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Inventor(s)	KATSUMATA; ATSUSHI et al.

DATA DIODE AND TRANSMISSION CONTROL METHOD

Abstract

A receiving device includes a determination part that determines the necessity of suppressing data transmission from a transmitting device via a unidirectional communication part, and a transmission suppression part that outputs a transmission suppression signal to the unidirectional communication part when the determination part determines that suppression of data transmission is necessary. The unidirectional communication part, when receiving the transmission suppression signal from the transmission suppression part, stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device. The transmitting device includes a comparison part that compares transmitted data with data from the unidirectional communication part, and stops data transmission when the comparison part determines that data do not match.

Inventors: **KATSUMATA; ATSUSHI (Tokyo, JP), TANABE; ITSUKI (Tokyo, JP), YAMASAKI; FUMIAKI (Tokyo, JP), KAGOURA; MAMORU (Tokyo, JP)**

Applicant: **Azbil Corporation** (Tokyo, JP)

Family ID: **96660234**

Assignee: **Azbil Corporation (Tokyo, JP)**

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of Japan Application No. 2024-019080, filed on Feb. 13, 2024. The entirety of the above-described patent application is hereby incorporated by reference herein and made a part of the present specification.

BACKGROUND

Technical Field

[0002] The disclosure relates to a data diode that performs unidirectional communication, and a transmission control method using a data diode.

Related Art

[0003] An operational technology (OT) network (control network) used in automation in a factory or the like is used for controlling various devices and is very important. In the case of this control network being maliciously hijacked, the control of the devices may become abnormal, leading to accidents that would not occur under normal circumstances.

[0004] Such an important control network generally maintains its security by not connecting to other networks.

[0005] On the other hand, there is a desire to use information generated on the control network externally. In such cases, a data diode is effective. This data diode enables communication in only one direction and is effective as a method for physically enhancing network security (see, for example, Japanese Patent Laid-Open No. 2015-133558).

[0006] In this manner, the data diode physically enables communication in only one direction. Hence, even if a malicious person attempts to hijack the data diode, there is no network for them to enter. To guarantee the above, no information transmission path in the reverse direction can be provided in the data diode in any way.

[0007] In this manner, since the data diode enables communication in only one direction, it is generally not possible for a transmitting side to obtain information from a receiving side. Hence, it is not possible to temporarily stop the transmission from the transmitting side according to the circumstances of the receiving side.

[0008] Here, a case is considered where data reception becomes temporarily difficult due to a state in which a buffer on the receiving side is full or the like.

[0009] In such cases, for example, in general communication, the receiving side communicates this state to the transmitting side and requests the transmitting side to temporarily stop transmission, thereby realizing high-quality communication.

[0010] However, the operation as described above cannot be implemented in the data diode. That is, in the data diode, due to unidirectional communication, how the data received accumulates on the receiving side cannot be grasped by the transmitting side.

[0011] Hence, generally, in the case of the data diode, a network is designed with sufficient margin to prevent the state as described above from occurring. In the event that the state as described above does occur, in the data diode, data may be lost, and because it is not possible to communicate this loss to the transmitting side, the communication may become incomplete.

[0012] How the data accumulates on the receiving side is determined by a data rate transmitted from the transmitting side and a data rate transmitted via an information technology (IT) network from the receiving side.

[0013] If the data rate on the receiving side is slow, for example, in the case where the IT network is congested, data from the transmitting side may accumulate and the buffer may not be able to store all the data, resulting in overflow and potential data loss.

SUMMARY

[0014] A data diode according to the disclosure includes: a transmitting device, transmitting data from a control network; a receiving device, transmitting input data to a business network; and a unidirectional communication part, transmitting data transmitted by the transmitting device to the receiving device and the transmitting device. The receiving device includes: a determination part, determining the necessity of suppressing data transmission from the transmitting device via the unidirectional communication part; and a transmission suppression part, in response to the determination part determining that suppression of data transmission is necessary, outputting a transmission suppression signal to the unidirectional communication part. The unidirectional communication part, in response to receiving the transmission suppression signal from the transmission suppression part, stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device. The transmitting device includes a comparison part that compares transmitted data with data from the unidirectional communication part, and the transmitting device stops data transmission in response to the comparison part determining that data do not match.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** illustrates a configuration example of a data diode according to Embodiment 1.

