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Kanemoto

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

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H04Q 5/22 (2006.01)
H04Q 9/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04Q 9/00*** (2013.01)

(58) **Field of Classification Search**
CPC G08C 17/02
USPC 340/10.1–10.5, 870.01; 455/428, 432.3, 455/557
See application file for complete search history.

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(57) **ABSTRACT**

A communication apparatus includes: a data generating unit that generates write data to be sent to any other communication apparatus at an arbitrary timing; a communication unit that repeatedly sends a read request to the other communication apparatus until the write data is generated and, at the same time, repeatedly receives a read response sent from the other communication apparatus in response to the read request; and a data acquisition unit that acquires read data, which is sent along with the read response by the other communication apparatus, when the read data is generated at an arbitrary timing by the other communication apparatus.

14 Claims, 7 Drawing Sheets

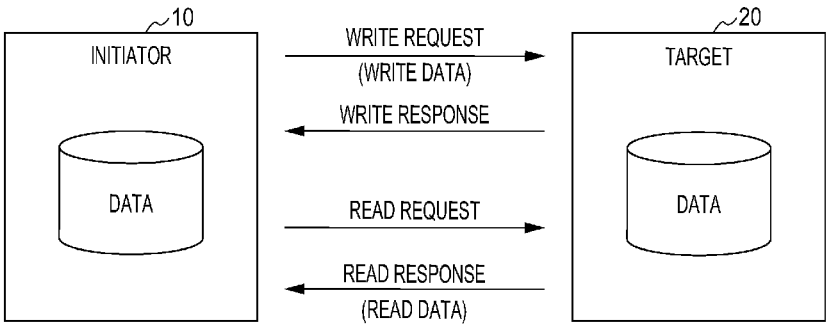

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FIG. 1

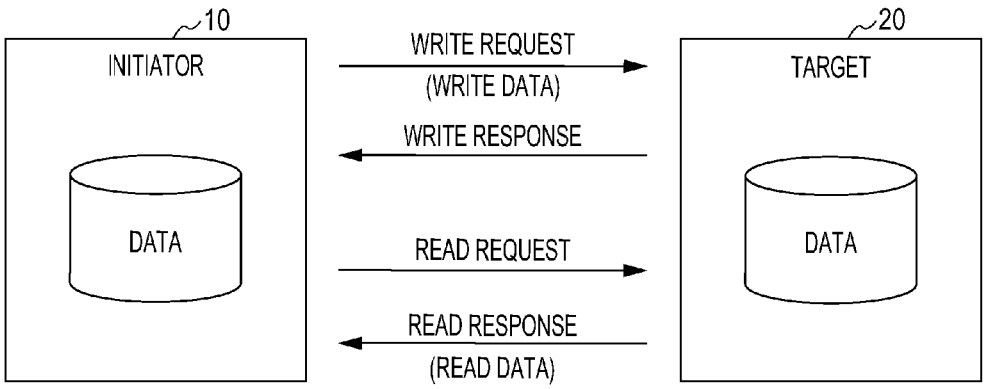

10
INITIATOR
DATA
WRITE REQUEST
(WRITE DATA)
WRITE RESPONSE
READ REQUEST
READ RESPONSE
(READ DATA)
20
TARGET
DATA

FIG. 2

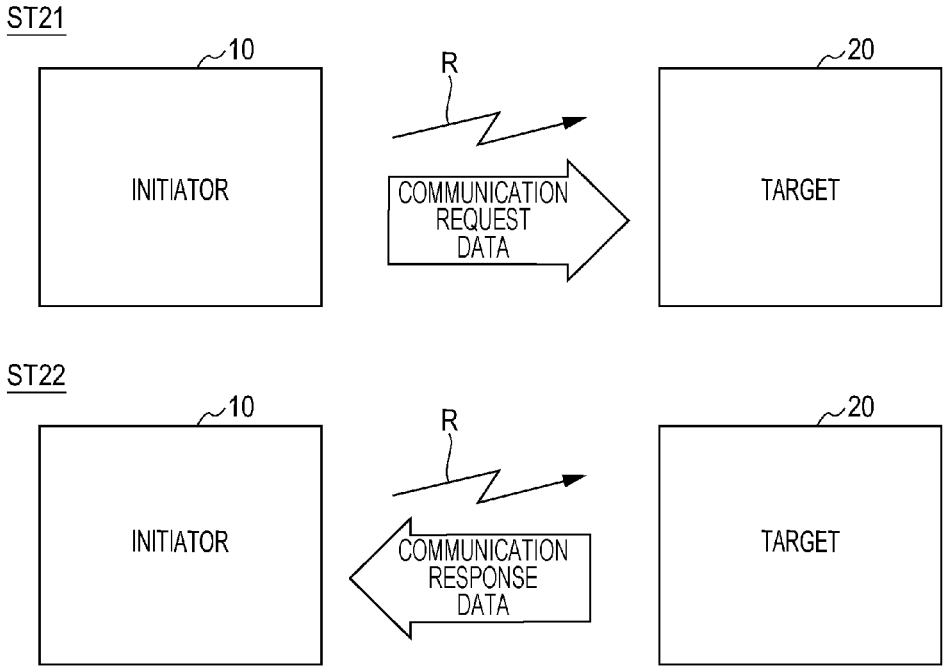

ST21
10
INITIATOR
R
COMMUNICATION
REQUEST
DATA
20
TARGET
ST22
10
INITIATOR
R
COMMUNICATION
RESPONSE
DATA
20
TARGET

FIG. 3

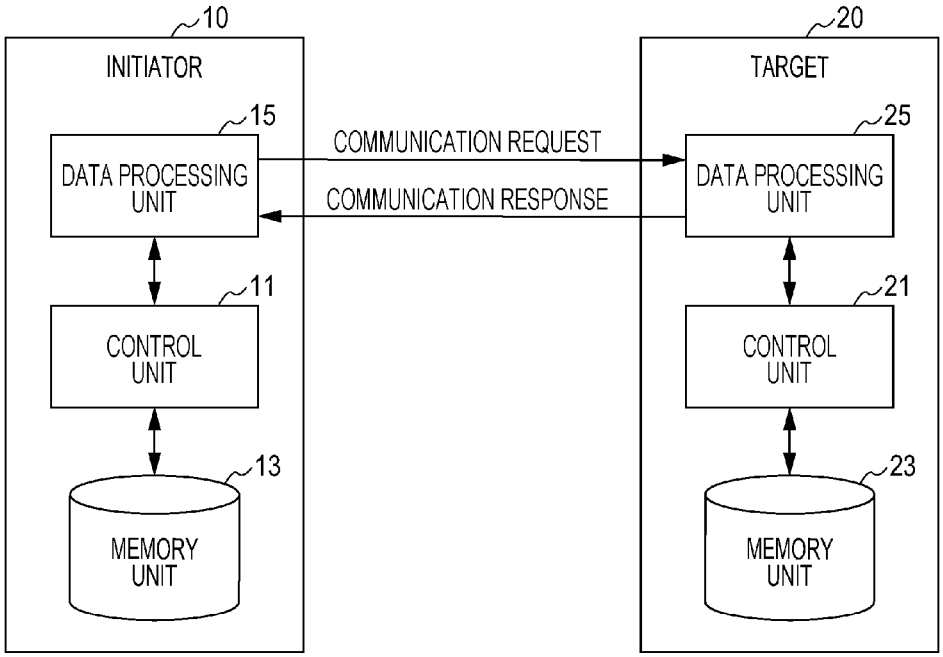

10
INITIATOR
15
DATA PROCESSING UNIT
11
CONTROL UNIT
13
MEMORY UNIT
COMMUNICATION REQUEST
COMMUNICATION RESPONSE
20
TARGET
25
DATA PROCESSING UNIT
21
CONTROL UNIT
23
MEMORY UNIT

