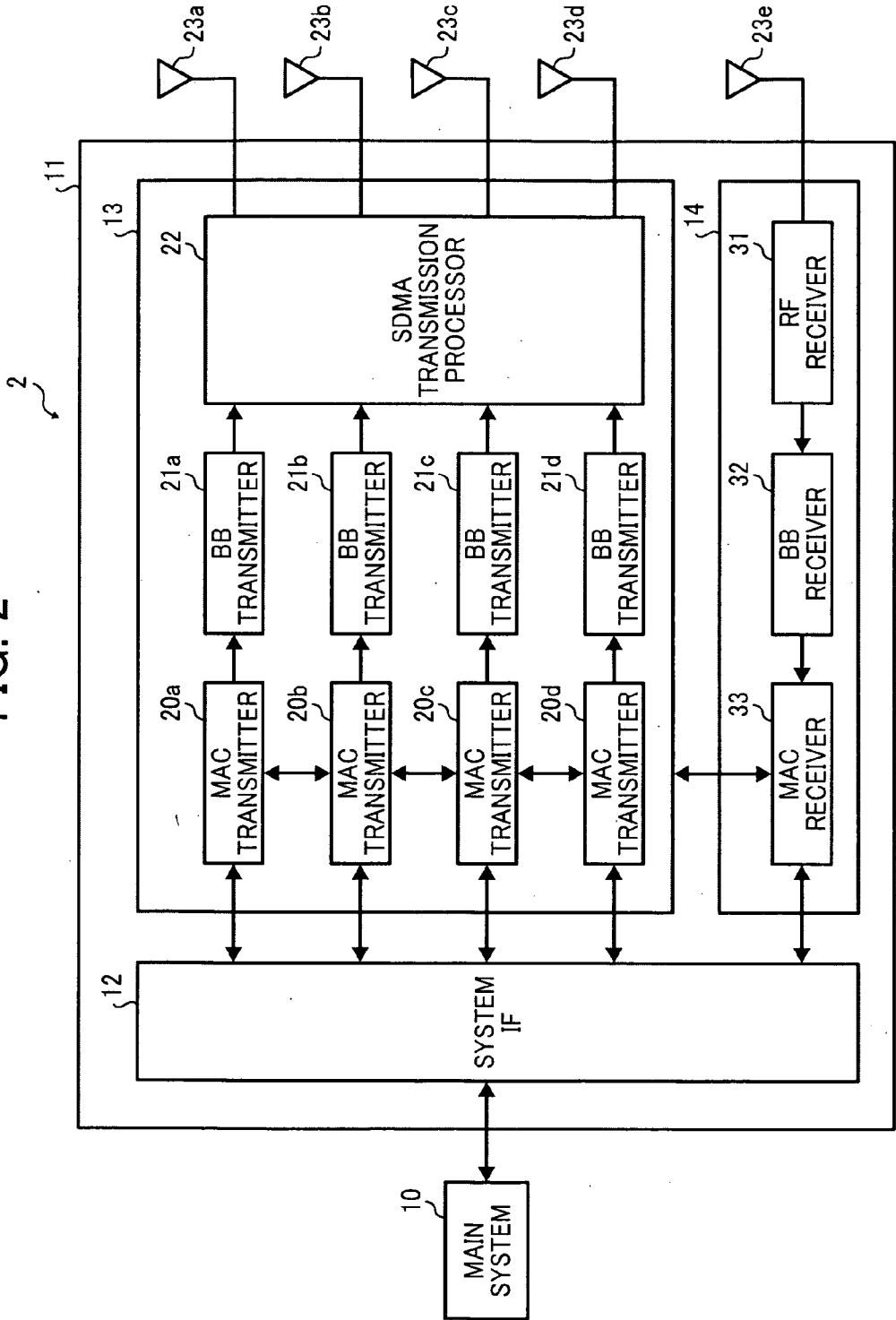


FIG. 3

