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(54) **COMMUNICATION DEVICE, COMMUNICATION NETWORK SYSTEM, AND COMMUNICATION METHOD**

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CPC ***H04W 28/04*** (2013.01)

(57) **ABSTRACT**

A transmission device, which is a communication device that transmits a message, transmits a message including a freshness value composed of a high-order digit counted up every time a message is started and a low-order digit counted up every time a message is transmitted. The reception device, which is a communication device that receives a message, receives the message on condition that the freshness value included in the received message is larger than the stored freshness value. The transmission device transmits the first message including the freshness value of the maximum value when the reading of the high-order digit fails at the time of activation. Then, the transmission device transmits, after the first message, the second message including the freshness value equal to or greater than the minimum value and less than the maximum value.

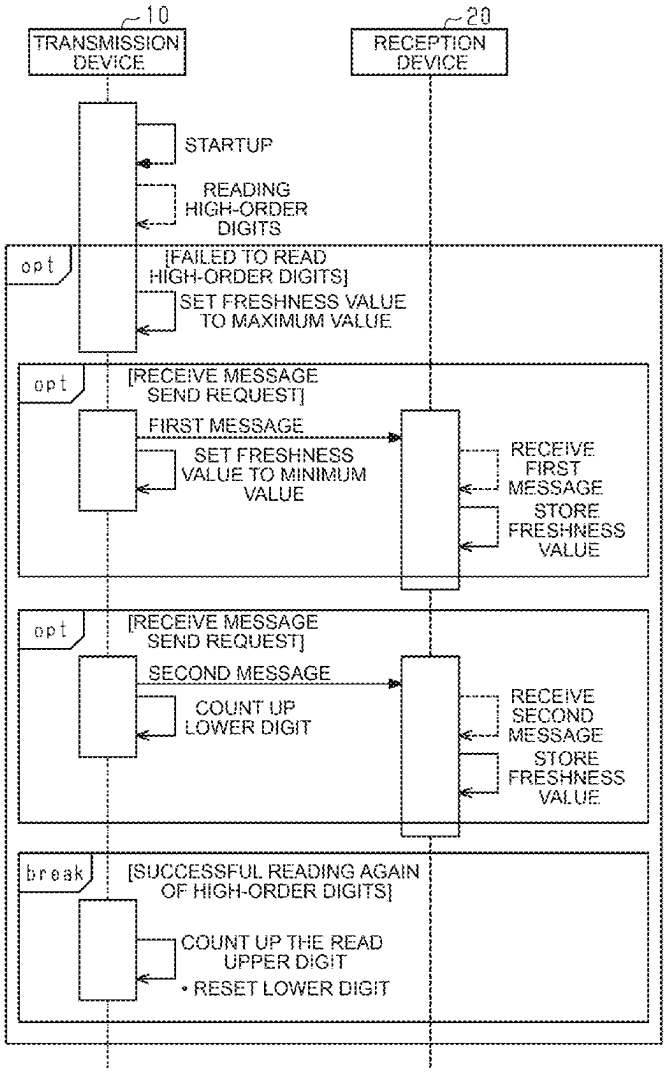


FIG. 1

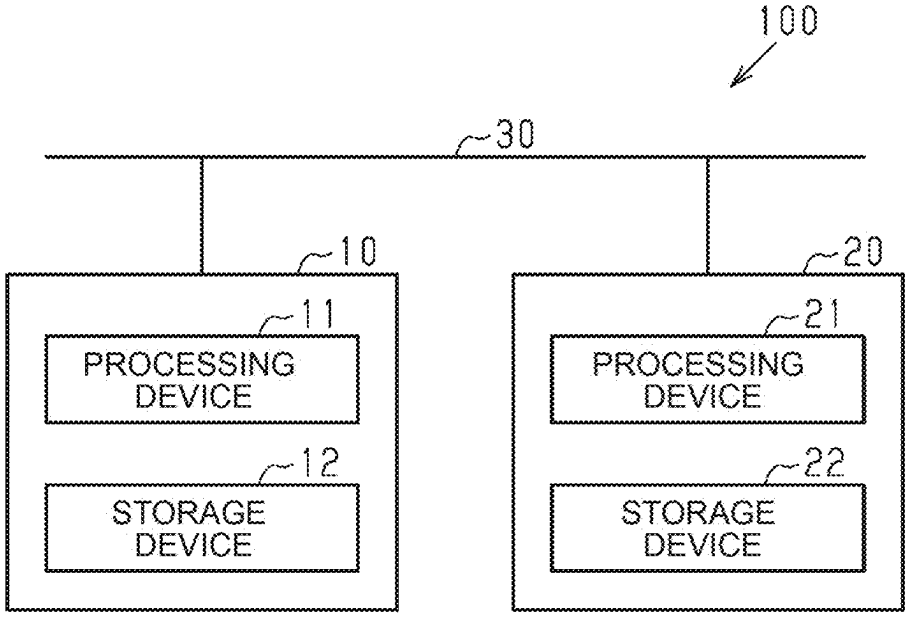

100
30
10
11
PROCESSING DEVICE
12
STORAGE DEVICE
20
21
PROCESSING DEVICE
22
STORAGE DEVICE

FIG. 2

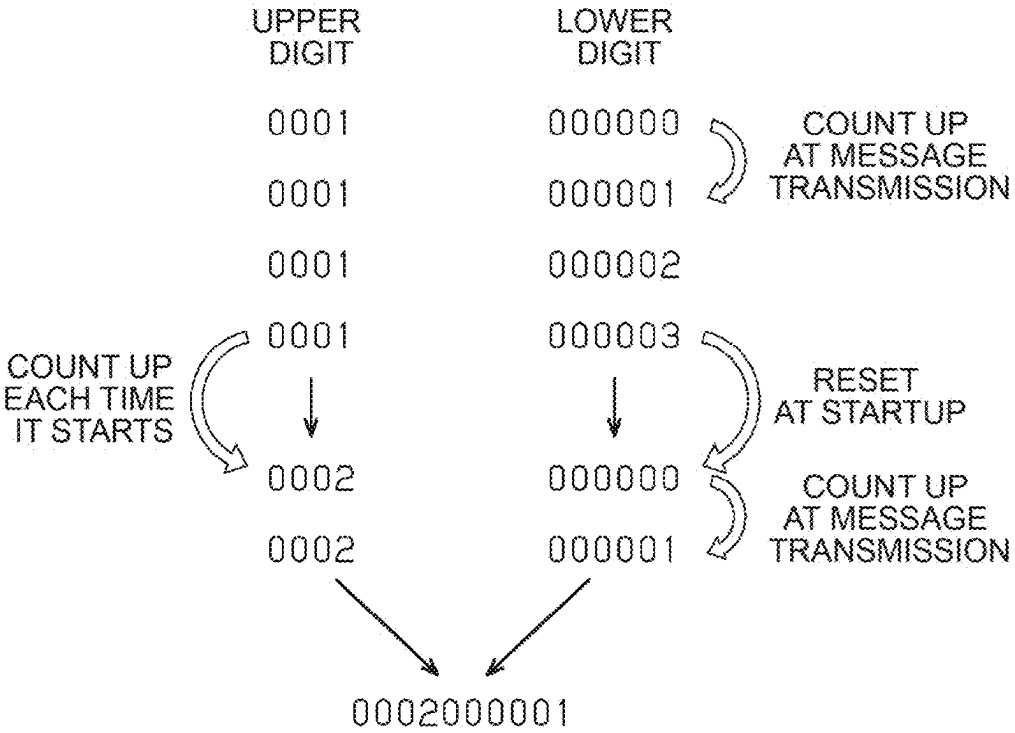

UPPER DIGIT
LOWER DIGIT
0001
000000
COUNT UP AT MESSAGE TRANSMISSION
0001
000001
0001
000002
COUNT UP EACH TIME IT STARTS
0001
000003
RESET AT STARTUP
0002
000000
COUNT UP AT MESSAGE TRANSMISSION
0002
000001
0002000001