[0016] FIG. **2**A to FIG. **2**C illustrate configuration examples (in the case where the data diode uses electrical signals) of a unidirectional communication part in Embodiment 1.

[0017] FIG. **3**A and FIG. **3**B illustrate configuration examples (in the case where the data diode uses electrical signals) of the unidirectional communication part in Embodiment 1.

[0018] FIG. **4**A and FIG. **4**B illustrate configuration examples (in the case where the data diode uses optical signals) of the unidirectional communication part in Embodiment 1.

[0019] FIG. **5** is a flowchart illustrating an example of a transmission control operation in the data diode according to Embodiment 1.

[0020] FIG. **6** illustrates a configuration example of a data diode according to Embodiment 2.

DESCRIPTION OF THE EMBODIMENTS

[0021] The disclosure provides a data diode in which the occurrence of overflow can be prevented while security is ensured.

[0022] Embodiments will be described in detail below with reference to the drawings.

Embodiment 1

[0023] FIG. **1** illustrates a configuration example of a data diode **1** according to Embodiment 1. The data diode **1** is a device that performs unidirectional communication from an OT network (control network) to an IT network (business network) using electrical signals or optical signals.

[0024] In the data diode **1** according to Embodiment 1, an aim is to achieve a necessary function without creating an information transmission path in the reverse direction. Here, the necessary function refers to a function of, by appropriately controlling communication according to differences or changes in communication capacity of each communication path, efficiently using the capacity of the communication path while preventing data loss. That is, the aim is to realize this function, which is common in normal communication, even in the data diode **1** where information transmission in the reverse direction is not possible.

[0025] As illustrated in FIG. **1**, the data diode **1** includes, for example, a transmitting device **11**, a unidirectional communication part **12**, and a receiving device **13**.

[0026] The transmitting device **11** transmits data from the OT network to the unidirectional communication part **12**.

[0027] As illustrated in FIG. **1**, the transmitting device **11** includes, for example, a reception part **111**, a buffer **112**, a transmission part **113**, and a comparison part **114**.

[0028] The reception part **111** receives data from the OT network.

[0029] The buffer **112** temporarily accumulates data received by the reception part **111**.

[0030] The transmission part **113** transmits data accumulated in the buffer **112** to the unidirectional communication part **12**. In FIG. **1**, the data transmitted from the transmission part **113** to the unidirectional communication part **12** is indicated as TX.

[0031] In the case where it is determined by the comparison part **114** that the data do not match (the word "match" includes the meaning of "substantially match"), the transmission part **113** stops transmitting the data accumulated in the buffer **112** to the unidirectional communication part **12**.

[0032] The comparison part **114** compares the data transmitted to the unidirectional communication part **12** by the transmission part **113** with data returned from the unidirectional communication part **12**. In FIG. **1**, the data returned from the unidirectional communication part **12** is indicated as LB.

[0033] The unidirectional communication part **12** transmits the data from the transmitting

[0034] device **11** to the receiving device **13**. The unidirectional communication part **12** also returns the data transmitted from the transmitting device **11** to the receiving device **13** back to the transmitting device **11**. In FIG. **1**, the data transmitted from the unidirectional communication part **12** to the receiving device **13** is indicated as RX.

[0035] If a transmission suppression signal is input from the receiving device **13**, the unidirectional communication part **12** stops transmitting data from the transmitting device **11** to both the receiving device **13** and the transmitting device **11**. In FIG. **1**, the transmission suppression signal transmitted from the receiving device **13** to the unidirectional communication part **12** is indicated as EN.

[0036] A configuration example of the unidirectional communication part **12** will be described later.

[0037] The receiving device **13** transmits the data from the transmitting device **11** via the unidirectional communication part **12** to the IT network.

[0038] As illustrated in FIG. **1**, the receiving device **13** includes, for example, a reception part **131**, a buffer **132**, a transmission part **133**, a determination part **134**, and a transmission suppression part **135**.

[0039] The reception part **131** receives the data from the transmitting device **11** via the unidirectional communication part **12**.

[0040] The buffer **132** temporarily accumulates the data received by the reception part **131**.

[0041] The transmission part **133** transmits the data accumulated by the buffer **132** to the IT network.