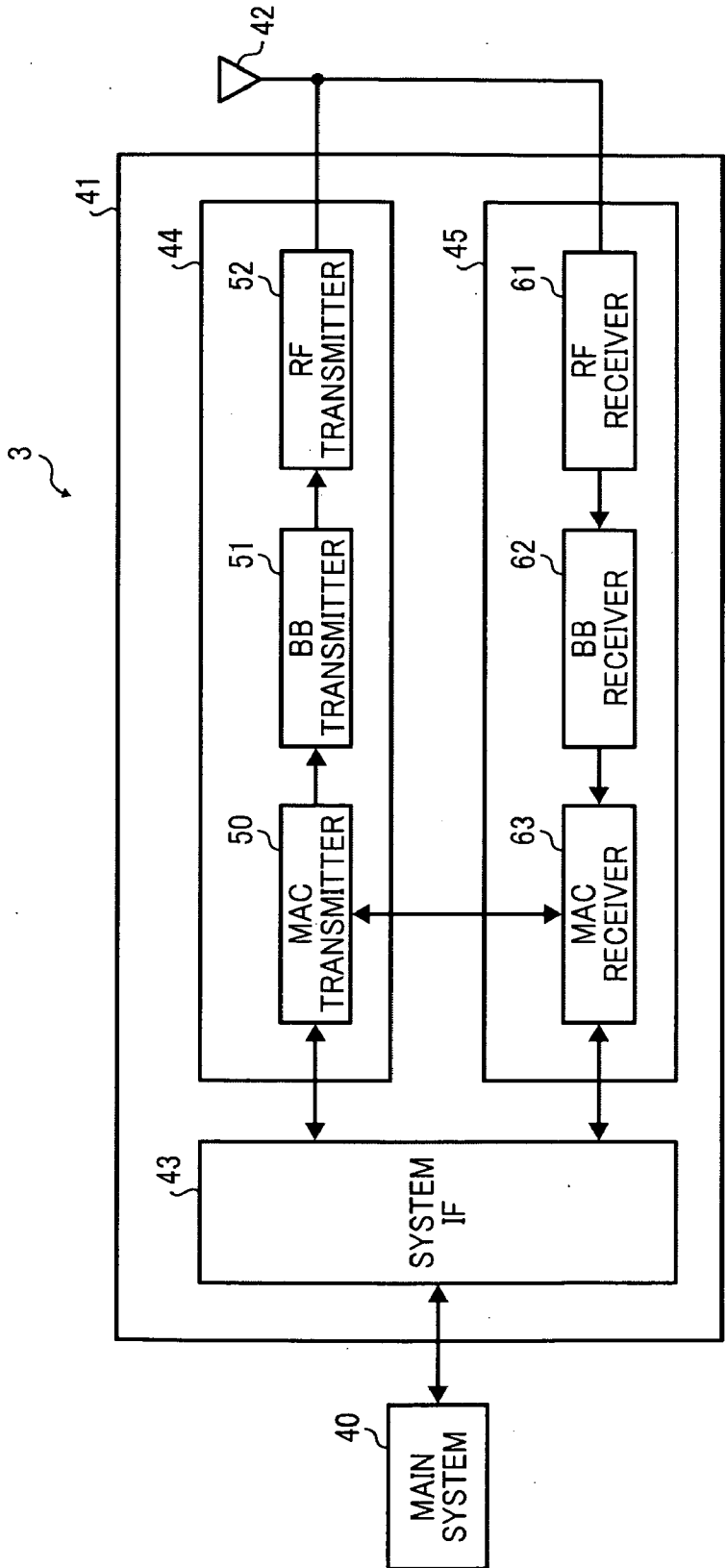


FIG. 4

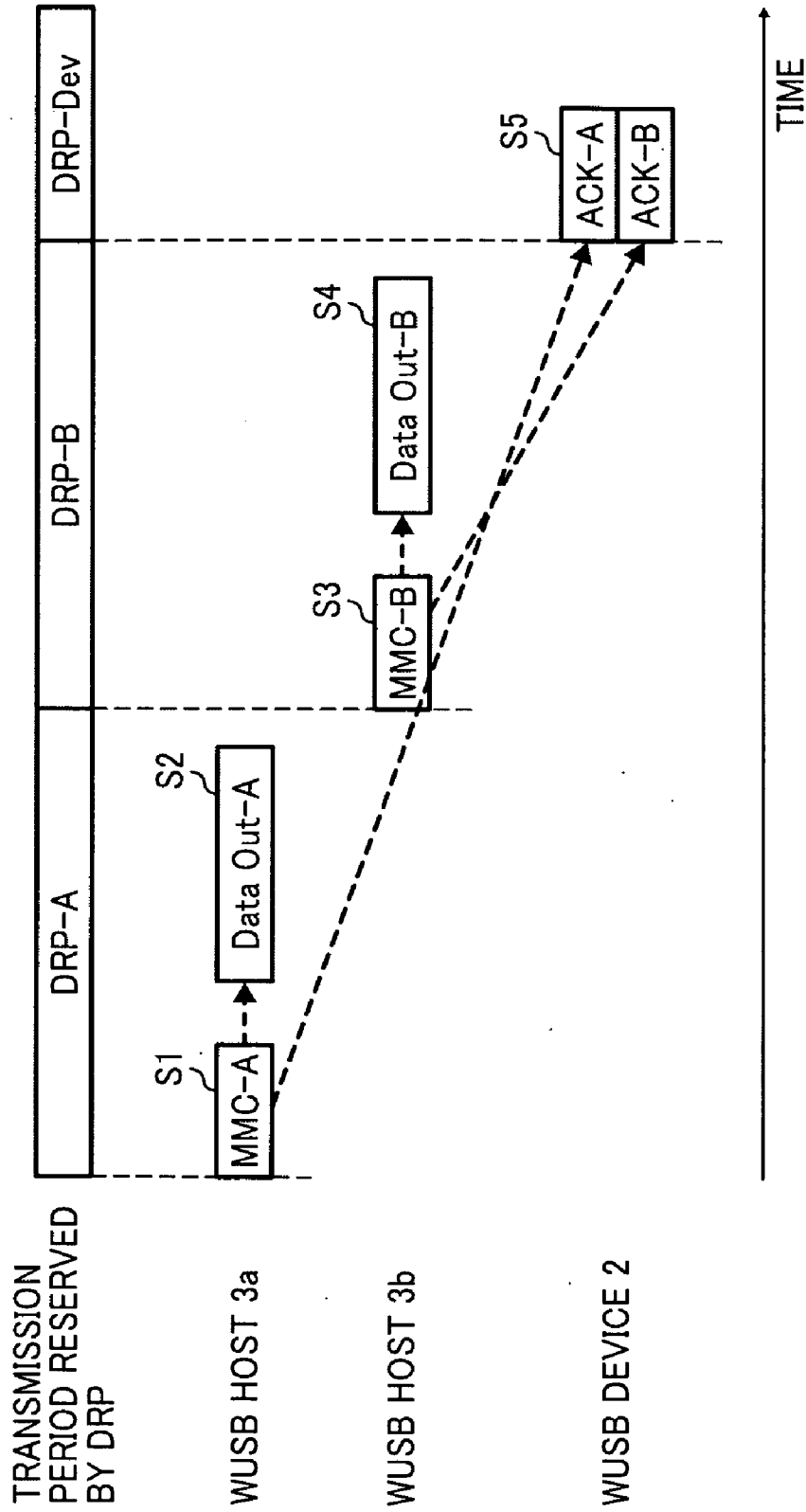