FIG. 3

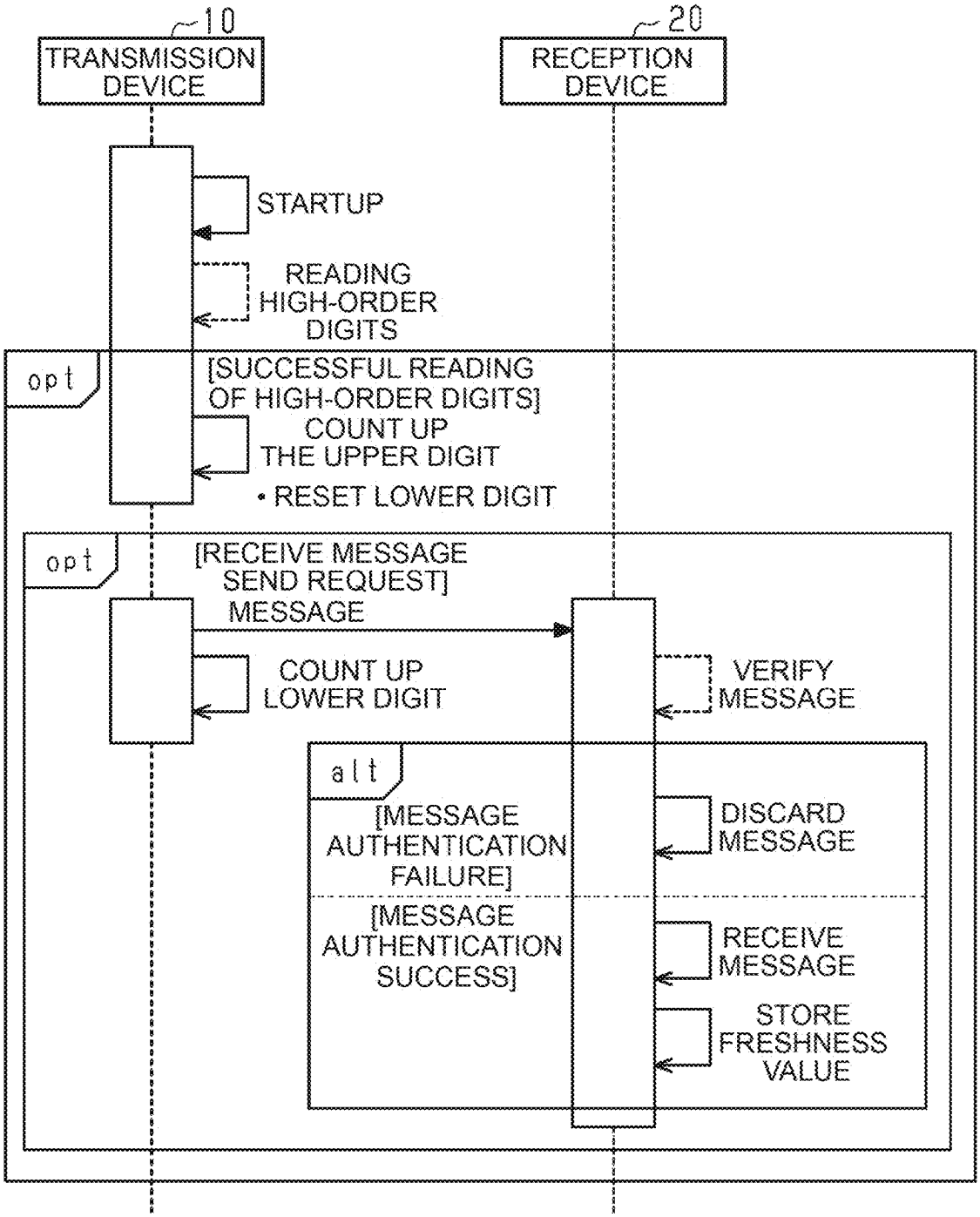
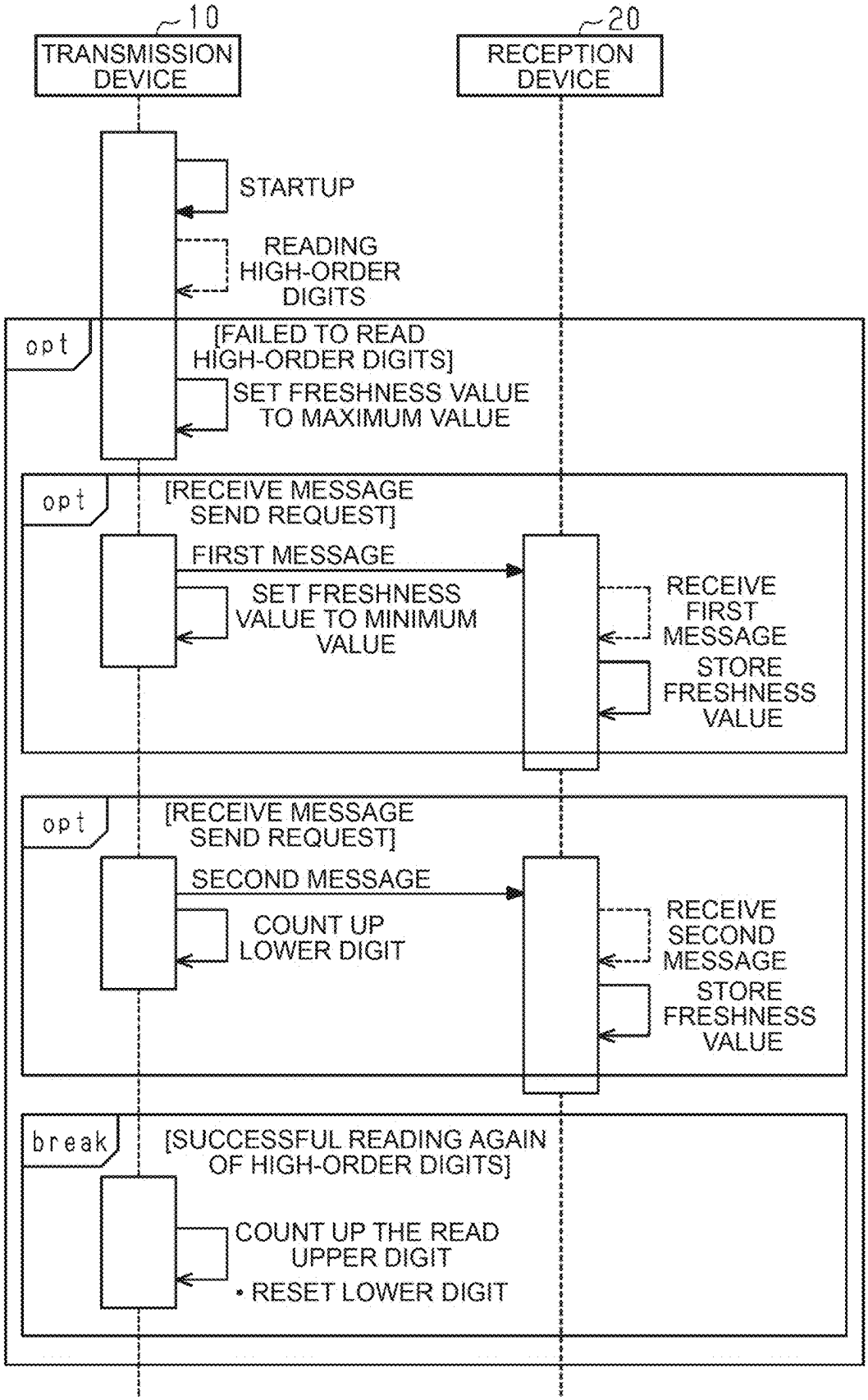

10
TRANSMISSION DEVICE
20
RECEPTION DEVICE
STARTUP
READING HIGH-ORDER DIGITS
opt
[SUCCESSFUL READING OF HIGH-ORDER DIGITS]
COUNT UP THE UPPER DIGIT
• RESET LOWER DIGIT
opt
[RECEIVE MESSAGE SEND REQUEST]
MESSAGE
COUNT UP LOWER DIGIT
VERIFY MESSAGE
alt
[MESSAGE AUTHENTICATION FAILURE]
DISCARD MESSAGE
[MESSAGE AUTHENTICATION SUCCESS]
RECEIVE MESSAGE
STORE FRESHNESS VALUE

FIG. 4


10
TRANSMISSION DEVICE
20
RECEPTION DEVICE
STARTUP
READING HIGH-ORDER DIGITS
opt
[FAILED TO READ HIGH-ORDER DIGITS]
SET FRESHNESS VALUE TO MAXIMUM VALUE
opt
[RECEIVE MESSAGE SEND REQUEST]
FIRST MESSAGE
SET FRESHNESS VALUE TO MINIMUM VALUE
RECEIVE FIRST MESSAGE
STORE FRESHNESS VALUE
opt
[RECEIVE MESSAGE SEND REQUEST]
SECOND MESSAGE
COUNT UP LOWER DIGIT
RECEIVE SECOND MESSAGE
STORE FRESHNESS VALUE
break
[SUCCESSFUL READING AGAIN OF HIGH-ORDER DIGITS]
COUNT UP THE READ UPPER DIGIT
• RESET LOWER DIGIT

COMMUNICATION DEVICE, COMMUNICATION NETWORK SYSTEM, AND COMMUNICATION METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-022076 filed on Feb. 16, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a communication device, a communication network system, and a communication method.