[0042] The determination part **134** determines the necessity of suppressing data transmission from the transmitting device **11** via the unidirectional communication part **12**. That is, for example, the determination part **134** continuously or regularly confirms free space in the buffer **132**, and, if the free space reaches a predetermined capacity or less, determines that suppression of data transmission is necessary.

[0043] In the receiving device **13**, in the case where data is transmitted by the transmission part **133**, it is not possible to immediately make free an area corresponding to the amount of data in the buffer **132**, and a free area can be provided when a response is obtained indicating that the data has been received by the IT network side being the destination. On the other hand, if a response is obtained indicating that the data could not be received by the IT network side being the destination, it is necessary to retransmit the data. Such an operation is also subject to determination by the determination part **134**.

[0044] The determination part **134** is realized by a processing circuit such as a system large scale integration (LSI), or a central processing unit (CPU) that executes a program stored in a memory or

the like.
[0045] If it is determined by the determination part **134** that suppression of data transmission is necessary, the transmission suppression part **135** outputs the transmission suppression signal to the unidirectional communication part **12**. The transmission suppression signal is a signal for requesting suppression of data transmission.
[0046] Next, configuration examples of the unidirectional communication part **12** will be described with reference to FIG. **2**A to FIG. **4**B.
[0047] First, configuration examples of the unidirectional communication part **12** in the case where the data diode **1** uses electrical signals will be described with reference to FIG. **2**A to FIG. **2**C and FIG. **3**A to FIG. **3**B.
[0048] For example, FIG. **2**A illustrates a configuration example of the case of stopping transmission by grounding two signal lines for performing differential transmission that are included in the unidirectional communication part **12**. In this case, as illustrated in FIG. **2**A for example, the unidirectional communication part **12** includes a driver **121***a*, a receiver **122***a*, a resistor **123***a*, a switch **124***a*, and a switch **125***a*.
[0049] The driver **121***a* has its input terminal connected to an output terminal (transmission part **113**) of the transmitting device **11**, its first output terminal connected to a first input terminal of the receiver **122***a* via one signal line, and its second output terminal connected to a second input terminal of the receiver **122***a* via the other signal line.
[0050] The receiver **122***a* has its first input terminal connected to a first output terminal of the driver **121***a* via one signal line, its second input terminal connected to a second output terminal of the driver **121***a* via the other signal line, and its output terminal connected to an input terminal (reception part **131**) of the receiving device **13** and an input terminal (comparison part **114**) of the transmitting device **11**.
[0051] The resistor **123***a* has one end connected to the first output terminal of the driver **121***a* and the first input terminal (that is, one signal line) of the receiver **122***a*, and the other end connected to the second output terminal of the driver **121***a* and the second input terminal (that is, the other signal line) of the receiver **122***a*.
[0052] The switch **124***a* has one end connected to the first output terminal of the driver **121***a* and the first input terminal (that is, one signal line) of the receiver **122***a*, and the other end grounded.
[0053] The switch **124***a* disconnects the lines in response to the transmission suppression signal being input from the receiving device **13**.
[0054] The switch **125***a* has one end connected to the second output terminal of the driver **121***a* and the second input terminal (that is, the other signal line) of the receiver **122***a*, and the other end grounded.
[0055] The switch **125***a* disconnects the lines in response to the transmission suppression signal being input from the receiving device **13**.
[0056] For example, FIG. **2**B illustrates a configuration example of the case of stopping transmission by short-circuiting two signal lines for performing differential transmission that are included in the unidirectional communication part **12**. In this case, as illustrated in FIG. **2**B for example, the unidirectional communication part **12** includes a driver **121***b*, a receiver **122***b*, a resistor **123***b*, and a switch **124***b*.
[0057] The driver **121***b* has its input terminal connected to the output terminal (transmission part **113**) of the transmitting device **11**, its first output terminal connected to a first input terminal of the receiver **122***b* via one signal line, and its second output terminal connected to the second input terminal of the receiver **122***b* via the other signal line.
[0058] The receiver **122***b* has its first input terminal connected to a first output terminal of the driver **121***b* via one signal line, its second input terminal connected to a second output terminal of the driver **121***b* via the other signal line, and its output terminal connected to the input terminal (reception part **131**) of the receiving device **13** and the input terminal (comparison part **114**) of the

transmitting device **11**.

[0059] The resistor **123***b* has one end connected to the first output terminal of the driver **121***b* and the first input terminal (that is, one signal line) of the receiver **122***b*, and the other end connected to the second output terminal of the driver **121***b* and the second input terminal (that is, the other signal line) of the receiver **122***b*.