FIG. 4

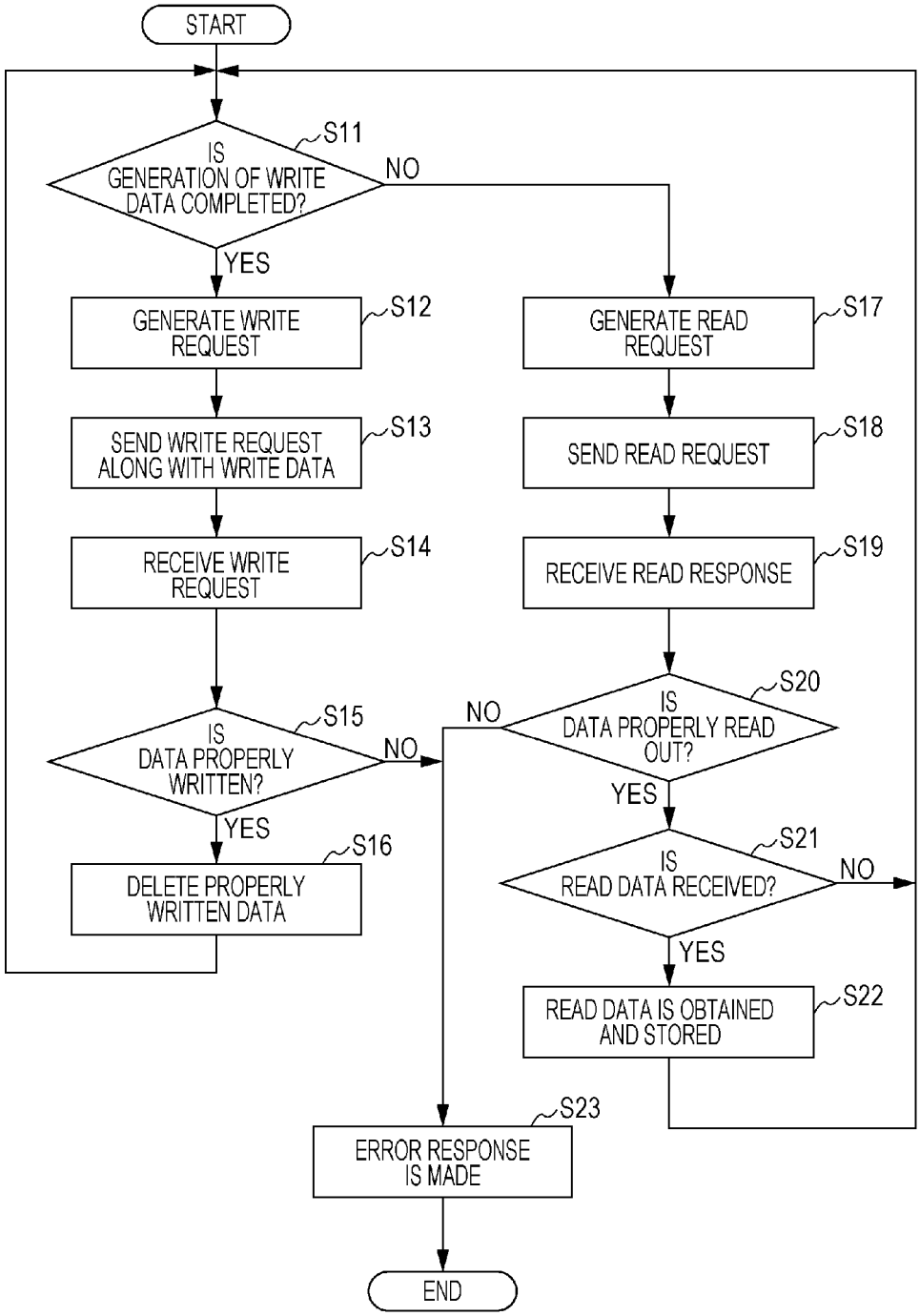

START
S11
IS GENERATION OF WRITE DATA COMPLETED?
NO
YES
GENERATE WRITE REQUEST
S12
SEND WRITE REQUEST ALONG WITH WRITE DATA
S13
RECEIVE WRITE REQUEST
S14
IS DATA PROPERLY WRITTEN?
S15
NO
YES
DELETE PROPERLY WRITTEN DATA
S16
GENERATE READ REQUEST
S17
SEND READ REQUEST
S18
RECEIVE READ RESPONSE
S19
IS DATA PROPERLY READ OUT?
S20
NO
YES
IS READ DATA RECEIVED?
S21
NO
YES
READ DATA IS OBTAINED AND STORED
S22
ERROR RESPONSE IS MADE
S23
END

FIG. 5

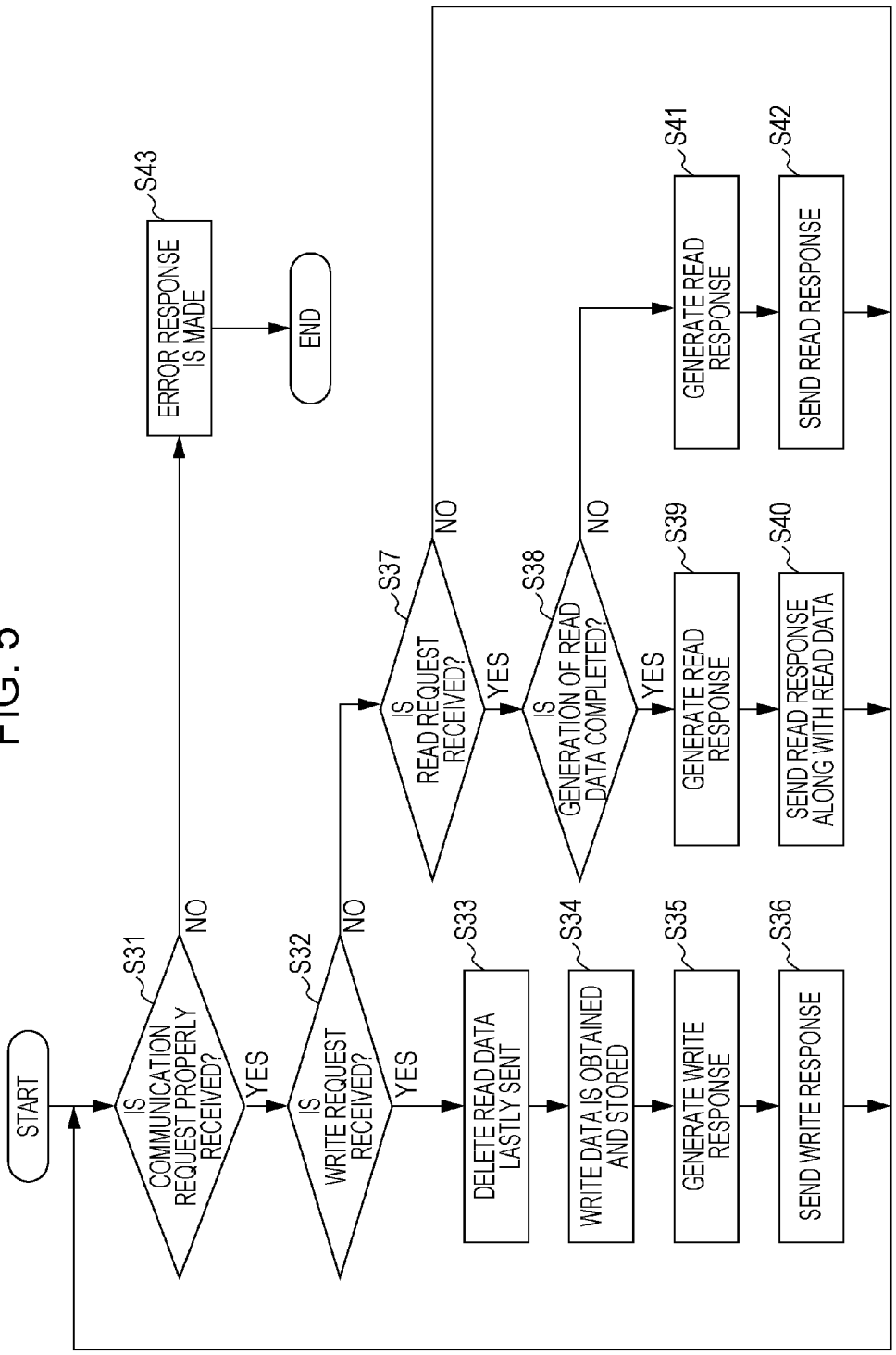

START
S31
IS COMMUNICATION REQUEST PROPERLY RECEIVED?
NO
YES
S43
ERROR RESPONSE IS MADE
END
S32
IS WRITE REQUEST RECEIVED?
NO
YES
S33
DELETE READ DATA LASTLY SENT
S34
WRITE DATA IS OBTAINED AND STORED
S35
GENERATE WRITE RESPONSE
S36
SEND WRITE RESPONSE
S37
IS READ REQUEST RECEIVED?
NO
YES
S38
IS GENERATION OF READ DATA COMPLETED?
NO
YES
S39
GENERATE READ RESPONSE
S40
SEND READ RESPONSE ALONG WITH READ DATA
S41
GENERATE READ RESPONSE
S42
SEND READ RESPONSE