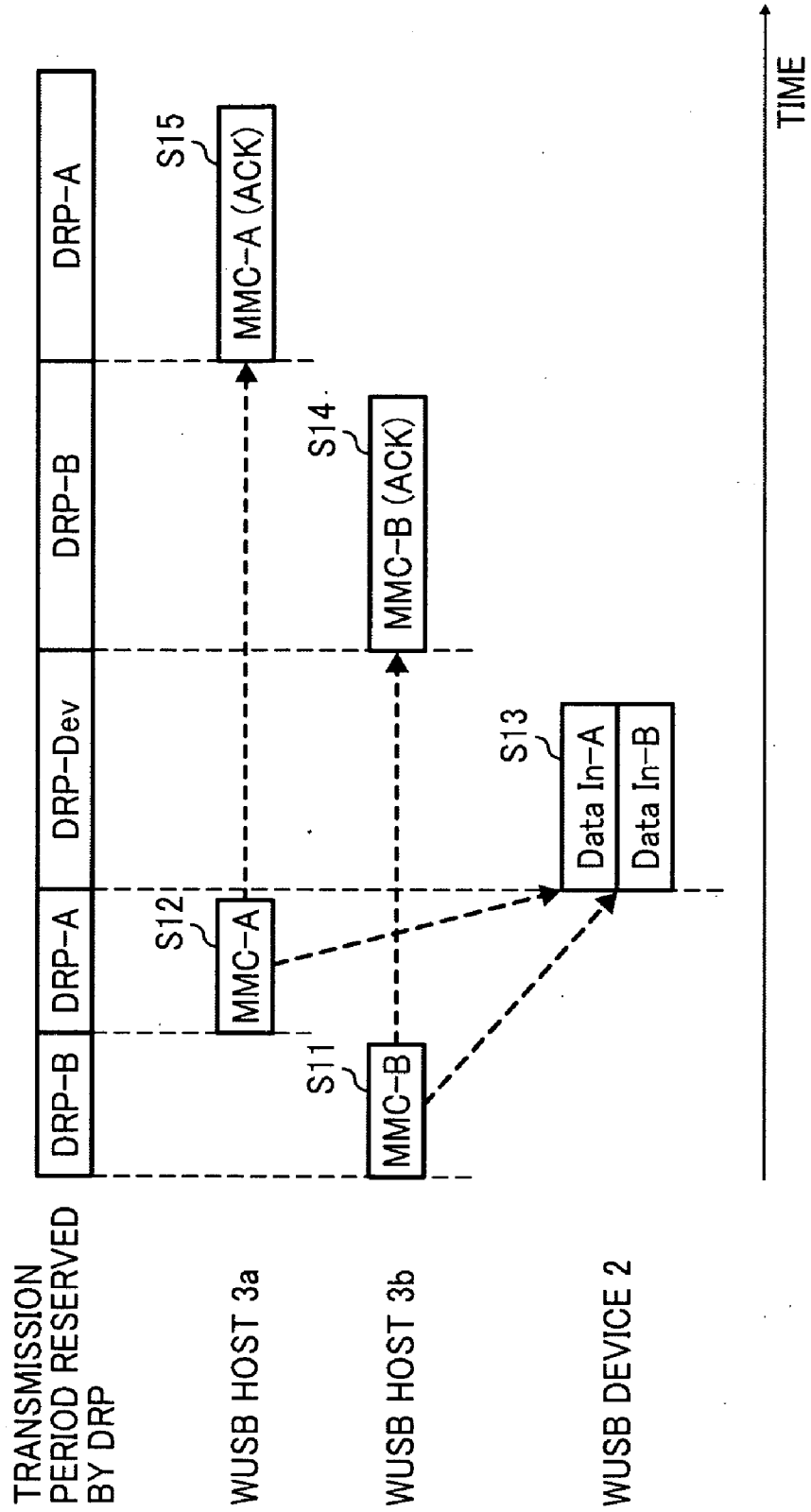