[0060] The switch **124***b* has one end connected to the first output terminal of the driver **121***b* and the first input terminal (that is, one signal line) of the receiver **122***b*, and the other end connected to the second output terminal of the driver **121***b* and the second input terminal (that is, the other signal line) of the receiver **122***b*.

[0061] The switch **124***b* connects the lines in response to the transmission suppression signal being input from the receiving device **13**.

[0062] For example, FIG. **2**C illustrates a configuration example of the case of stopping transmission by grounding one single signal line for performing single-ended transmission that is included in the unidirectional communication part **12**. In this case, as illustrated in FIG. **2**C for example, the unidirectional communication part **12** includes a driver **121***c*, a receiver **122***c*, and a switch **124***c*.

[0063] The driver **121***c* has its input terminal connected to the output terminal (transmission part **113**) of the transmitting device **11**, and its output terminal connected to an input terminal of the receiver **122***c* via the signal line.

[0064] The receiver **122***c* has its input terminal connected to the output terminal of the driver **121***c* via the signal line, and its output terminal connected to the input terminal (reception part **131**) of the receiving device **13** and the input terminal (comparison part **114**) of the transmitting device **11**.

[0065] The switch **124***c* has one end connected to the output terminal of the driver **121***c* and the input terminal (that is, the signal line) of the receiver **122***c*, and the other end grounded.

[0066] The switch **124***c* connects the lines in response to the transmission suppression signal being input from the receiving device **13**.

[0067] For example, FIG. **3**A illustrates a configuration example of the case where the unidirectional communication part **12** stops transmission using an enable terminal in a driver **121***d*. This method can be implemented for both single-ended transmission and differential transmission. FIG. **3**A illustrates a case of a single-ended configuration. In this case, as illustrated in FIG. **3**A for example, the unidirectional communication part **12** includes the driver **121***d* and a receiver **122***d*.

[0068] The driver **121***d* has its input terminal connected to the output terminal (transmission part **113**) of the transmitting device **11**, and its output terminal connected to an input terminal of the receiver **122***d* via a signal line.

[0069] The driver **121***d* stops signal output in response to the transmission suppression signal being input from the receiving device **13** to the enable terminal.

[0070] The receiver **122***d* has its input terminal connected to the output terminal of the driver **121***d* via a signal line, and its output terminal connected to the input terminal (reception part **131**) of the receiving device **13** and the input terminal (comparison part **114**) of the transmitting device **11**.

[0071] For example, FIG. **3**B illustrates a configuration example of the case where the unidirectional communication part **12** stops transmission using an enable terminal in a receiver **122***e*. This method can be implemented for both single-ended transmission and differential transmission. FIG. **3**B illustrates a case of a single-ended configuration. In this case, as illustrated in FIG. **3**B for example, the unidirectional communication part **12** includes a driver **121***e* and the receiver **122***e*.

[0072] The driver **121***e* has its input terminal connected to the output terminal (transmission part **113**) of the transmitting device **11**, and its output terminal connected to an input terminal of the receiver **122***e* via a signal line.

[0073] The receiver **122***e* has its input terminal connected to the output terminal of the driver **121***e* via a signal line, and its output terminal connected to the input terminal (reception part **131**) of the receiving device **13** and the input terminal (comparison part **114**) of the transmitting device **11**.

[0074] The receiver **122***e* stops signal output in response to the transmission suppression signal being input from the receiving device **13** to the enable terminal.

[0075] Next, a configuration example of the unidirectional communication part **12** in the case where the data diode **1** uses optical signals (in the case of optical communication) will be described with reference to FIG. **4**A and FIG. **4**B.

[0076] For example, FIG. **4**A illustrates a configuration example of the case where the unidirectional communication part **12** stops transmission using an enable terminal in a driver **121***f*. In this case, as illustrated in FIG. **4**A for example, the unidirectional communication part **12** includes the driver **121***f*, an optical transceiver (optical Tx) **126***f*, an optical transceiver (optical Rx) **127***f*, and a receiver **122***f*.

[0077] The driver **121***f* has its input terminal connected to the output terminal (transmission part **113**) of the transmitting device **11**, its first output terminal connected to a first input terminal of the optical transceiver **126***f*, and its second output terminal connected to the second input terminal of the optical transceiver **126***f*.