FIG. 6

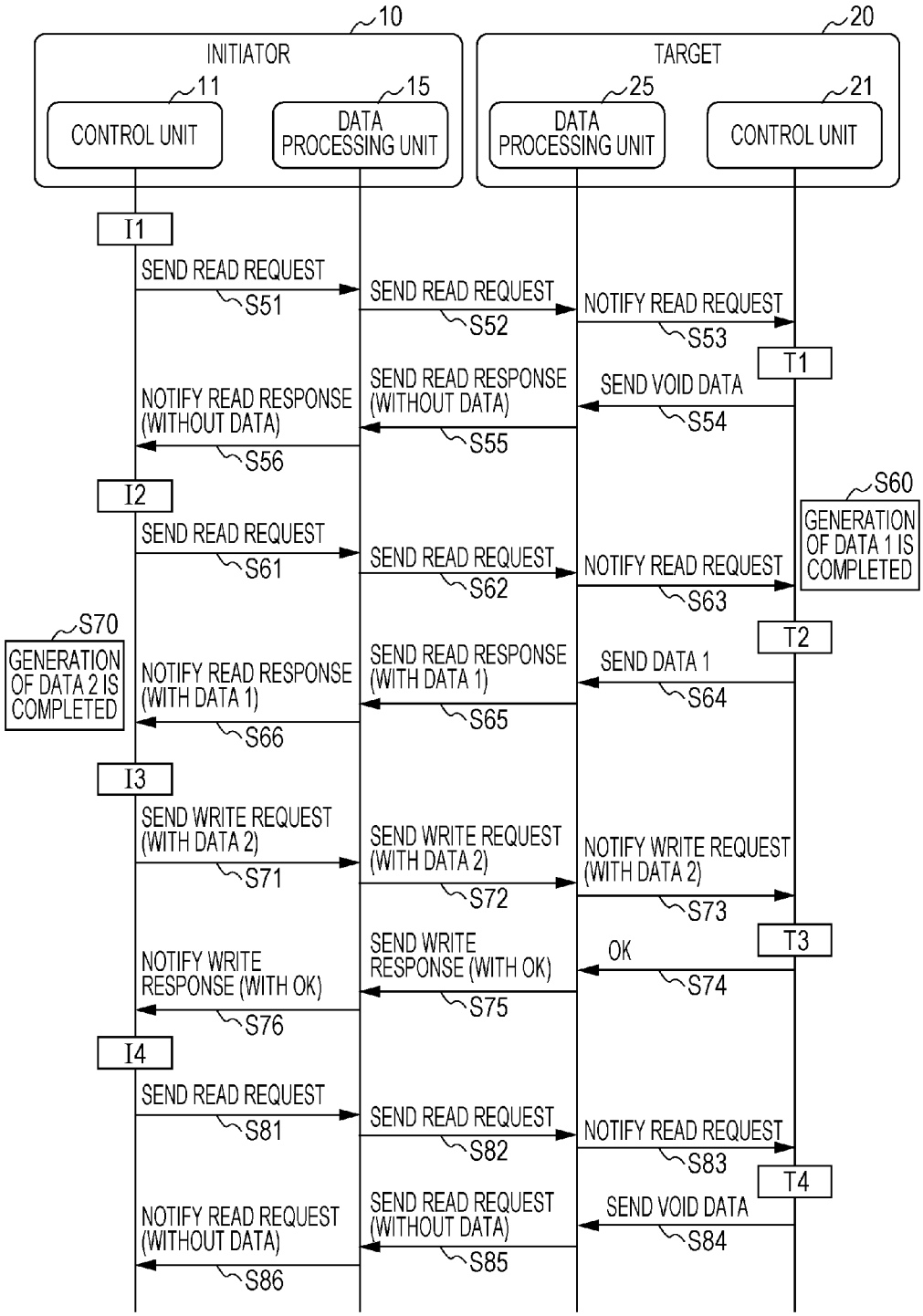

10
INITIATOR
11
CONTROL UNIT
15
DATA PROCESSING UNIT
20
TARGET
25
DATA PROCESSING UNIT
21
CONTROL UNIT
I1
SEND READ REQUEST
S51
SEND READ REQUEST
S52
NOTIFY READ REQUEST
S53
T1
SEND VOID DATA
S54
SEND READ RESPONSE (WITHOUT DATA)
S55
NOTIFY READ RESPONSE (WITHOUT DATA)
S56
I2
S60
GENERATION OF DATA 1 IS COMPLETED
SEND READ REQUEST
S61
SEND READ REQUEST
S62
NOTIFY READ REQUEST
S63
T2
S70
GENERATION OF DATA 2 IS COMPLETED
SEND DATA 1
S64
SEND READ RESPONSE (WITH DATA 1)
S65
NOTIFY READ RESPONSE (WITH DATA 1)
S66
I3
SEND WRITE REQUEST (WITH DATA 2)
S71
SEND WRITE REQUEST (WITH DATA 2)
S72
NOTIFY WRITE REQUEST (WITH DATA 2)
S73
T3
OK
S74
SEND WRITE RESPONSE (WITH OK)
S75
NOTIFY WRITE RESPONSE (WITH OK)
S76
I4
SEND READ REQUEST
S81
SEND READ REQUEST
S82
NOTIFY READ REQUEST
S83
T4
SEND VOID DATA
S84
SEND READ REQUEST (WITHOUT DATA)
S85
NOTIFY READ REQUEST (WITHOUT DATA)
S86