2. Description of Related Art

[0003] Japanese Unexamined Patent Application Publication No. 2012-169829 (JP 2012-169829 A) describes a communication network system. The communication network system includes a plurality of communication devices. In the communication network system, the communication devices exchange messages with each other.

[0004] In the message exchange between the communication devices, the communication device that transmits the message transmits the message including a freshness value. The freshness value includes a high-order digit that is counted up every time the communication device is activated, and a low-order digit that is counted up every time a message is transmitted.

[0005] In the message exchange between the communication devices, the communication device that receives the message from another communication device checks the freshness value included in the message. The communication device accepts the message when the received freshness value is larger than the freshness value included in the message that has been accepted before receiving the message.

SUMMARY

[0006] In order to count up the high-order digit of the freshness value, the communication device reads, at the time of activation, the high-order digit stored at the time of shutdown. At this time, the communication device may fail to read the high-order digit. In this case, the communication device cannot assign an appropriate freshness value to the message. Therefore, the communication device cannot transmit a message including an appropriate freshness value to another communication device while the communication device fails to read the high-order digit.

[0007] A communication device according to a first aspect of the present disclosure is a transmission-side communication device that transmits a message in a communication network system.

[0008] The communication network system includes a plurality of communication devices. In exchange of a message between the communication devices in the communication network system,
the transmission-side communication device transmits the message including a predetermined range of a freshness value including a high-order digit that is counted up every time the transmission-side communication device is activated and a low-order digit that is counted up every time the message is transmitted.
In the exchange of the message between the communication devices in the communication network system,
a reception-side communication device that receives the message accepts the message under a condition that the freshness value included in the received message is larger than the freshness value that is stored.
The reception-side communication device stores the freshness value included in the accepted message.
The reception-side communication device
accepts, when the message including the freshness value that is a maximum value is received, the message including the freshness value that is smaller than the maximum value and received after the message including the freshness value that is the maximum value.
The transmission-side communication device includes
a processing device.
When the transmission-side communication device fails to read the high-order digit at a time of activation,
the processing device transmits a first message including the freshness value that is the maximum value.
The processing device transmits, after the first message, a second message including the freshness value that is equal to or larger than a minimum value and smaller than the maximum value.

[0009] A communication network system according to a second aspect of the present disclosure includes
a plurality of communication devices.
In exchange of a message between the communication devices in the communication network system,
a transmission-side communication device that transmits the message transmits the message including a predetermined range of a freshness value including a high-order digit that is counted up every time the transmission-side communication device is activated and a low-order digit that is counted up every time the message is transmitted.
In the exchange of the message between the communication devices in the communication network system,
a reception-side communication device that receives the message accepts the message under a condition that the freshness value included in the received message is larger than the freshness value that is stored.
The reception-side communication device stores the freshness value included in the accepted message.
The reception-side communication device accepts, when the message including the freshness value that is a maximum value is received, the message including the freshness value that is smaller than the maximum value and received after the message including the freshness value that is the maximum value.
In the communication network system, the transmission-side communication device transmits, when failing to read the high-order digit at a time of activation, a first message including the freshness value that is the maximum value.
In the communication network system, the transmission-side communication device transmits, after the first message, a second message including the freshness value that is equal to or larger than a minimum value and smaller than the maximum value.

[0010] A communication method according to a third aspect of the present disclosure is applied to a transmission-side communication device that transmits a message in a

communication network system. The communication network system includes a plurality of communication devices.

In exchange of a message between the communication devices in the communication network system,

the transmission-side communication device

transmits the message including a predetermined range of a freshness value including a high-order digit that is counted up every time the transmission-side communication device is activated and a low-order digit that is counted up every time the message is transmitted.

In the exchange of the message between the communication devices in the communication network system,

a reception-side communication device that receives the message

accepts the message under a condition that the freshness value included in the received message is larger than the freshness value that is stored.

The reception-side communication device stores the freshness value included in the accepted message.

The reception-side communication device accepts, when the message including the freshness value that is a maximum value is received, the message including the freshness value that is smaller than the maximum value and received after the message including the freshness value that is the maximum value.

The communication method includes causing the transmission-side communication device to transmit, when failing to read the high-order digit at a time of activation, a first message including the freshness value that is the maximum value. The communication method includes causing the transmission-side communication device to transmit, after the first message, a second message including the freshness value that is equal to or larger than a minimum value and smaller than the maximum value.

[0011] With the communication device, the communication network system, and the communication method, it is possible to transmit the message including the appropriate freshness value even when failing to read the high-order digit of the freshness value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

[0013] FIG. **1** is a schematic diagram illustrating a configuration of a communication network system including a communication device according to an embodiment;

[0014] FIG. **2** is an explanatory diagram illustrating a freshness value included in a message transmitted by the communication device according to the embodiment;

[0015] FIG. **3** is a sequence diagram illustrating an aspect of communication in the communication network system when the communication device of the embodiment succeeds in reading the high-order digit of the freshness value; and

[0016] FIG. **4** is a sequence diagram illustrating an aspect of communication in the communication network system in a case where the communication device of the embodiment fails to read the high-order digit of the freshness value.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] Hereinafter, an embodiment of a communication device will be described with reference to FIG. **1** to FIG. **4**.