[0078] The driver **121***f* stops signal output in response to the transmission suppression signal being input from the receiving device **13** to the enable terminal.

[0079] The optical transceiver **126***f* converts an input signal from an electrical signal to an optical signal. The optical transceiver **126***f* has its first input terminal connected to the first output terminal of the driver **121***f*, its second input terminal connected to the second output terminal of the driver **121***f*, and its output terminal connected to an input terminal of the optical transceiver **127***f* via an optical fiber.

[0080] The optical transceiver **127***f* converts an input signal from an optical signal to an electrical signal. The optical transceiver **127***f* has its input terminal connected to the output terminal of the optical transceiver **126***f* via an optical fiber, its first output terminal connected to a first input terminal of the receiver **122***f*, and its second output terminal connected to a second input terminal of the receiver **122***f*.

[0081] The receiver **122***f* has its first input terminal connected to the first output terminal of the optical transceiver **127***f*, its second input terminal connected to the second output terminal of the optical transceiver **127***f*, and its output terminal connected to the input terminal (reception part **131**) of the receiving device **13** and the input terminal (comparison part **114**) of the transmitting device **11**.

[0082] For example, FIG. **4**B illustrates a configuration example of the case where the unidirectional communication part **12** stops transmission using an enable terminal in a receiver **122***g*. In this case, as illustrated in FIG. **4**B for example, the unidirectional communication part **12** includes a driver **121***g*, an optical transceiver (optical Tx) **126***g*, an optical transceiver (optical Rx) **127***g*, and the receiver **122***g*.

[0083] The driver **121***g* has its input terminal connected to the output terminal (transmission part **113**) of the transmitting device **11**, its first output terminal connected to a first input terminal of the optical transceiver **126***g*, and its second output terminal connected to a second input terminal of the optical transceiver **126***g*.

[0084] The optical transceiver **126***g* converts an input signal from an electrical signal to an optical signal. The optical transceiver **126***g* has its first input terminal connected to the first output terminal of the driver **121***g*, its second input terminal connected to the second output terminal of the driver **121***g*, and its output terminal connected to an input terminal of the optical transceiver **127***g* via an optical fiber.

[0085] The optical transceiver **127***g* converts an input signal from an optical signal to an electrical signal. The optical transceiver **127***g* has its input terminal connected to the output terminal of the optical transceiver **126***g* via an optical fiber, its first output terminal connected to a first input terminal of the receiver **122***g*, and its second output terminal connected to a second input terminal of the receiver **122***g*.

[0086] The receiver **122***g* has its first input terminal connected to the first output terminal of the optical transceiver **127***g*, its second input terminal connected to the second output terminal of the optical transceiver **127***g*, and its output terminal connected to the input terminal (reception part **131**) of the receiving device **13** and the input terminal (comparison part **114**) of the transmitting device **11**.

[0087] The receiver **122***g* stops signal output in response to the transmission suppression signal being input from the receiving device **13** to the enable terminal.

[0088] Next, a transmission control operation example of the data diode **1** according to Embodiment 1 illustrated in FIG. **1** will be described with reference to FIG. **5**.

[0089] In the data diode **1** according to Embodiment 1, the transmitting device **11** transmits data from the OT network to the unidirectional communication part **12**, the unidirectional communication part **12** transmits data from the transmitting device **11** to the receiving device **13**, and the receiving device **13** transmits data from the transmitting device **11** via the unidirectional communication part **12** to the IT network. The unidirectional communication part **12** also returns the data transmitted from the transmitting device **11** to the receiving device **13** back to the transmitting device **11**.

[0090] In the transmission control operation example of the data diode **1** according to Embodiment 1 illustrated in FIG. **1**, first, as illustrated in FIG. **5** for example, the determination part **134** in the receiving device **13** determines the necessity of suppressing data transmission from the transmitting device **11** via the unidirectional communication part **12** (step ST**101**). That is, the determination part **134** continuously or regularly confirms free space in the buffer **132**, and, if the free space reaches a predetermined capacity or less, determines that suppression of data transmission is necessary.

[0091] Next, if it is determined by the determination part **134** that suppression of data transmission is necessary, the transmission suppression part **135** in the receiving device **13** outputs the transmission suppression signal to the unidirectional communication part **12** (step ST**102**).