FIG. 5



## WIRELESS ACCESS SYSTEM

### BACKGROUND OF THE INVENTION

**[0001]** 1. Field of the Invention

**[0002]** The present invention relates to a wireless access system using a space-division multiple access communication as multiple wireless communication.

**[0003]** 2. Discussion of the Related Art

**[0004]** Conventionally, as disclosed in Japanese Patent No. 3926669, a wireless access system including a wireless control station and at least one wireless terminal device is known, in which the wireless control station transmits data in compliance with each of the wireless terminal devices through space-division multiple access communication. Meanwhile, data transmission to a wireless terminal device located in each directional space divided by space-division multiple access communication control is exclusively permitted, and time-division data are transmitted to the wireless control station while the wireless terminal device is permitted to transmit data by the wireless control station.

**[0005]** In the conventional wireless access system, data are transmitted from the wireless control station to the wireless terminal device through space-division multiple access communication in down transmission, and from the wireless terminal device to the wireless control station through time-division multiple access communication in up transmission. Therefore, in multiple access communication between the wireless control station and the wireless terminal device, interference between wireless transmission signals from the wireless terminal device is prevented, and interference waves at the wireless control station do not need removing.

**[0006]** However, multiple access communication between plural wireless control stations and wireless terminal devices is not considered.

**[0007]** In particular, a feasible technology for sharing one wireless terminal device among plural wireless control stations and controlling access is not disclosed.

### SUMMARY OF THE INVENTION

**[0008]** Accordingly, an object of the present invention is to provide a wireless access system capable of preventing interference with wireless transmission signals between the wireless control stations without needing removal of interference waves in the wireless terminal device in multiple wireless communication between plural wireless control stations and wireless terminal devices.

**[0009]** Another object of the present invention is to provide a wireless terminal device.

**[0010]** A further object of the present invention is to provide a wireless access method.

**[0011]** To achieve such objects, the present invention contemplates the provision of a wireless access system, comprising:

**[0012]** plural wireless control stations;

**[0013]** a wireless terminal device to transmit and receive data to and from the plural wireless control stations,

**[0014]** wherein the wireless control stations adjust with each other to reserve data transmission periods so as not to overlap with those of the other wireless control stations and transmit data in the reserved periods, and

**[0015]** the wireless terminal device transmits data to at least one of the wireless control stations through space-division multiple access communication.