[0018] A configuration of the communication network system **100** will be described. As illustrated in FIG. **1**, the communication network system **100** includes a plurality of communication devices. Specifically, the communication network system **100** includes a transmission device **10** and a reception device **20** as communication devices. The communication network system **100** is applied to, for example, a vehicle. The transmission device **10** and the reception device **20** in the communication network system **100** are, for example, electronic control devices provided in a vehicle.

[0019] As illustrated in FIG. **1**, the transmission device **10** and the reception device **20** are connected to each other via a communication bus **30**. The transmission device **10** transmits a message to the reception device **20** through the communication bus **30**. That is, the transmission device **10** is a transmission-side communication device that transmits a message in the exchange of messages between the communication devices. On the other hand, the reception device **20** is a communication device on the reception side that receives a message in the exchange of messages between the communication devices.

[0020] As illustrated in FIG. **1**, the transmission device **10** includes a processing device **11** and a storage device **12**. A program is stored in the storage device **12**. The processing device **11** executes programs stored in the storage device **12** to execute various processes. The processing device **11** includes a processor.

[0021] As illustrated in FIG. **1**, the reception device **20** includes a processing device **21** and a storage device **22**. A program is stored in the storage device **22**. The processing device **21** executes programs stored in the storage device **22** to execute various processes. The processing device **21** includes a processor.

Summary of Freshness Values

[0022] The transmission device **10** transmits a message including the freshness value to the reception device **20**. FIG. **2** illustrates a freshness value included in a message transmitted by the transmission device **10**.

[0023] As illustrated in FIG. **2**, the freshness value includes a high-order digit and a low-order digit.

As illustrated in FIG. **2**, the transmission device **10** counts up the upper digit of the freshness value at the time of activation. That is, the upper digit of the freshness value is counted up every time the transmission device **10** is activated.

[0024] As illustrated in FIG. **2**, the transmission device **10** counts up the lower digit of the freshness value at the time of transmission of the message. That is, the lower digit of the freshness value is counted up every time the transmission device **10** transmits a message.

[0025] As illustrated in FIG. **2**, the transmission device **10** resets the lower digit of the freshness value at the time of activation. That is, the lower digit of the freshness value is reset each time the transmission device **10** is activated.

[0026] The freshness value is formed by combining the upper digit and the lower digit. As shown in the lower part of FIG. **2**, for example, when the upper digit is "0002" and the lower digit is "000001", the freshness value included in the message is "0002000001".

[0027] The higher the upper digit, the higher the freshness value. When the upper digits are the same, the higher the lower digit, the higher the freshness value. In the communication network system **100**, the upper digit has a minimum value of "0001" and a maximum value of "9999". In the communication network system **100**, the lower digit has a minimum value of "000000" and a maximum value of "999999". Therefore, in the communication network system **100**, the minimum value of the freshness value is "0001000000". In the communication network system **100**, the maximum value of the freshness value is "9999999999". Thus, there is a predetermined range of freshness values. Flow of Communication When Transmission Device **10** Succeeds in Reading High-Order Digit

[0028] FIG. **3** and FIG. **4** illustrate aspects of communication in a communication network system **100**. In FIG. **3** and FIG. **4**, the processing device **11** executes the processing executed by the transmission device **10**. In FIG. **3** and FIG. **4**, the processing performed by the reception device **20** is performed by the processing device **21**.

[0029] As described above, the upper digit of the freshness value is counted up every time it is started. Therefore, when stopping the operation, the transmission device **10** stores the high-order digit of the freshness value included in the message transmitted by itself in the storage device **12**. Then, the transmission device **10** reads the high-order digit of the freshness value stored in the storage device **12** at the time of activation. At this time, the transmission device **10** may fail to read the high-order digit of the freshness value. FIG. **3** shows a specific example of the mode of communication in the communication network system **100** when the transmission device **10** succeeds in reading the high-order digit of the freshness value. On the other hand, FIG. **4** shows a specific example of the mode of communication in the communication network system **100** when the transmission device **10** fails to read the high-order digit of the freshness value.

[0030] First, with reference to FIG. **3**, an aspect of communication in the communication network system **100** in a case where the transmission device **10** succeeds in reading the high-order digit of the freshness value will be described. As shown in the upper part of FIG. **3**, the transmission device **10** reads the upper digit of the freshness value after the activation. The transmission device **10** is activated, for example, when the ignition switch of the vehicle is turned on.

[0031] As illustrated in the upper part of FIG. **3**, when the reading of the high-order digit is successful, the transmission device **10** counts up the high-order digit of the freshness value. At this time, the transmission device **10** counts up the high-order digit that has been successfully read in the manner described with reference to FIG. **2**. On the other hand, the transmission device **10** resets the lower digit of the freshness value. In this way, when the reading of the high-order digit is successful, the freshness value is set to a value consisting of the high-order digit counted up and the low-order digit reset to the minimum value.

[0032] As illustrated in the lower part of FIG. **3**, the transmission device **10** transmits a message when receiving a message transmission request. For example, the transmission device **10** transmits a message when it receives a message requesting transmission of a message from the reception device **20**. In the lower part of FIG. **3**, the transmission device **10** transmits a message including the freshness value set in the upper part of FIG. **3**.

[0033] As illustrated in the lower part of FIG. **3**, the transmission device **10** counts up the lower digit of the freshness value after transmitting the message. At this time, the transmission device **10** counts up the lower digit of the freshness value in the manner described with reference to FIG. **2**.

[0034] As illustrated in the lower part of FIG. **3**, the reception device **20** that has received the message verifies the received message. The reception device **20** verifies the integrity of the received message by verifying the message. That is, the reception device **20** confirms whether or not the message is correctly transmitted from the transmission device **10**, whether or not the message is affected by a cyber attack or the like, and the like through the verification of the message.

[0035] When the reception device **20** confirms the integrity of the received message through the verification of the message, the authentication of the message is successful. On the other hand, when the integrity of the received message cannot be confirmed through the verification of the message, the reception device **20** fails to authenticate the message.