FIG. 7

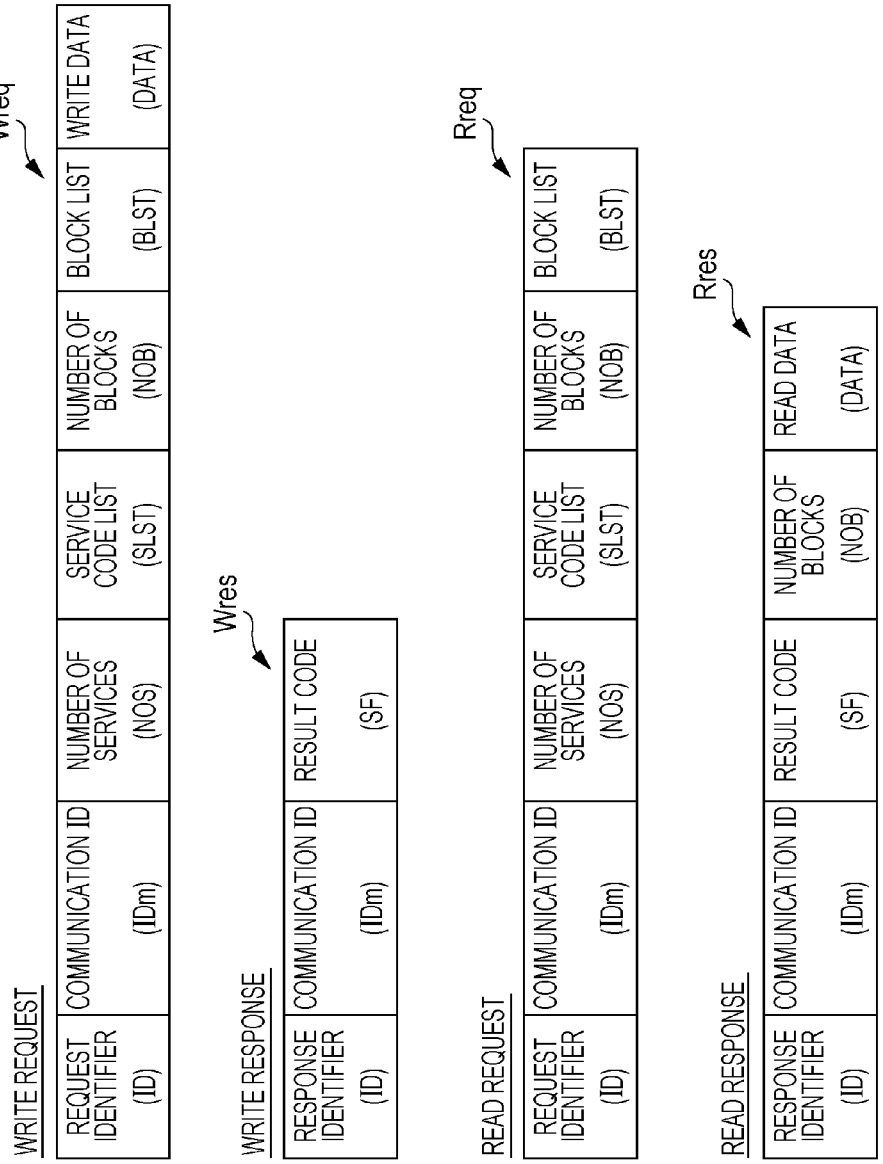
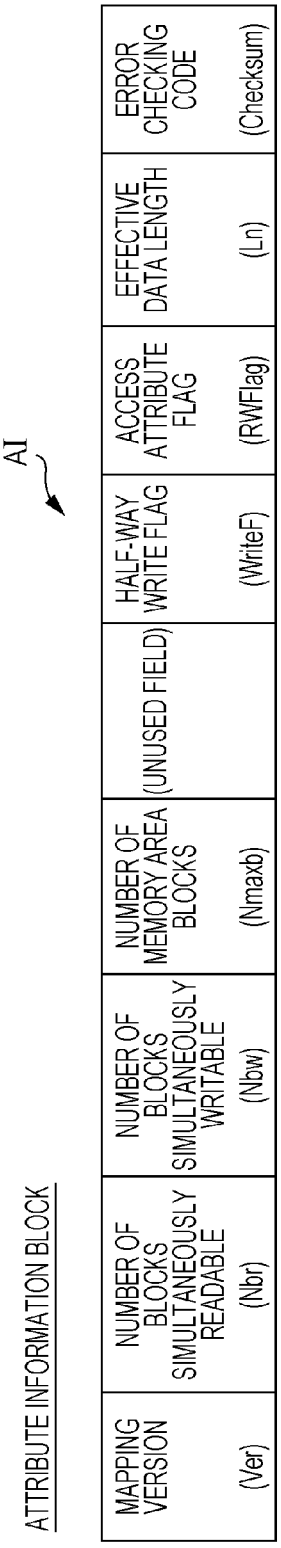

WRITE REQUEST
REQUEST IDENTIFIER (ID)
COMMUNICATION ID (IDm)
NUMBER OF SERVICES (NOS)
SERVICE CODE LIST (SLST)
NUMBER OF BLOCKS (NOB)
BLOCK LIST (BLST)
WRITE DATA (DATA)
Wreq
WRITE RESPONSE
RESPONSE IDENTIFIER (ID)
COMMUNICATION ID (IDm)
RESULT CODE (SF)
Wres
READ REQUEST
REQUEST IDENTIFIER (ID)
COMMUNICATION ID (IDm)
NUMBER OF SERVICES (NOS)
SERVICE CODE LIST (SLST)
NUMBER OF BLOCKS (NOB)
BLOCK LIST (BLST)
Rreq
READ RESPONSE
RESPONSE IDENTIFIER (ID)
COMMUNICATION ID (IDm)
RESULT CODE (SF)
NUMBER OF BLOCKS (NOB)
READ DATA (DATA)
Rres

FIG. 8


AI
ATTRIBUTE INFORMATION BLOCK
MAPPING VERSION (Ver)
NUMBER OF BLOCKS SIMULTANEOUSLY READABLE (Nbr)
NUMBER OF BLOCKS SIMULTANEOUSLY WRITABLE (Nbw)
NUMBER OF MEMORY AREA BLOCKS (Nmaxb)
(UNUSED FIELD)
HALF-WAY WRITE FLAG (WriteF)
ACCESS ATTRIBUTE FLAG (RWFlag)
EFFECTIVE DATA LENGTH (Ln)
ERROR CHECKING CODE (Checksum)

COMMUNICATION APPARATUS, COMMUNICATION SYSTEM, AND COMMUNICATION METHOD

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority from Japanese Patent Application No. JP 2011-033543 filed in the Japanese Patent Office on Feb. 18, 2011, the entire content of which is incorporated herein by reference.

BACKGROUND

The present disclosure relates to communication apparatuses, communication systems, and communication methods.

In related technologies such as those disclosed in Japanese Unexamined Patent Application Publications No. 2008-160856 and No. 2010-134672, there are some cases where passive communication between two communication apparatuses is performed in response to a communication request (one of commands) made only by one of the two communication apparatuses. In these cases, the one communication apparatus that makes the communication request works as an initiator, and the other communication apparatus works as a target.

SUMMARY

Each of the initiator and the target generates data at an arbitrary timing. Upon completing the generation of data to be sent to the target, the initiator sends a communication request to the target at an arbitrary timing and can send the data to the target. On the other hand, even if the target completes the generation of data to be sent to the initiator, it is difficult for the target to send the data to the initiator until the target receives a communication request from the initiator.

In order to resolve the above problem, a method in which a flag showing the presence or absence of data to be sent to the initiator is stored in a memory of the target and this flag information is periodically checked by the initiator is conceivable. In the above method, however, time is wasted for the initiator to confirm the presence of the flag and then send the communication request. On top of that, extra resources are used for storing the flag information and checking the flag information.

With the above-described problems in mind, embodiments of the present disclosure are intended to provide communication apparatuses, a communication system, and a communication method, in which the communication apparatus that works as a target can send data at an arbitrary timing to a communication apparatus that works as an initiator.

An embodiment of the present disclosure provides a communication apparatus including: a data generating unit that generates write data to be sent to any other communication apparatus at an arbitrary timing; a communication unit that repeatedly sends a read request to the other communication apparatus until the write data is generated and, at the same time, repeatedly receives a read response sent from the other communication apparatus in response to the read request; and a data acquisition unit that acquires read data, which is sent along with the read response by the other communication apparatus, when the read data is generated at an arbitrary timing by the other communication apparatus.

Another embodiment of the present disclosure provides a communication apparatus including: a data generating unit that generates read data to be sent to any other communication apparatus at an arbitrary timing; and a communication unit that repeatedly receives a read request sent from the other communication apparatus until write data is generated by the other communication apparatus and, at the same time, repeatedly sends a read response to the other communication apparatus in response to the read request, and sends the read data along with the read response to the other communication apparatus when the read data is generated.

Another embodiment of the present disclosure provides a communication system having a first communication apparatus and a second communication apparatus, in which the first communication apparatus includes: a data generating unit that generates write data to be sent to a second communication apparatus at an arbitrary timing; a communication unit that repeatedly sends a read request to the second communication apparatus until the write data is generated and, at the same time, repeatedly receives a read response sent from the second communication apparatus in response to the read request; and a data acquisition unit that acquires read data, which is sent along with the read response by the second communication apparatus, when the read data is generated at an arbitrary timing by the second communication apparatus, and the second communication apparatus includes: a data generating unit that generates read data to be sent to the first communication apparatus at an arbitrary timing; and a communication unit that repeatedly receives the read request sent from the first communication apparatus until the write data is generated by the first communication apparatus and, at the same time, repeatedly sends the read response to the first communication apparatus in response to the read request, and sends the read data along with the read response to the first communication apparatus when the read data is generated.

Another embodiment of the present disclosure provides a communication method including: causing a first communication apparatus to generate write data to be sent to a second communication apparatus at an arbitrary timing; causing the second communication apparatus to generate read data to be sent to the first communication apparatus at an arbitrary timing; causing the first communication apparatus to repeatedly send a read request to the second communication apparatus until the write data is generated; causing the second communication apparatus to repeatedly send a read response in response to the read request to the first communication apparatus; and causing the first communication apparatus to receive the read request and acquire the read data, which is sent along with the read response by the second communication apparatus, when the read data is generated by the second communication apparatus.