**[0016]** These and other objects, features and advantages of the present invention will become apparent upon consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0017]** FIG. 1 is a block diagram of an embodiment of the wireless access system of the present invention;

**[0018]** FIG. 2 is a block diagram of a WUSB device constituting the embodiment of the wireless access system of the present invention;

**[0019]** FIG. 3 is a block diagram of a WUSB host constituting the embodiment of the wireless access system of the present invention;

**[0020]** FIG. 4 is a timing diagram of a first operational example of the embodiment of the wireless access system of the present invention; and

**[0021]** FIG. 5 is a timing diagram of a second operational example of the embodiment of the wireless access system of the present invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0022]** Generally, the present invention provides a wireless access system largely improving communication capacity through space-division multiple access communication when transmitting from a wireless terminal in multiple wireless communication between plural wireless control stations and wireless terminal devices and preventing interferences between wireless transmission signals from the wireless control station when transmitting to need no removal of interference waves in the wireless terminal device. More particularly, the present invention relates to a wireless access system, comprising:

**[0023]** plural wireless control stations;

**[0024]** a wireless terminal device to transmit and receive data to and from the plural wireless control stations,

**[0025]** wherein the wireless control stations adjust with each other to reserve data transmission periods so as not to overlap with those of the other wireless control stations and transmit data in the reserved periods, and

**[0026]** the wireless terminal device transmits data to at least one of the wireless control stations through space-division multiple access communication.

**[0027]** As shown in FIG. 1, an embodiment of the wireless access system of the present invention includes a WUSB device **2** and plural WUSB hosts **3a** to **3c**. In FIG. 1, three WUSB hosts **3a** to **3c** are shown, but the number of the WUSB hosts is not limited thereto.

**[0028]** The WUSB device **2** represents the wireless terminal device of the present invention, and includes peripheral equipment such as combined machines, printers and projectors. Each of the WUSB hosts **3a** to **3c** represents the wireless control station of the present invention, and includes a versatile personal computer capable of communicating with WUSB.

**[0029]** As shown in FIG. 2, the WUSB device **2** includes a main unit system **10** to control a main unit of peripheral equipment such as combined machines, printers and projectors, and a WUSB device communicator **11** to transmit and receive data to and from each of the WUSB hosts **3a** to **3c**.

**[0030]** The WUSB device communicator **11** includes a main system **10**, a system IF **12** which inputs and outputs data, a SDMA transmitter **13** which transmits data to each of the WUSB hosts **3a** to **3c** through space-division multiple access (SDMA) communication and a TDMA receiver **14** which receives data transmitted from each of the WUSB hosts **3a** to **3c** through time-division multiple access (TDMA) communication.

**[0031]** The SDMA transmitter **13** includes media access control (MAC) transmitters **20a** to **20d**, baseband (BB) transmitters **21a** to **21d**, a SDMA transmission processor **22** and antenna elements **23a** to **23d**.

**[0032]** In FIG. 2, each four MAC transmitters **20a** to **20d**, BB transmitters **21a** to **21d** and antenna elements **23a** to **23d** are shown, but the numbers thereof are not limited thereto.

**[0033]** Each of the MAC transmitters **20a** to **20d** subject data input from the main system **10** through the system IF **12** to a transmission process relating to MAC layer and output the processed data to the BB transmitters **21a** to **21d**, respectively.

**[0034]** The BB transmitters **21a** to **21d** modulate the data input from the MAC transmitters **20a** to **20d** to BB signals, respectively. The SDMA transmission processor **22** duplicates each of the BB signals to the number of the transmission antenna elements, multiplies the BB signal by an adjustment factor relating to an amplitude and a phase in the direction of the WUSB hosts **3a** to **3c** to up-convert the signal to a radio frequency (RF) signal, and transmits the RF signals as electric waves through the antenna elements **23a** to **23d**, respectively.

**[0035]** In FIG. 1, same signals only different in amplitude and phase are transmitted from the four antenna elements, and a directive signal in the direction of the WUSB host **3a** is synthesized in a space. When adjustment factor relating to an amplitude and a phase in the direction of the WUSB hosts **3b** and **3c**, a directive signal is synthesized as well.

**[0036]** The electric waves transmitted from each of the antenna elements **23a** to **23d** are synthesized in a space and transmitted to directional spaces **4a** to **4c**, respectively as FIG. 1 shows. At least one of the antenna elements **23a** to **23c** is located at least one of directional spaces **4a** to **4c**.

**[0037]** In FIG. 2, the TDMA receiver **14** includes an antenna **30**, an RF receiver **31** which down-converts an RF signal received through the antenna **30** to a BB signal, a BB receiver **32** which demodulates the BB signal and a MAC receiver **33** which subjects the demodulated data to a reception process relating to MAC layer and outputs the data to the main system **10** through the system IF **12**. The TDMA receiver **14** can share the antenna elements **23a** to **23d** instead of the antenna **30** by time-division with the SDMA transmitter **13**.