[0036] The reception device **20** verifies the message based on the freshness value included in the received message. As will be described later, when the received message is successfully authenticated, the reception device **20** stores the freshness value included in the message in the storage device **22**. The reception device **20** verifies the message by comparing the magnitude of the freshness value included in the received message with the freshness value stored in the storage device **22**.

[0037] For example, the reception device **20** stores the freshness value included in the latest message in the message that has been successfully authenticated in the storage device **22**. Then, when the freshness value included in the received message is larger than the freshness value stored in the storage device **22**, the reception device **20** succeeds in authenticating the message.

[0038] In a case where the transmission device **10** continuously transmits a message, the reception device **20** may receive a message in an order different from the order in which the transmission device **10** transmitted the message. In such a situation, the reception device **20** may store the freshness value included in the plurality of messages that have been successfully authenticated in the storage device **22**.

[0039] For example, the reception device **20** stores, in the storage device **22**, a freshness value included in five messages counted from the latest message for the message that has been successfully authenticated. The freshness value stored in the reception device **20** is not limited to five. Thereafter, the reception device **20** compares the minimum freshness value stored in the storage device **22** with the freshness value included in the received message. If the freshness value included in the received message is greater than the minimum freshness value, the reception device **20** checks whether the freshness value included in the received message is the same as any freshness value stored in the storage device **22**. That is, the reception device **20** checks whether the freshness value included in the received message is the same as the freshness value included in the message that has been successfully authenticated in the past. When the reception device **20** confirms that the freshness value included in the received message is different from the

freshness value included in the message that has been successfully authenticated in the past, the message is successfully authenticated.

[0040] As illustrated in the lower part of FIG. **3**, when authentication of the received message fails, the reception device **20** rejects the message. That is, the reception device **20** discards the message without accepting the message.

[0041] As illustrated in the lower part of FIG. **3**, when the received message is successfully authenticated, the reception device **20** receives the message. Thereafter, the freshness value included in the received message is stored in the storage device **22**.

[0042] In this way, the reception device **20** receives the message on condition that the freshness value included in the received message is larger than the stored freshness value. Then, the reception device **20** stores the freshness value included in the received message.

[0043] Hereinafter, in FIG. **3**, when a message transmission request is received, the processing illustrated in the lower part of FIG. **3** is executed. That is, the transmission device **10** counts up the lower digit of the freshness value after transmitting the message every time the transmission request of the message is received. Then, the reception device **20** that has received the message verifies the message.

[0044] When the freshness value of the maximum value is stored, and the freshness value included in the next received message is less than the maximum value, the reception device **20** receives the message. That is, when receiving the message including the freshness value of the maximum value, the reception device **20** receives the message including the freshness value less than the maximum value received after the message.

Communication Flow when Transmission Device **10** Fails to Read High-Order Digits

[0045] Next, with reference to FIG. **4**, an aspect of communication in the communication network system **100** in a case where the transmission device **10** fails to read the high-order digit of the freshness value will be described.

[0046] In the upper part of FIG. **4**, the mode of reading the upper digit of the freshness value after the transmission device **10** is activated is the same as the upper part of FIG. **3**.

As illustrated in the upper part of FIG. **4**, in a case where the reading of the upper digit fails, the transmission device **10** sets the freshness value to the maximum value.

[0047] As illustrated in the middle part of FIG. **4**, when receiving a message transmission request, the transmission device **10** transmits a first message. The first message is a message transmitted by the transmission device **10** after the transmission device **10** fails to read the high-order digit. At this time, the message transmitted by the transmission device **10** includes the freshness value of the maximum value set in the upper stage of FIG. **4**. As described above, the processing device **11** of the transmission device **10** executes the transmission of the first message including the freshness value of the maximum value when the reading of the high-order digit fails at the time of activation.

[0048] As illustrated in the middle part of FIG. **4**, the reception device **20** that has received the first message receives the first message. As described above, the reception device **20** receives the message when the freshness value included in the received message is larger than the freshness value stored in the reception device. The freshness value of the maximum value easily satisfies such a condition. Note that, in order to ensure that the reception device **20** receives the first message, the reception device **20** may adopt a configuration in which, when a message including a maximum freshness value is received, the message is received without performing verification.

[0049] As illustrated in the middle part of FIG. **4**, the reception device **20** that has received the first message stores the freshness value included in the first message in the storage device **22**.

As illustrated in the middle part of FIG. **4**, after transmitting the first message, the transmission device **10** sets the freshness value to the minimum value.

[0050] As illustrated in the lower part of FIG. **4**, after transmitting the first message, the transmission device **10** transmits the second message when receiving the message transmission request. The second message is a message transmitted after the transmission device **10** transmits the first message. The processing device **11** of the transmission device **10** performs transmitting, after the first message, a second message including a freshness value that is greater than or equal to the minimum value and less than the maximum value.

[0051] The second message includes a freshness value that is greater than or equal to the minimum value and less than the maximum value. As described above, when receiving the message including the maximum freshness value, the reception device **20** receives the message including the freshness value less than the maximum value received after the message. Therefore, the reception device **20** that has received the first message can successfully authenticate the second message. In the present embodiment, the second message transmitted by the transmission device **10** includes the freshness value of the minimum value set in the middle stage of FIG. **4**. That is, when transmitting the second message, the processing device **11** of the transmission device **10** performs transmission of the message including the freshness value of the minimum value.

[0052] As illustrated in the lower part of FIG. **4**, the reception device **20** that has received the second message receives the second message. Thereafter, the reception device **20** stores the freshness value included in the second message.

[0053] As illustrated in the lower part of FIG. **4**, after transmitting the second message, the transmission device **10** counts up the lower digit of the freshness value. At this time, the transmission device **10** counts up the lower digit of the freshness value in the manner described with reference to FIG. **2**.