[0092] Next, if the transmission suppression signal is input from the receiving device **13**, the unidirectional communication part **12** stops transmitting data from the transmitting device **11** to both the receiving device **13** and the transmitting device **11** (step ST**103**).

[0093] Next, the comparison part **114** in the transmitting device **11** compares the data transmitted to the unidirectional communication part **12** by the transmission part **113** with the data returned from the unidirectional communication part **12** (step ST**104**).

[0094] Next, if it is determined by the comparison part **114** that the data do not match, the transmission part **113** stops transmitting the data accumulated in the buffer **112** to the unidirectional communication part **12** (step ST**105**).

[0095] As described above, in the data diode **1** according to Embodiment 1, data (signals) from the transmitting device **11** are transmitted to the driver **121**, and the data (signals) received by the receiver **122** are communicated to the receiving device **13** as well as looped back to the transmitting device **11**. The transmitting device **11** then compares the data transmitted by itself with the looped-back data. Here, if both sets of data being compared match, the transmitting device **11** can determine that the communication path is not blocked by the receiving device **13**.

[0096] On the other hand, if the transmission suppression signal is transmitted from the receiving device **13** to the unidirectional communication part **12**, the unidirectional communication part **12** stops transmitting the data from the transmitting device **11** to both the receiving device **13** and the transmitting device **11**. Accordingly, in the transmitting device **11**, both sets of data being compared do not match, and the transmitting device **11** can determine that the communication path is blocked by the receiving device **13**. In this way, the transmitting device **11** can be informed that the receiving device **13** is in a state of being unable to receive data for some reason, and may respond by stopping transmission and, for example, perform retransmission after a while.

[0097] In this manner, in the data diode **1** according to Embodiment 1, in the case where the receiving device **13** desires to stop data transmission from the transmitting device **11**, the receiving device **13** intentionally causes a communication error by blocking communication in the unidirectional communication part **12**. Then, the transmitting device **11** is able to determine that a communication error has occurred by comparing the transmitted data with the looped-back data, and is able to stop transmission.

[0098] At this time, to transmit information to the transmitting device **11**, the receiving device **13** does not directly communicate a signal to the transmitting device **11**, but transmits the information by blocking a unidirectional communication path. Hence, even if this blocking signal were to be maliciously hijacked, it is evident that it is only possible to block communication, and it is not possible to enter the OT network.

[0099] It is evident that the transmitting device **11** merely loops back a signal being transmitted through the unidirectional communication path, and this cannot be controlled from the receiving device **13**.

[0100] From the above, the data diode **1** according to Embodiment 1 is able to control transmission and reception while maintaining the nature of the data diode **1**.

[0101] In the data diode **1**, optical communication may be used to realize unidirectional communication. This is because in the case of optical communication, a transmitting side includes a light-emitting element, a receiving side includes a light-receiving element, and an optical communication path is provided therebetween, making it visually apparent that the communication is unidirectional. A characteristic of optical communication is that high-speed and highly reliable communication can be achieved.

[0102] In the data diode **1**, it is also possible to use an electrical component to realize unidirectional communication. With the electrical component, it is easy to block the communication, thus making it possible to control communication by utilizing this blocking function.

[0103] In optical communication, an optical transceiver connected to an optical fiber includes a built-in light-emitting element or light-receiving element. To drive the optical transceiver, a differential signal being a high-speed electrical signal is often used. Hence, even in the case of unidirectional communication using optical communication, the blocking function can be implemented by an electrical signal portion.

[0104] Specifically, for example, in the case of a differential communication path, blocking can be achieved by grounding each differential communication path with an analog switch, by short-circuiting both differential signals, or the like.

[0105] For example, in the case of a normal single-ended communication path that is not differential, blocking can be achieved by grounding the signal with an analog switch.

[0106] For example, for both differential or single-ended, if enable input is provided for a driver or receiver being used, blocking can be achieved by utilizing this input.