**[0038]** Each of the WUSB hosts **3a** to **3c** (hereinafter referred to as "WUSB host **3**" collectively) include, as shown in FIG. 3, a main system **40** which performs a process relating to a layer prior to the MAC layer, a WUSB host communicator **41** for transmitting and receiving data to and from a WUSB device **2**, and an antenna **42**.

**[0039]** The WUSB host communicator **41** includes a system IF **43** which inputs and outputs data with the main system **40**, a transmitter **44** which transmits data to the WUSB device **2** through TDMA communication and a receiver **45** which receives a directional space signal transmitted from the WUSB device **2** through TDMA communication to its own station.

**[0040]** The transmitter **44** includes a MAC transmitter **50**, a BB transmitter **51** and an RF transmitter **52**. The MAC transmitter **50** subjects data input from the main system **40** through the system IF **43** to a transmission process relating to MAC layer and outputs the processed data to the BB transmitter **51**.

**[0041]** The BB transmitter **51** modulates data input from the MAC transmitter **50** to a BB signal. The RF transmitter **52** up-converts the BB signal to an RF signal, and transmits the RF signal as an electric wave through an antenna **42**.

**[0042]** The receiver **45** includes an RF receiver **61** which down-converts an RF signal received through the antenna **42** to a BB signal, a BB receiver **62** which demodulates the BB signal and a MAC receiver **63** which subjects the demodulated data to a reception process relating to MAC layer and outputs the data to the main system **40** through the system IF **43**.

**[0043]** A signal received by the antenna **42** is transmitted by the WUSB device **2** so as to have a directivity to a directional space the WUSB host **3** is located in, and a signal transmitted to the other directional spaces as an interference signal has a level considerably lower than that of a signal to its own station. Therefore, the WUSB host **3** does not need an interference wave removal process at the receiving side.

**[0044]** The MAC transmitters **20a** to **20d** and the MAC receiver **33** of the WUSB device **2**, and the MAC transmitter **50** and the MAC receiver **63** of each of the WUSB hosts **3a** to **3c** will specifically be explained.

**[0045]** The MAC transmitters **20a** to **20d** and the MAC receiver **33** of the WUSB device **2**, and the MAC transmitter **50** and the MAC receiver **63** of each of the WUSB hosts **3a** to **3c** perform transmission and reception process relating to MAC layer substantially according to WUSB standard using WiMedia standard (WiMedia Alliance, "MAC Specification: RELEASE 1.5", [online], Dec. 1, 2009, [searched on Jun. 23, 2010], internet <URL: <http://www.wimedia.org/imwp/download.asp?ContentID=16552>>).

**[0046]** In WiMedia standard, every station (WUSB device **2** and WUSB hosts **3a** to **3c**) of every super frame having a cycle of 65,536  $\mu$ s, formed of 256 media access slots (MAS) having a 256  $\mu$ s period transmits and receives a beacon to and from each other in a beacon period at the head of the frame to synchronize time of system. Every station adjusts and reserves MAS with beacon and transmits and receives data to and from the other stations with time-division using a reserved MAS period.

**[0047]** A protocol which reserves MAS is called DRP (Distributed Reservation Protocol). The beacon signal includes MAS reservation request, response information (DRP IE) and present reservation status information (DRP Availability IE). Every station can always grasp the reservation status of 256 MAS with information included in the beacon signal.

**[0048]** In the WUSB standard, the WUSB host transmits a management frame called MMC (Micro-scheduled management Command) to a WUSB device to be controlled, and each WUSB device transmits and receives data and communication response packet to and from the WUSB host at a time designated by the MMC transmitted from the WUSB host.

**[0049]** Therefore, the WUSB standard using the WiMedia standard reserves MAS which is a data transmission period of the WUSB host and MAS which is a data transmission period of the WUSB device according to DRP, and transmits and receives data with the reserved MAS.

**[0050]** The MAC transmitters **20a** to **20d** of the WUSB device **2** reserve MAS which is a data transmission period



according to DRP as the MAC transmitter **50** of the WUSB hosts **3a** to **3c** to transmit data in the same period through SDMA communication, and transmits data with the reserved MAS.

**[0051]** The MAC receiver **63** of each of the WUSB hosts **3a** to **3c**, monitors MAS data reserved by MAC transmitters **20a** to **20d** of the WUSB device **2**, and when the MAC receiver **63** detects data addressed thereto, it subjects the data to a reception process relating to MAC layer.

**[0052]** An operation example of the thus wireless access system **1** will be explained, referring to FIGS. **4** and **5**.

**[0053]** In FIG. **4**, first, the WUSB host **3a** transmits data, next, the WUSB host **3b** transmits data, and the WUSB device **2** having received the data returns a response signal (ACK) through SDMA communication.