As described above, according to the embodiments of the present disclosure, two communication apparatuses, a communication system, and a communication method, in which one of the two communication apparatuses that works as a target can send data at an arbitrary timing to the other that works as an initiator, can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram showing an overview of a communication method according to an embodiment of the present disclosure;

FIG. **2** is a diagram showing passive communication performed between an initiator and a target;

FIG. **3** is a block diagram showing the functional configuration of a communication system;

FIG. **4** is a flowchart showing the operation of the initiator;

FIG. **5** is a flowchart showing the operation of the target;

FIG. **6** is a sequence diagram showing the communication method according to the embodiment of the present disclosure;

FIG. **7** is a diagram showing examples of data structures of communication requests/communication responses; and

FIG. **8** is a diagram showing an example of a data structure of an attribute information block.

DETAILED DESCRIPTION OF EMBODIMENTS

Preferred embodiments of the present disclosure will be described with reference to the accompanying drawings hereinafter. In this specification and the accompanying drawings, components that have effectively the same functional configuration are indicated by the same reference numerals and repeated description is avoided.

1. OVERVIEW OF COMMUNICATION METHOD

First, an overview of a communication method according to an embodiment of the present disclosure will be described with reference to FIG. **1**. FIG. **1** is a diagram showing an overview of a communication method according to an embodiment of the present disclosure.

As shown in FIG. **1**, the communication method according to the embodiment of the present disclosure is a communication method in which communication is performed between a first communication apparatus working as an initiator **10** and a second communication apparatus working as a target **20**. For example, the initiator **10** includes a reader/writer, and the target **20** includes an RFID (radio frequency identification) module and a host (CPU). Passive communication is performed between the initiator **10** and the target **20** in response to a communication request (one of commands) such as a write request or a read request sent by the initiator **10**.

In the communication method according to the embodiment of the present disclosure, the initiator **10** generates write data to be sent to the target **20** at an arbitrary timing, and the target **20** generates read data to be sent to the initiator **10** at an arbitrary timing. After generating write data, the initiator **10** sends a write request and the write data to the target **20**, and the target **20** acquires the write data in response to the write request.

The initiator **10** repeatedly sends a read request to the target **20** until the initiator **10** generates write data, and the target **20** repeatedly sends a read response in response to the read request to the initiator **10**. Subsequently, after the target **20** generates read data, the initiator **10** acquires the read data along with the read response sent by the target **20**.

In the above-described way, even if the target **20** does not have a notification function of issuing a communication request, the target **20** can send the read data to the initiator **10** at an arbitrary timing by sending the read data at the timing of the read data generation in response to the read request the target **20** repeatedly receives. Therefore, two-way communication can be effectively performed between the initiator **10** and the target **20** in synchronization with the timing of the read data generation or the write data generation.

2. CONFIGURATION OF COMMUNICATION SYSTEM

Next, a configuration of a communication system according to the embodiment of the present disclosure will be described with reference to FIG. **2** and FIG. **3**. FIG. **2** is a diagram showing passive communication performed between the initiator **10** and the target **20**.

As shown in FIG. **2**, passive communication is performed between the initiator **10** and the target **20** in compliance with an NFC (near field communication) protocol or the like. The NFC protocol is a protocol for short range wireless communication that employs electromagnetic induction phenomenon and uses a single frequency carrier, for example, 13.56 MHz in the ISM (industrial, scientific and medical) band. Short range wireless communication is communication performed between two communication apparatuses spaced apart from each other by about several tens of centimeters, and this type of wireless communication includes communication performed between two communication apparatuses that are contacting each other.

In the NFC, communication is performed in a passive mode or in an active mode. In a passive mode, as shown in FIG. **2**, communication is performed in such a way that one communication apparatus works as the initiator **10**, and the other works as the target **20**. The initiator **10** sends a communication request (one of commands) to the target **20**, and the target **20** sends a communication response (one of responses) to the initiator **10** in response to the communication request. The initiator **10** sends the communication request and data to the target **20** by modulating an electromagnetic wave R (used as a carrier wave) generated by the initiator **10** itself (in the state ST**21**), and the target **20** sends the communication response and data to the initiator **10** by load-modulating the electromagnetic wave R (used as the carrier wave) generated by the initiator **10** (in the state ST**22**).

FIG. **3** is a block diagram showing the functional configuration of the communication system. As shown in FIG. **3**, the communication system includes the initiator **10** and the target **20**.

The initiator **10** includes a controller and a reader/writer connected to the controller (neither is shown). The controller can be a personal computer, a PDA, a mobile phone, a consumer electronics device, or the like. Alternatively, the controller can be a CPU mounted in the above devices. The target **20** includes a host (CPU) and an RFID module connected to the host (neither is shown). The host can be a personal computer, a PDA, a mobile phone, a consumer electronics device, or the like. Alternatively, the host can be a CPU mounted in the above devices. The controller and the reader/writer are connected to each other via a communication interface. The host and the RFID are also connected to each other via a communication interface.

The first communication apparatus working as the initiator **10** includes a control unit **11**, a memory unit **13**, and a data processing unit **15**. The control unit **11** works as a data generating unit and a data acquisition unit, and the data processing unit **15** works as a communication unit. FIG. **3** shows that the controller unit **11**, the memory unit **13**, and the data processing unit **15** included in the initiator **10** are configured as an all-one-unit, but each of these units can be provided as a separate unit.

The control unit **11** generates write data to be sent to the target **20** at an arbitrary timing. The controller **11** judges whether the generation of the write data is completed or not, and, if completed, generates a write request, and controls the

data processing unit **15** so that the write request as well as the write data is sent to the target **20**. The controller **11** repeatedly generates a read request until the write data is generated, and controls the data processing unit so that the read request is sent to the target **20**. In addition, the control unit **11** controls the data processing unit **15** so that the data processing unit **15** acquires read data along with a read response sent from the target **20** when the target **20** generates the read data. In addition, the control unit **11** stores the acquired read data in the memory unit **13**.

The data processing unit **15** sends the write request along with the write data to the target **20** and also sends the read request to the target **20** by sending an electromagnetic wave that the data processing unit **15** modulates with the use of an antenna coil or the like. In addition, the data processing unit **15** receives a write response from the target **20** and also receives the read response along with the read data from the target **20** by receiving an electromagnetic wave load-modulated by the target **20**. The data processing unit **15** repeatedly sends the read request to the target **20** until the write data is generated, and sends the write request along with the write data to the target **20** when the write data is generated.

The second communication apparatus working as the target **20** includes a control unit **21**, a memory unit **23**, and a data processing unit **25**. The control unit **21** works as a data generating unit and a data acquisition unit, and the data processing unit **25** works as a communication unit. FIG. **3** shows that the controller unit **21**, the memory unit **23**, and the data processing unit **25** included in the target **20** are configured as an all-one-unit, but each of these units can be provided as a separate unit.

Upon receiving the write request, the control unit **21** acquires the write data sent by the initiator **10** along with the write request, and stores the write data in the memory unit **23**. In addition, the control unit **21** controls the data processing unit **25** so that the write response is sent to the initiator **10**. The control unit **21** generates the read data to be sent to the initiator **10** at an arbitrary timing. Upon receiving the read request, the controller **21** judges whether the generation of the read data is completed or not, and, if completed, controls the data processing unit **25** so that the read response is sent to the initiator **10**. The control unit controls the data processing unit **25** so that the data processing unit **25** sends the read response as well as the read data to the initiator **10** when the generation of the read data is completed, and sends the read response to the initiator **10** when the generation of the read data is not completed.

The data processing unit **25** receives the write request along with the write data sent from the initiator **10** and also receives the read request sent from the initiator **10** by receiving the electromagnetic wave that is modulated with the use of the antenna coil or the like. In addition, the data processing unit **25** sends the write response to the initiator **10** and also sends the read response to the initiator by load-modulating and sending the electromagnetic wave sent by the initiator **10**. The data processing unit **25** sends the read data as well as the read response to the initiator **10** when the generation of the read data is completed, and sends only the read response to the initiator **10** when the generation of the read data is not completed.