[0054] The reception device **20** stores the freshness value included in the second message, and verifies the message to be received next to the second message based on the freshness value included in the second message. That is, after transmitting the second message, the transmission device **10** can cause the reception device **20** to receive the transmitted message by counting up the lower digit of the freshness value each time the message is transmitted. In this way, even if the reading of the upper digit fails, the transmission device **10** can reset the criterion of the message authentication of the reception device **20** by transmitting the first message and the second message.

[0055] The transmission device **10** includes the freshness value of the minimum value in the second message. There-

fore, the transmission device **10** can reset the freshness value to the minimum value by the second message and restart the counting. As a result, the transmission device **10** can resume the transmission of the message including the freshness value for which the authentication is successful.

[0056] After the reading of the high-order digit of the freshness value fails, the transmission device **10** periodically attempts to read the high-order digit again. As illustrated in the lower part of FIG. **4**, when the high-order digit of the freshness value is successfully read again, the transmission device **10** sets the freshness value to a value consisting of the high-order digit counted up by one from the read value and the low-order digit reset to the minimum value. Thereafter, the transmission device **10** transmits the message while counting up the freshness value set after the successful reading.

[0057] As described above, the processing device **11** of the transmission device **10** performs the re-reading of the high-order digit after the reading of the high-order digit fails. The processing device **11** of the transmission device **10** causes the read high-order digit to be counted up when the reading of the high-order digit succeeds, and sets a freshness value including the counted high-order digit and the low-order digit of the minimum value.

[0058] Thus, when the reading of the higher-order digit succeeds by the re-reading, the communication device can resume the counting while continuing the counting of the higher-order digit before the reading of the higher-order digit fails. The upper digit of the freshness value is information indicating the number of times the transmission device **10** is activated. Therefore, the transmission device **10** does not need to lose such information.

Operations of Present Embodiment

[0059] The reception device **20**, which is the communication device of the reception side, receives the message when the freshness value included in the received message is larger than the freshness value stored in the reception side. When the freshness value is the maximum value for both the high-order digit and the low-order digit, such a condition is easily satisfied.

[0060] The transmission device **10**, which is the communication device on the transmission side, sets the freshness value of the first message to the maximum value when the reading of the high-order digit of the freshness value fails at the time of activation. Accordingly, the transmission device **10** can cause the reception device **20** to receive the first message even if the reading of the high-order digit of the freshness value fails at the time of activation.

[0061] In addition, in a case where a message having a maximum freshness value is received, the reception device **20** stores the freshness value for the next message to be received, after receiving the message even when the freshness value is smaller than the maximum value. As a result, the reference of the freshness value in the reception device **20** is reset.

[0062] The transmission device **10** sets the freshness value of the second message to a value equal to or greater than the minimum value and less than the maximum value. Thereafter, the transmission device **10** can send a message from the freshness value included in the second message as a starting point while counting up the freshness value.

Effects of Present Embodiment

[0063] (1) The transmission device **10**, which is a communication device on the transmission side, can transmit a message including an appropriate freshness value even when reading of a high-order digit of the freshness value fails.

[0064] (2) When transmitting the second message, the processing device **11** of the transmission device **10** transmits the message including the freshness value of the minimum value. The transmission device **10** sets the minimum value as the freshness value included in the second message. That is, the transmission device **10** uses a value that is the most deviated from the maximum value as the freshness value included in the second message. As a result, the transmission device **10** can reset the freshness value included in the message to be transmitted to the minimum value by the second message and restart the counting.

[0065] (3) The processing device **11** of the transmission device **10** performs the re-reading of the high-order digit after the reading of the high-order digit fails. The processing device **11** of the transmission device **10**, when the re-reading of the high-order digit succeeds, counts up the read high-order digit and performs setting of a freshness value including the high-order digit counted up and the low-order digit of the minimum value.

[0066] When the re-reading of the high-order digit succeeds, the transmission device **10** sets the freshness value using the value that has been successfully read. Thus, when the reading of the higher-order digit succeeds by the re-reading, the transmission device **10** can resume the counting while continuing the counting of the higher-order digit until the reading of the higher-order digit fails.

[0067] (4) The communication network system **100** includes a plurality of communication devices. In the message exchange between the communication devices, the transmission device **10**, which is the communication device on the transmission side that transmits the message, transmits a message including a freshness value in a predetermined range configured by the upper digit and the lower digit. The upper digit is counted up every time the transmission device **10** is activated. The lower digit is counted up every time the transmission device **10** transmits a message. In the message exchange between the communication devices, the reception device **20**, which is the communication device of the reception side that receives the message, receives the message on condition that the freshness value included in the received message is larger than the stored freshness value. In addition, the reception device **20** stores the freshness value included in the received message. Then, when receiving the message including the freshness value of the maximum value, the reception device **20** receives the message including the freshness value less than the maximum value received after the message. In the communication network system **100**, the transmission device **10** transmits a first message including a maximum freshness value when reading of a high-order digit fails at the time of activation. Then, the transmission device **10** transmits, after the first message, the second message

including the freshness value that is equal to or greater than the minimum value and less than the maximum value.

[0068] In the communication network system **100**, the transmission device **10** sets the freshness value of the first message to the maximum value when the reading of the high-order digit of the freshness value fails at the time of startup. Thereafter, in the communication network system **100**, the transmission device **10** sets the freshness value of the second message to a value equal to or greater than the minimum value and less than the maximum value. Thereafter, the transmission device **10** can send a message from the freshness value included in the second message as a starting point while counting up the freshness value. In this way, the communication network system **100** can transmit a message including an appropriate freshness value even when the communication device on the transmitting side fails to read the high-order digit of the freshness value.