**[0054]** In FIG. **4**, in one super frame of the WiMedia standard, DRP-A represents at least one MAS reserved by the MAC transmitter **50** of the WUSB host **3a**, DRP-B represents at least one MAS reserved by the MAC transmitter **50** of the WUSB host **3b**, and DRP-Dev represents at least one MAS reserved by the MAC transmitters **20a** to **20d** of the WUSB device **2**.

**[0055]** First, in DRP-A, the MAC transmitter **50** of the WUSB host **3a** transmits MMC (MMC-A in Fig.) including data transmission time, ACK transmission request time of the data and next MMC transmission time, and the WUSB device **2** receives this (STEP S1). The MAC transmitter **50** of the WUSB host **3a** designates time in DRP-Dev as the ACK transmission request time.

**[0056]** At the data transmission time designated by MMC, the MAC transmitter **50** of the WUSB host **3a** transmits data (Data Out-A in Fig.), and the WUSB device **2** receives this (STEP S2).

**[0057]** Next, in DRP-B, the MAC transmitter **50** of the WUSB host **3b** transmits MMC (MMC-B in Fig.) including data transmission time, ACK transmission request time of the data and next MMC transmission time, and the WUSB device **2** receives this (STEP S3). The MAC transmitter **50** of the WUSB host **3b** designates time in DRP-Dev as the ACK transmission request time.

**[0058]** At the data transmission time designated by MMC, the MAC transmitter **50** of the WUSB host **3b** transmits data (Data Out-B in Fig.), and the WUSB device **2** receives this (STEP S4).

**[0059]** Next, in DRP-Dev, at the ACK transmission request time designated by each MMC, the MAC transmitters **20a** to **20b** of the WUSB device **2** corresponding to the directional spaces **4a** and **4b** where the WUSB hosts **3a** and **3b** are located start transmitting ACK or NACK relative to the reception result of each data, and the WUSB hosts **3a** and **3b** receive ACK addressed thereto (STEP S5).

**[0060]** Each signal which represents ACK transmitted from the MAC transmitters **20a** and **20b** of the WUSB device **2** is transmitted to the directional spaces **4a** and **4b** by the SDMA transmitter **22** through the antenna elements **23a** and **23c**.

**[0061]** FIG. **5** represents an example where the WUSB host **3b** requests for data first, the WUSB host **3a** requests for data, the WUSB device **2** transmits the requested data through SDMA communication, and the WUSB hosts **3a** and **3b** return ACK relative to the data they received.

**[0062]** In FIG. **5**, in a super frame in the WiMedia standard, DRP-A represents at least one MAS reserved by the MAC transmitter **50** of the WUSB host **3a**, DRP-B represents at least one MAS reserved by the MAC transmitter **50** of the

WUSB host **3b**, and DRP-Dev represents at least one MAS reserved by the MAC transmitters **20a** to **20d** of the WUSB device **2**.

**[0063]** First, in DRP-B, the MAC transmitter **50** of the WUSB host **3b** transmits MMC (MMC-B in Fig.) including data transmission request time and next MMC transmission time including ACK relative to the data, and the WUSB device **2** receives this (STEP S11). The MAC transmitter **50** of the WUSB host **3b** designates time in DRP-Dev as the data transmission request time.

**[0064]** Next, in DRP-A, the MAC transmitter **50** of the WUSB host **3a** transmits MMC (MMC-A in Fig.) including data transmission request time and next MMC transmission time including ACK relative to the data, and the WUSB device **2** receives this (STEP S12). The MAC transmitter **50** of the WUSB host **3a** designates time in DRP-Dev as the data transmission request time.

**[0065]** Next, in DRP-Dev, at the data transmission request time designated by each MMC, the MAC transmitters **20a** to **20b** of the WUSB device **2** corresponding to the directional spaces **4a** and **4b** where the WUSB hosts **3a** and **3b** are located start transmitting each data (Data In-A and Data In-B in Fig.), and the WUSB hosts **3a** and **3b** receive ACK addressed thereto (STEP S13).

**[0066]** Each signal which represents data transmitted from the MAC transmitters **20a** and **20b** of the WUSB device **2** is transmitted to the directional spaces **4a** and **4b** by the SDMA transmitter **22** through the antenna elements **23a** and **23c**.

**[0067]** Next, in DRP-B, at the next MMC transmission time designated by MMC-B, the MAC transmitters **50** of the WUSB host **3b** transmits MMC (MMC-B (ACK) in Fig.) including ACK or NACK response showing data reception results from the WUSB device (STEP S14).