3. OPERATION OF COMMUNICATION SYSTEM

Next, the procedure of data communication performed between the initiator **10** and the target **20** will be described with reference to FIG. **4** to FIG. **6**. FIG. **4** is a flowchart showing the operation of the initiator **10**, and FIG. **5** is a flowchart showing the operation of the target **20**. In the following description, it will be assumed that a short range wireless communication link is established between the initiator **10** and the target **20** through a polling request and a polling response.

The control unit **11** of the initiator **10** generates write data at an arbitrary timing. The write data is data that is sent from the initiator **10** to the target **20** so that the data is stored in the target **20**. As shown in FIG. **4**, the control unit **11** judges whether the generation of the write data is completed or not (at step S**11**). The control unit **11** performs write processing at step S**12** to step S**16** when the generation of the write data to be sent to the target **20** is completed ("Yes" at step S**11**), and performs read processing at step S**17** to step S**22** when the generation of the write data to be sent to the target **20** is not completed ("No" at step S**11**).

In the write processing, the control unit **11** generates a write request as a communication request (at step S**12**). The write request is generated in order for the initiator **10** to request the target **20** to write data. The control unit **11** supplies the write request and the write data to the data processing unit **15**. The write data can be directly supplied to the data processing unit **15** by the control unit **11**, or can be supplied after being read out from the memory **13** by the control unit **11**.

The data processing unit **15** sends the write request and the write data to the target **20** (at step S**13**), and receives a write response sent from the target **20** in response to the write request (at step S**14**). The write data can be sent in the form of being included in the write request, or can be sent independently of the write request. The write response is generated by the target **20** in order for the target to inform the initiator **10** of the result of the data writing. The data processing unit **15** supplies the received write response to the control unit **11**.

The control unit **11** judges whether the data is properly written into the target **20** or not on the basis of the write response (at step S**15**). If it is judged that the data is properly written ("Yes" at step S**15**), the control unit **11** deletes the data, which is stored in the memory unit **13** and has already been written into the target **20**, from the memory unit **13** (at step S**16**). If it is not judged that the data is properly written ("No" at step S**15**), the control unit **11** makes an error response (at step S**23**). In this error response, the control unit **11** can cause the flow to go back to the process at step S**12** to restart the write processing, or can cause the flow to go back to the process at step S**11** to judge whether the generation of the write data is completed or not.

On the other hand, in the read processing, the control unit **11** generates a read request as a communication request (at step S**17**). The read request is generated in order for the initiator **10** to request the target **20** to read out data. The control unit **11** supplies the read request to the data processing unit **15**.

The data processing unit **15** sends the read request to the target **20** (at step S**18**), and receives a read response sent from the target **20** in response to the read request (at step S**19**). The read response is generated by the target **20** in order for the target **20** to inform the initiator **10** of the result of the data reading. The data processing unit **15** supplies the received read response to the control unit **11**.

In this case, the data processing unit **15** receives read data along with the read response sent from the target **20** when the generation of the read data is completed by the target **20**, that is, when the generation of the read data to be sent to the initiator **10** is completed by the target **20** that has already

received the read request from the initiator **10**. On the other hand, the data processing unit **15** does not receive the read data from the target **20** when the generation of the read data is not completed by the target **20**. The read data can be received in the form of being included in the read response, or can be received independently of the read response.

The control unit **11** judges whether the data is properly read out by the target **20** or not on the basis of the read response (at step S**20**). If it is judged that the data is properly read out ("Yes" at step S**20**), the control unit **11** judges whether the data processing unit **15** receives the read data or not (at step S**21**). If it is not judged that the data is properly read ("No" at step S**20**), the control unit **11** makes an error response (at step S**23**). In this error response, the control **11** can cause the flow to go back to the process at step S**17** to restart the read processing, or can cause the flow to go back to the process at step S**11** to judge whether the generation of the write data is completed or not. If the data processing unit **15** has received the read data ("Yes" at step S**21**), the control unit **11** acquires the read data from the data processing unit **15**, and stores the read data in the memory unit **13** (at step S**22**).

In addition, even if the generation of the read data is not completed by the target **20**, the data processing unit **15** can receive dummy data along with the read response sent from the target **20**. The dummy data is essentially not data to be sent to the initiator **10**, and it is data useless for the initiator **10**. Again in this case, the dummy data can be received in the form of being included in the read response, or can be received independently of the read response.

After the process at step S**16**, the process at step S**22**, or when the data processing unit **15** has not received the read data ("No" at step S**21**), the control unit **11** restarts the process at step S**11**. The control unit **11** repeatedly performs the above-described processes as long as the short range wireless communication link is established between the initiator **10** and the target **20**.

The control unit **21** of the target **20** receives a communication request (one of commands) from the reader/writer via the data processing unit **25**. As shown in FIG. **5**, the control unit **21** judges whether the communication request is properly received or not (at step S**31**). If it is judged that the communication request is properly received ("Yes" at step S**31**), the control unit **21** performs the following processes. If it is not judged that the communication request is properly received ("No" at step S**31**), the control unit **21** makes an error response (at step S**43**). The control unit **21** performs write processing at step S**33** to step S**36** when receiving a write request ("Yes" at step S**32**), and performs read processing at step S**38** to step S**42** when receiving a read request ("Yes" at step S**37**).

In the write processing, the control unit **21** deletes the read data that has been last sent to the initiator **10** as well as the last read response from the memory unit **13** (at step S**33**). The above process is performed because the fact that the write request is received by the control unit **21** means that the last read processing has been successfully completed between the initiator **10** and the target **20**. The control unit **21** acquires write data as well as the write request, which is received by the data processing unit **25**, from the data processing unit **25**, and stores the write data in the memory unit **23** (at step S**34**). The control unit **21** supplies the result of the data writing to the data processing unit **25**. The data processing unit **25** generates a write response including the result of the data writing (at step S**35**), and sends the write response to the initiator **10** (at step S**36**).

In the read processing, the control unit **21** judges whether the generation of read data to be sent is completed or not (at step S**38**). Here, the control unit **21** generates the read data at an arbitrary timing. The read data is data to be sent from the target **20** so that the read data is read out by the initiator **10**.

When the generation of the read data is completed ("Yes" at step S**38**), that is, when the generation of the read data to be sent to the initiator **10** is completed, the control unit **21** supplies the result of the data reading along with the read data to the data processing unit **25**. The data processing unit **25** generates a read response including the result of the data reading (at step S**39**), and sends the read response along with the read data to the initiator **10** (at step S**40**). The read data can be sent in the form of being included in the read response, or can be sent independently of the read response. On the other hand, when the generation of the read data is not completed ("No" at step S**38**), the control unit **21** supplies the result of the data reading to the data processing unit **25**. The data processing unit **25** generates a read response including the result of the data reading (at step S**41**), and sends the read response to the initiator **10** (at step S**42**).

In addition, even if the generation of the read data is not completed, the data processing unit **25** can send dummy data along with the read response to the initiator **10**. Again in this case, the dummy data can be sent in the form of being included in the read response, or can be sent independently of the read response.

After the processes at step S**36**, step S**40** and step S**42**, the control unit **21** makes the flow to go back to the step S**31** to restart the operation of the target **20**. The control unit **21** repeatedly performs the above-described processes as long as the short range wireless communication link is established between the initiator **10** and the target **20**.

FIG. **6** is a sequence diagram showing a communication method according to the embodiment of the present disclosure. In the following description, it will be assumed that a short range wireless communication link is established between the initiator **10** and the target **20** through a polling request and a polling response.

An example of the sequence diagram in FIG. **6** shows four timings I**1**, I**2**, I**3**, and I**4** in the control unit **11** of the initiator **10**, and it will be assumed that write data (data **2**) is generated just before a timing I**3** (at step S**70**). In addition, there are four timings T**1**, T**2**, T**3**, and T**4** in the control unit **21** of the target **20**, and it will be assumed that read data (data **1**) is generated just before a timing T**2** (at step S**60**).