[0107] As described above, according to Embodiment 1, the data diode **1** includes: the transmitting device **11**, transmitting data from the OT network; the receiving device **13**, transmitting input data to the IT network; and the unidirectional communication part **12**, transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11**. The receiving device **13** includes: the determination part **134**, determining the necessity of suppressing data transmission from the transmitting device **11** via the unidirectional communication part **12**; and the transmission suppression part **135**, in response to the determination part **134** determining that suppression of data transmission is necessary, outputting the transmission suppression signal to the unidirectional communication part **12**. The unidirectional communication part **12**, in response to receiving the transmission suppression signal from the transmission suppression part **135**, stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11**. The transmitting device **11** includes the comparison part **114** that compares transmitted data with data from the unidirectional communication part **12**, and stops data transmission in response to the comparison part **114** determining that data do not match.

[0108] Accordingly, in the data diode **1** according to Embodiment 1, the occurrence of overflow can be prevented while security is ensured.

[0109] According to Embodiment 1, the unidirectional communication part **12** includes two signal lines for performing differential transmission, and stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11** by grounding the two signal lines.

[0110] According to Embodiment 1, the unidirectional communication part **12** includes two signal lines for performing differential transmission, and stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11** by short-circuiting the two signal lines.

[0111] According to Embodiment 1, the unidirectional communication part **12** includes one single signal line for performing single-ended transmission, and stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11** by grounding this signal line.

[0112] According to Embodiment 1, the unidirectional communication part **12** includes the driver **121** and the receiver **122** that perform single-ended transmission or differential transmission, and stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11** in response to the transmission suppression signal being input to the enable terminal in the driver **121**.

[0113] According to Embodiment 1, the unidirectional communication part **12** includes the driver **121** and the receiver **122** that perform single-ended transmission or differential transmission, and stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11** in response to the transmission suppression signal being input to the enable terminal in the receiver **122**.

[0114] Accordingly, in the data diode **1** according to Embodiment 1, the occurrence of overflow can be prevented while security is ensured.

[0115] According to Embodiment 1, the transmission control method is a transmission control method in the data diode **1**, the data diode **1** including the transmitting device **11** that transmits data from the OT network, the receiving device **13** that transmits input data to the IT network, and the unidirectional communication part **12** that transmits data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11**. The receiving device **13** includes the determination part **134** that determines the necessity of suppressing data transmission from the transmitting device **11** via the unidirectional communication part **12**, and the transmission suppression part **135** that outputs the transmission suppression signal to the unidirectional communication part **12** in the case where it is determined by the determination part **134** that suppression of data transmission is necessary. The unidirectional communication part **12** stops transmitting data transmitted by the transmitting device **11** to the receiving device **13** and the transmitting device **11** in response to the transmission suppression signal being input from the transmission suppression part **135**. The transmitting device **11** includes the comparison part **114** that compares transmitted data with data from the unidirectional communication part **12**, and stops data transmission in the case where it is determined by the comparison part **114** that data do not match.

[0116] Accordingly, in the transmission control method according to Embodiment 1, the occurrence of overflow can be prevented while security is ensured.

Embodiment 2

[0117] FIG. **6** illustrates a configuration example of the data diode **1** according to Embodiment 2. In the data diode **1** according to Embodiment 2 illustrated in FIG. **6**, compared to the data diode **1** according to Embodiment 1 illustrated in FIG. **1**, a determination part (second determination part) **115** and a request part **116** are added to the transmitting device **11**. Other configuration examples in