**[0068]** Next, in DRP-A, at the next MMC transmission time designated by MMC-A, the MAC transmitters **50** of the WUSB host **3a** transmits MMC (MMC-A (ACK) in Fig.) including ACK or NACK response showing data reception results from the WUSB device (STEP S15).

**[0069]** As explained above, the wireless access system **1** of the present invention transmits data from the WUSB device **2** to the WUSB hosts **3a** to **3c** through SDMA communication in upbound transmission and from the WUSB hosts **3a** to **3c** to the WUSB device **2** through TDMA communication in downbound transmission. Therefore, in multiple wireless communication between the plural WUSB hosts **3a** to **3c** and the WUSB device **2**, interference between wireless signals from the WUSB hosts **3a** to **3c** is prevented and interference wave removal process in the WUSB device **2** is not needed.

**[0070]** The wireless access system **1** of the present invention conjugately controls the plural WUSB hosts **3a** to **3c** and one WUSB device **2** using time division. Plural WUSB hosts can conjugately use a WUSB device, which is difficult for conventional WUSB standard ("Wireless Universal Serial Bus Specification Revision 1.0", [online], May 12, 2005, [searched on Jun. 23, 2010], internet <URL:http://www.usb.org/developers/wusb/wusb\_2007\_0214.zip>).

**[0071]** The wireless access system **1** of the present invention connects the WUSB device **2** such as printers, combined machines and projectors to the plural WUSB hosts **3a** to **3c** such as personal computers at the same time so that they can conjugately use the WUSB device **2**.

**[0072]** An example in which the wireless access system **1** of the present invention performs time-division duplex communication between the WUSB device **2** and the WUSB hosts **3a**

to 3c according to WiMedia standard has been explained. In the present invention, the wireless access system may perform time-division duplex communication between the WUSB device 2 and the WUSB hosts 3a to 3c using PCF (Point Coordination Function) control of WLAN (Wireless Local Area Network).

[0073] An example in which communication between the WUSB device 2 and the WUSB hosts 3a to 3c is made by time-division duplex communication has been explained, and in the present invention, the wireless access system of the present invention may perform frequency-division duplex communication between the WUSB device 2 and the WUSB hosts 3a to 3c.

[0074] Additional modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced other than as specifically described herein.

[0075] This document claims priority and contains subject matter related to Japanese Patent Application No. 2010-157591 filed on Jul. 12, 2010, the entire contents of which are herein incorporated by reference.

What is claimed is:

- 1. A wireless access system, comprising: plural wireless control stations; and a wireless terminal device to transmit and receive data to and from the plural wireless control stations, wherein each wireless control station adjusts to every other wireless control station to reserve data transmission periods that do not overlap with those of the other wireless control stations and transmits data in the reserved periods, and the wireless terminal device transmits data to at least one of the wireless control stations using space-division multiple access communication.
- 2. The wireless access system of claim 1, wherein the wireless terminal device adjusts to the plural wireless control stations to reserve a data transmission period that does not overlap with those of the plural wireless control stations, and transmits data in the reserved period.
- 3. The wireless access system of claim 2, wherein the wireless terminal device previously reserves a time band for

performing space-division multiple access communication so as not to overlap with a transmission period of at least one of the wireless control stations and notifies each of the wireless control stations of the time band,

each of the wireless control stations requests the wireless terminal device under its control to transmit data and a response signal so as to be included in a time band reported from another wireless terminal device, and the wireless terminal device transmits the data and response signal according to the transmission request from the wireless control station.

4. The wireless access system of claim 1, wherein the wireless terminal device transmits data to the wireless control station with a carrier wave having a frequency different from that of the data received from the wireless control station.

5. The wireless access system of claim 1, wherein the wireless terminal device comprises:

- a space-division multiple access transmitter to transmit different modulated signals to plural directional spaces; and
- a time-division multiple access receiver to only receive a single modulated signal.

6. A wireless terminal device to transmit and receive data to and from plural wireless control stations, comprising:

- a space-division multiple access transmitter to transmit different modulated signals to plural directional spaces; and
- a time-division multiple access receiver to only receive a single modulated signal.

7. A wireless access method, comprising: transmitting and receiving data with a wireless terminal device to and from plural wireless control stations; adjusting each of the wireless control stations to every other wireless control station to reserve data transmission periods that do not overlap with those of any other wireless control station;

transmitting data in the reserved data transmission periods; and

transmitting data from the wireless terminal device to at least one of the wireless control stations using space-division multiple access communication.

\* \* \* \* \*