First, because the generation of write data is not completed by the control unit **11** of the initiator **10** before the timing I**1**, the initiator **10** generates read request and supplies the read request to the data processing unit **15** (at step S**51**). The data processing unit **15** sends the read request to the target **20** (at step S**52**).

The data processing unit **25** of the target **20** receives the read request, and notifies the control unit **21** of the read request (at step S**53**). Because the generation of read data is not completed by the control unit **21** before the timing T**1**, the control unit **21** supplies void data or dummy data to the data processing unit **25** (at step S**54**). The data processing unit **25** generates read response, and sends the read response along with the void data or dummy data to the initiator **10** (at step S**55**).

The data processing unit **15** of the initiator **10** receives the read response, and notifies the control unit **11** of the read response (at step S**56**). In this case, the data processing unit

15 can supply the read response without no read data, or can supply the read response with the dummy data to the control unit 11.

Next, because the generation of write data is not completed by the control unit 11 of the initiator 10 before the timing I2, the initiator 10 generates read request and supplies the read request to the data processing unit 15 (at step S61). The data processing unit 15 sends the read request to the target 20 (at step S62).

The data processing unit 25 of the target 20 receives the read request, and notifies the control unit 21 of the read request (at step S63). Because the generation of read data (data 1) is completed by the control unit 21 before the timing T2 (at step S60), the control unit 21 supplies the read data to the data processing unit 25 (at step S64). The data processing unit 25 generates read response, and sends the read response along with the read data to the initiator 10 (at step S65).

The data processing unit 15 of the initiator 10 receives the read response, and notifies the control unit 11 of the read response (at step S66). In this case, the data processing unit 15 supplies the read data to the control unit 11, and the control unit 11 acquires the read data to store the read data in the memory unit 13. As a result, the read data is read out from the target 20 by the initiator 10.

Next, because the generation of write data (data 2) is completed by the control unit 11 of the initiator 10 before the timing I3 (at step S70), the control unit 11 generates write request and supplies the write request as well as the write data to the data processing unit 15 (at step S71). The data processing unit 15 sends the write request as well as the write data to the target 20 (at step S72).

Upon receiving the write request, the data processing unit 25 of the target 20 notifies the control unit of the write request and sends the write data to the control unit 21 (at step S73). The control unit 21 acquires the write data to store the write data in the memory unit 23, and notifies the data processing unit 25 of the result of the data writing (OK) (at step S74). As a result, the write data is written in the target 20 by the initiator 10. The data processing unit 25 generates write response, and sends the write response to the initiator 10 (at step S75).

The data processing unit 15 of the initiator 10 receives the write response, and notifies the control unit 11 of the write response (at step S76).

Next, because the generation of write data is not completed by the control unit 11 of the initiator 10 before the timing I4, the control unit 11 generates read request and supplies the read request to the data processing unit 15 (at step S81). The data processing unit 15 sends the read request to the target 20 (at step S82).

Upon receiving the read request, the data processing unit 25 of the target 20 notifies the control unit 21 of the read request (at step S83). Because the generation of read data is not completed by the control unit 21 before the timing T4, the control unit 21 supplies void data or dummy data to the data processing unit 25 (at step S84). The data processing unit 25 generates read response, and sends the read response along with the void data or dummy data to the initiator 10 (at step S85).

The data processing unit 15 of the initiator 10 receives the read response, and notifies the control unit 11 of the read response (at step S86). In this case, the data processing unit 15 can supply the read response without no read data, or can supply the read response with the dummy data to the control unit 11.

The above description about FIG. 6 has been made in the case where the read processing and the write processing are performed in this order. However, even in the case where the write processing and the read processing are performed in this order, or in the case where the same processing is successively performed, the same description as above can be made. In each of the above cases, read processing is repeatedly performed between the initiator 10 and the target 20 until the initiator 10 generates write data.

4. EXAMPLE OF COMMUNICATION SYSTEM

The following description will be made about the case where the above-described communication method is applied to a short range wireless communication compliant with Type 3 Tag Operation specification defined by the NFC forum (registered trademark).

FIG. 7 is a diagram showing examples of data structures of communication requests/communication responses. A write request is equivalent to an "Updated Command" defined by the specification, and its data structure Wreq includes fields for a request identifier (ID), a communication ID (IDm), the number of services (NOS), a service code list (SLST), the number of blocks (NOB), a block list (BLST), and write data (DATA). The write request with this data structure Wreq that includes write data is sent from the initiator 10 to the target 20. A write response is equivalent to an "Updated Response" defined by the specification, and its data structure Wreq includes fields for a response identifier (ID), a communication ID (IDm), and a result code (SF).

Upon receiving a write request, the data processing unit 25 of the target 20 extracts the request identifier, the number of blocks, the block list, and the write data of the write request, and supplies them to the control unit 21. Here, the number of blocks and the block list respectively indicate the number of blocks and the block codes of write data to be written in the target 20. After the write processing is completed, the control unit 21 supplies a result code showing the result of the data writing to the data processing unit 25. Here, the result code indicates whether the write processing is successfully completed or not. The data processing unit 25 generates a write response including data of a response identification and a communication ID, and sends the write response along with the result code to the initiator 10.

A read request is equivalent to a "Check Command" defined by the specification, and its data structure Rreq includes fields for a request identifier (ID), a communication ID (IDm), the number of services (NOS), a service code list (SLST), the number of blocks (NOB), a block list (BLST). A read response is equivalent to a "Check Response" defined by the specification, and its data structure Rres includes fields for a response identifier (ID), a communication ID (IDm), a result code (SF), the number of blocks (NOB), and read data (DATA). The read response with this data structure Rres that includes read data is sent from the target 20 to the initiator 10.

Upon receiving a read request, the data processing unit 25 of the target 20 extracts the request identifier, the number of blocks, and the block list of the read request, and supplies them to the control unit 21. Here, the number of blocks and the block list respectively indicate the number of blocks and the block codes of read data to be read out from the target 20. After the read processing is completed, the control unit 21 supplies a result code, the number of blocks, and the read data to the data processing unit 25. Here, the result code indicates whether the read processing is successfully com-

pleted or not, and the number of blocks indicates the block number of the read data. The data processing unit **25** generates a read response including a response identification, a communication ID, the number of blocks, the read data, and sends the read response along with the result code to the initiator **10**.

FIG. **8** is a diagram showing an example of a data structure of an attribute information block. As shown in FIG. **8**, the data structure AI of the attribute information block includes fields for a mapping version (Ver), the number of blocks simultaneously readable (Nbr), the number of blocks simultaneously writable (Nbw), the number of memory area blocks (Nmaxb), a half-way write flag (WriteF), an access attribute flag (RWFlag), an effective data length (Ln), and an error checking code (Checksum).

Upon receiving a read request, the target **20** updates the effective data length field and the error checking code field of the attribute information block, and supplies them along with a read response to the initiator **10**. In this case, when the target **20** generates read data, the effective data length field is updated with the data length of the read data. When the target **20** does not generate read data, the effective data length field is updated with the value of "0". Upon receiving the attribute information block along with the read response, the target **20** reads out plural pieces of data whose number is designated by the value in the effective data length field from the read data field of the read response.

5. CONCLUSION

As described above, according to the communication system and communication method of the present disclosure, the target **20** can send read data to the initiator **10** at an arbitrary timing through responding at the timing of the read data generation in response to a read request that the target repeatedly receives even if it does not have the notification function of communication request. Therefore, a two-way communication can be effectively performed between the initiator **10** and the target **20** in synchronization with the timing of data generation.

Although the detailed descriptions have been made about the preferred embodiments of the present disclosure with reference to the accompanying drawings, the present disclosure is not to be restricted by the above-described embodiments. It will be obvious that those skilled in the art of the present disclosure can easily conceive of various alterations and modifications of the above embodiments of the present disclosure within the scope of the technical ideas described in the following claims, and it is to be understood that such alterations and modifications naturally fall within the technical scope of the present disclosure.