the data diode **1** according to Embodiment 2 illustrated in FIG. **6** are similar to the configuration examples in the data diode **1** according to Embodiment 1 and are assigned the same reference numerals. Only the different portions will be described.
[0118] The determination part **115** determines the necessity of temporary stop of transmission of or retransmission of data from the OT network. That is, for example, the determination part **115** continuously or regularly confirms free space in the buffer **112**, and, if the free space reaches a predetermined capacity or less, determines that temporary stop of transmission of or retransmission of data is necessary.
[0119] The request part **116**, in the case where it is determined by the determination part **115** that temporary stop of transmission of or retransmission of data is necessary, outputs a request signal to the OT network (source of data). The request signal is a signal for requesting temporary stop of transmission of or retransmission of data, such as Nack.
[0120] Then, the OT network side, in response to the request signal being input from the transmitting device **11**, performs temporary stop of transmission of or retransmission of data to the transmitting device **11**.
[0121] For example, in the case of a Transmission Control Protocol (TCP) communication protocol, temporary stop of transmission of data can be achieved by the transmitting device **11** rejecting a connection request from the OT network side, and retransmission of data can be achieved by the transmitting device **11** responding that data from the OT network side has not been received.
[0122] That is, in the TCP, data transfer is started after a connection is established.
[0123] At this time, a signal indicating a connection establishment request is transmitted from the source. If there is little free space in the buffer **112**, the transmitting device **11** transmits to the source the request signal that rejects the connection establishment request. When the transmitting device **11** rejects the connection establishment request, the source becomes unable to transmit data, and temporary stop of transmission of data is thereby achieved.
[0124] In the case where a connection has been established and data transfer has begun, if the data is large, the source divides that data into multiple packets for transmission. Then, if the free space in the buffer **112** is decreased during reception of these multiple packets, the transmitting device **11** is unable to store all the packets in the buffer **112**. Hence, the transmitting device **11** transmits to the source a sequence number (number indicating how much data can be received) of the packets that can stored in the buffer **112** as the request signal. Accordingly, the source is able to retransmit the packets that could not be stored in the buffer **112**.
[0125] As described above, according to Embodiment 2, the transmitting device **11** includes: the determination part **115**, determining the necessity of temporary stop of transmission of or retransmission of data from the OT network; and the request part **116**, in response to the determination part **115** determining that temporary stop of transmission of or retransmission of data is necessary, outputting the request signal to the OT network.
[0126] Accordingly, in addition to the effects of Embodiment 1, the data diode **1** according to Embodiment 2 is able to cope with the case where there is little free space in the buffer **112** on the transmitting device **11** side.
[0127] It should be noted that free combinations of each embodiment, or modifications of any component in each embodiment, or omission of any component in each embodiment are possible.

Claims

1. A data diode comprising: a transmitting device, transmitting data from a control network; a receiving device, transmitting input data to a business network; and a unidirectional communication part, transmitting data transmitted by the transmitting device to the receiving device and the transmitting device, wherein the receiving device comprises: a determination part, determining necessity of suppressing data transmission from the transmitting device via the unidirectional communication part; and a transmission suppression part, in response to the determination part determining that suppression of data transmission is necessary, outputting a transmission suppression signal to the unidirectional communication part; the unidirectional communication part, in response to receiving the transmission suppression signal from the transmission suppression part, stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device; the transmitting device comprises a comparison part that compares transmitted data with data from the unidirectional communication part, and the transmitting device stops data transmission in response to the comparison part determining that data do not match.

2. The data diode according to claim 1, wherein the unidirectional communication part comprises two signal lines for performing differential transmission, and stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device by grounding the two signal lines.

3. The data diode according to claim 1, wherein the unidirectional communication part comprises two signal lines for performing differential transmission, and stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device by short-circuiting the two signal lines.

4. The data diode according to claim 1, wherein the unidirectional communication part comprises one single signal line for performing single-ended transmission, and stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device by grounding the one single signal line.

5. The data diode according to claim 1, wherein the unidirectional communication part comprises a driver and a receiver that perform single-ended transmission or differential transmission, and stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device by a transmission suppression signal being input to an enable terminal in the driver.

6. The data diode according to claim 1, wherein the unidirectional communication part comprises a driver and a receiver that perform single-ended transmission or differential transmission, and stops transmitting data transmitted by the transmitting device to the receiving device and the transmitting device by a transmission suppression signal being input to an enable terminal in the receiver.

7. The data diode according to claim 1, wherein the transmitting device comprises: a second determination part, determining necessity of temporary stop of transmission of or retransmission of data from the control network; and a request part, in response to the second determination part determining that temporary stop of transmission of or retransmission of data is necessary, outputting a request signal to the control network.

8. A transmission control method in a data diode, the data diode comprising a transmitting device that transmits data from a control network, a receiving device that transmits input data to a business network, and a unidirectional communication part that transmits data transmitted by the transmitting device to the receiving device and the transmitting device, wherein the transmission control method comprises: in the receiving device, by a determination part, determining necessity of suppressing data transmission from the transmitting device via the unidirectional communication part; and by a transmission suppression part, outputting a transmission suppression signal to the unidirectional communication part in response to a determination by the determination part that suppression of data transmission is necessary; in response to receiving the transmission suppression signal from the transmission suppression part, by the unidirectional communication part, stopping transmitting data transmitted by the transmitting device to the receiving device and the transmitting device; in the transmitting device, by a comparison part, comparing transmitted data with data from the unidirectional communication part, and in response to a determination by the comparison part that data do not match, stopping data transmission.