[0069] (5) The communication method is applied to the transmission device **10**, which is a communication device on the transmission side that transmits a message, in the exchange of messages between the communication devices in the communication network system **100**. The communication network system **100** includes a plurality of communication devices. In the message exchange between the communication devices, the transmission device **10** transmits a message including a freshness value in a predetermined range configured by a high-order digit counted up every time the communication device starts up and a low-order digit counted up every time the communication device transmits the message. In the message exchange between the communication devices, the reception device **20**, which is the communication device of the reception side that receives the message, receives the message on condition that the freshness value included in the received message is larger than the stored freshness value. In addition, the reception device **20** stores the freshness value included in the received message. Then, when receiving the message including the freshness value of the maximum value, the reception device **20** receives the message including the freshness value less than the maximum value received after the message. The communication method includes the step of transmitting the first message including the freshness value of the maximum value when the transmission device **10** fails to read the high-order digit at the time of activation. The communication method includes a step in which the transmission device **10** transmits, after the first message, a second message including a freshness value equal to or greater than a minimum value and less than a maximum value.

[0070] In the communication method, when the transmission device **10** fails to read the high-order digit of the freshness value at the time of activation, the transmission device **10** sets the freshness value of the first message to the maximum value. Thereafter, the communication method causes the transmission device **10** to set the freshness value of the second message to a value equal to or greater than the minimum value and less than the maximum value. Thereafter, the transmission device **10** can send a message from the freshness value included in the second message as a starting point while counting up the freshness value. In this way, the communication method can transmit a message including an appropriate freshness value even when the communication device on the transmitting side fails to read the upper digit of the freshness value.

Modifications

[0071] The present embodiment can be realized with the following modifications. The present embodiment and the following modifications can be combined with each other within a technically consistent range to be realized.

[0072] In the above-described embodiment, two communication devices, a transmission device **10** and a reception device **20**, are connected to the communication network system **100**. The mode of connection of the communication device in the communication network system **100** is not limited to the above-described embodiment. That is, the topology of the communication device in the communication network system **100** is not limited to the above-described embodiment. The number of communication buses and the number of connected communication devices in the communication network system **100** are not limited to the above-described embodiments.

[0073] In the above-described embodiment, the communication device in the communication network system **100** is connected through the communication bus **30**. Meanwhile, the communication device in the communication network system **100** may be wirelessly connected.

[0074] In the above-described embodiment, the transmission device **10** transmits a message including the freshness value of the minimum value as the second message. On the other hand, the freshness value included in the second message transmitted by the transmission device **10** may be greater than the minimum value and less than the maximum value.

What is claimed is:

1. A communication device in a communication network system including a plurality of communication devices configured such that in exchange of a message between the communication devices,

a transmission-side communication device that transmits the message transmits the message including a predetermined range of a freshness value including a high-order digit that is counted up every time the transmission-side communication device is activated and a low-order digit that is counted up every time the message is transmitted, and

a reception-side communication device that receives the message

accepts the message under a condition that the freshness value included in the received message is larger than the freshness value that is stored,

stores the freshness value included in the accepted message, and

when the message including the freshness value that is a maximum value is received, accepts the message including the freshness value that is smaller than the maximum value and received after the message including the freshness value that is the maximum value,

the communication device being the transmission-side communication device comprising a processing device, wherein

the processing device is configured to, when failing to read the high-order digit at a time of activation,

transmit a first message including the freshness value that is the maximum value, and

transmit, after the first message, a second message including the freshness value that is equal to or larger than a minimum value and smaller than the maximum value.

2. The communication device according to claim **1**, wherein the processing device is configured to when transmitting the second message, transmit the message including the freshness value that is the minimum value.

3. The communication device according to claim **1**, wherein the processing device is configured to read the high-order digit again after failure to read the high-order digit, and when the high-order digit is successfully read again, count up the read high-order digit and set the freshness value including the high-order digit that has been counted up and the low-order digit that is a minimum value.

4. A communication network system comprising a plurality of communication devices configured such that in exchange of a message between the communication devices,

a transmission-side communication device that transmits the message transmits the message including a predetermined range of a freshness value including a high-order digit that is counted up every time the transmission-side communication device is activated and a low-order digit that is counted up every time the message is transmitted, and

a reception-side communication device that receives the message

accepts the message under a condition that the freshness value included in the received message is larger than the freshness value that is stored,

stores the freshness value included in the accepted message, and

when the message including the freshness value that is a maximum value is received, accepts the message including the freshness value that is smaller than the maximum value and received after the message including the freshness value that is the maximum value, wherein

the transmission-side communication device is configured to

when failing to read the high-order digit at a time of activation, transmit a first message including the freshness value that is the maximum value, and

transmit, after the first message, a second message including the freshness value that is equal to or larger than a minimum value and smaller than the maximum value.

5. A communication method in a communication network system including a plurality of communication devices configured such that in exchange of a message between the communication devices,

a transmission-side communication device that transmits the message transmits the message including a predetermined range of a freshness value including a high-order digit that is counted up every time the transmission-side communication device is activated and a low-order digit that is counted up every time the message is transmitted, and

a reception-side communication device that receives the message

accepts the message under a condition that the freshness value included in the received message is larger than the freshness value that is stored,

stores the freshness value included in the accepted message, and

when the message including the freshness value that is a maximum value is received, accepts the message including the freshness value that is smaller than the maximum value and received after the message including the freshness value that is the maximum value,

the communication method being applied to the transmission-side communication device, the communication method comprising causing the transmission-side communication device to, when failing to read the high-order digit at a time of activation,

transmit a first message including the freshness value that is the maximum value, and

transmit, after the first message, a second message including the freshness value that is equal to or larger than a minimum value and smaller than the maximum value.

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