For example, the descriptions of the above embodiments of the present disclosure have been made under the assumption that the control unit **11** of the initiator **10** and the control unit **21** of the target **20** respectively judge whether the generation of the write data and the generation of read data are successfully completed or not. However, whether the generation of the write data and the generation of read data are successfully completed or not can be judged respectively by the data processing unit **15** of the initiator **10** and by the data processing unit **25** of the target **20**. In this case, after the data processing units **15** and **25** are respectively notified of the generations of the write data and the read data by the control units **11** and **21**, these processing units judge whether the generations of the write data and the read data are successfully completed or not.

What is claimed is:

1. A communication apparatus comprising:

a data generating unit for generating write data to be sent to another communication apparatus at an arbitrary timing;

a communication unit for repeatedly sending a read request to the other communication apparatus until the write data is generated and, at the same time, for repeatedly receiving a read response sent from the other communication apparatus in response to the read request; and

a data acquisition unit for acquiring read data, which is sent along with the read response by the other communication apparatus, when the read data is generated at an arbitrary timing by the other communication apparatus,

in which only after the read data has been fully generated and after receipt of a respective read request after the read data has been fully generated, the other communication apparatus sends the read data for acquisition by the data acquisition unit of the communication apparatus, such that the other communication apparatus sends the fully generated read data to the communication apparatus without having to issue a notification communication to the communication apparatus indicating that the read data has been fully generated prior to sending the fully generated read data thereto, and

in which communication between the communication apparatus and the other communication apparatus, including all of the sending of the read request by the communication unit, all of the sending and receiving of the read response, and all of the sending and receiving of the read data, is by way of a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communication (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

2. The communication apparatus according to claim **1**, in which when the write data is completely generated, the communication unit is configured to send the write data along with a write request for receipt by the other communication apparatus and to not send the read request for receipt by the other communication apparatus.

3. The communication apparatus according to claim **2**, in which after the write data and the write request are sent and a response is received indicating that the write data has been properly written to the other communication, the communication apparatus is configured to start sending the read request for receipt by the other communication apparatus.

4. A communication apparatus comprising:

a data generating unit for generating read data to be sent to another communication apparatus at an arbitrary timing; and

a communication unit for repeatedly receiving a read request sent from the other communication apparatus until write data is generated by the other communication apparatus and, at the same time, for repeatedly sending a read response to the other communication apparatus in response to the read request, and for sending the read data along with the read response to the other communication apparatus when the read data is generated,

in which only after the read data has been fully generated and after receipt of a respective read request after the read data has been fully generated, the communication apparatus sends the read data for receipt by the other

communication apparatus, such that the communication apparatus is configured to send the fully generated read data to the other communication apparatus without having to issue a notification communication to the other communication apparatus indicating that the read data has been fully generated prior to sending the fully generated read data thereto, and

in which communication between the communication apparatus and the other communication apparatus, including all of the sending of the read response by the communication unit, all of the sending and receiving of the read request, and all of the sending and receiving of the read data, is by way of a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communication (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

5. A communication system comprising:

a first communication apparatus that includes:

a data generating unit for generating write data to be sent to a second communication apparatus at an arbitrary timing;

a communication unit for repeatedly sending a read request to the second communication apparatus until the write data is generated and, at the same time, for repeatedly receiving a read response sent from the second communication apparatus in response to the read request; and

a data acquisition unit for acquiring read data, which is sent along with the read response by the second communication apparatus, when the read data is generated at an arbitrary timing by the second communication apparatus, and

the second communication apparatus includes:

a data generating unit for generating read data to be sent to the first communication apparatus at an arbitrary timing; and

a communication unit for repeatedly receiving the read request sent from the first communication apparatus until the write data is generated by the first communication apparatus and, at the same time, for repeatedly sending the read response to the first communication apparatus in response to the read request, and for sending the read data along with the read response to the first communication apparatus when the read data is generated,

in which only after the read data has been fully generated and after receipt of a respective read request after the read data has been fully generated, the communication unit of the second communication apparatus sends the read data for receipt by the first communication apparatus, such that the second communication apparatus is configured to send the fully generated read data to the first communication apparatus without having to issue a notification communication to the first communication apparatus indicating that the read data has been fully generated prior to sending the fully generated read data thereto, and

in which communication between the first communication apparatus and the second communication apparatus, including all of the sending and receiving of the read request, all of the sending and receiving of the read response, and all of the sending and receiving of the read data, is by way of a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communication (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

6. A communication method comprising:

causing a first communication apparatus to generate write data to be sent to a second communication apparatus at an arbitrary timing;

causing the second communication apparatus to generate read data to be sent to the first communication apparatus at an arbitrary timing;

causing the first communication apparatus to repeatedly send a read request to the second communication apparatus until the write data is generated;

causing the second communication apparatus to repeatedly send a read response in response to the read request to the first communication apparatus; and

causing the first communication apparatus to receive the read response and acquire the read data, which is sent along with the read response by the second communication apparatus, when the read data is generated by the second communication apparatus,

in which only after the read data has been fully generated and after receipt of a respective read request after the read data has been fully generated, the second communication apparatus sends the read data for receipt by the first communication apparatus, such that the second communication apparatus sends the fully generated read data to the first communication apparatus without having to issue a notification communication to the first communication apparatus indicating that the read data has been fully generated prior to sending the fully generated read data thereto, and

in which communication between the first communication apparatus and the second communication apparatus, including all of the sending and receiving of the read request, all of the sending and receiving of the read response, and all of the sending and receiving of the read data, is by way of a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communication (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

7. A communication apparatus to communicate with other communication apparatus via short range wireless communication, said communication apparatus comprising:

a data generating unit for generating write data to be sent to another communication apparatus at an arbitrary timing; and

a communication unit for repeatedly sending a read request via the short range wireless communication to the other communication apparatus until the write data is generated and, for repeatedly receiving a read response via the short range wireless communication from the other communication apparatus in response to the read request,

when the write data has been generated, the communication unit is configured to send the write data instead of the read request via the short range wireless communication to the other communication apparatus, and

all of the short range wireless communication between the communication apparatus and the other communication apparatus is a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communi-

cation (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

8. The communication apparatus according to claim **7**, further comprising a data acquisition unit for acquiring read data, which is sent along with the read response by the other communication apparatus, when the read data is generated by the other communication apparatus.

9. The communication apparatus according to claim **7**, wherein, the communication unit is configured to repeatedly send the read request to the other communication apparatus after establishing communication with the other communication apparatus.

10. A communication apparatus to communicate with other communication apparatus via short range wireless communication, said communication apparatus comprising:

a data generating unit for generating read data to be sent to another communication apparatus at an arbitrary timing;

a communication unit for repeatedly receiving a read request sent via the short range wireless communication from the other communication apparatus until write data is generated by the other communication apparatus and, for repeatedly sending a read response via the short range wireless communication to the other communication apparatus in response to the read request; and

a data acquisition unit for acquiring read data, which is sent via the short range wireless communication along with the read response by the other communication apparatus, when the read data is generated by the other communication apparatus,

all of the short range wireless communication between the communication apparatus and the other communication apparatus is a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communication (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

11. A communication apparatus to communicate with other communication apparatus via short range wireless communication, said communication apparatus comprising:

a data generating unit for generating read data to be sent to another communication apparatus at an arbitrary timing; and

a communication unit for repeatedly receiving a read request sent via the short range wireless communication from the other communication apparatus until write data is generated by the other communication apparatus and, for repeatedly sending a read response via the short range wireless communication to the other communication apparatus in response to the read request,

wherein the communication unit is configured to send the read data via the short range wireless communication along with the read response to the other communication apparatus when the read data is generated, and

all of the short range wireless communication between the communication apparatus and the other communication apparatus is a single type of communication technology with a single type of protocol which is passive communication in compliance with a near field communication (NFC) protocol for communication apparatuses spaced within approximately several tens of centimeters of each other.

12. The communication apparatus according to claim **11**, wherein, on receiving a write request sent from the other communication apparatus, the communication apparatus is configured to delete the read data sent to the other communication apparatus along with the last read response.

13. The communication apparatus according to claim **11**, wherein, the communication unit is configured to receive the write data from the other communication apparatus after establishing communication with the other communication apparatus, when the write data is generated by the other communication apparatus.

14. The communication apparatus according to claim **11**, wherein, the communication unit is configured to repeatedly send a read response to the other communication apparatus in response to the read request, when the read data is not generated.

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