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(54) **DETECTION DEVICE, DETECTION METHOD, AND DETECTION PROGRAM**

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(57) **ABSTRACT**

A detection apparatus includes processing circuitry configured to acquire, from a storage having stored therein normal communication models for determining, for each function of a communication device, whether or not communication of the communication device having the function is normal, at least one normal communication model that corresponds to a function of a monitoring target communication device, and monitor communication of the monitoring target communication device using the acquired normal communication model, and detect an abnormality in the communication.

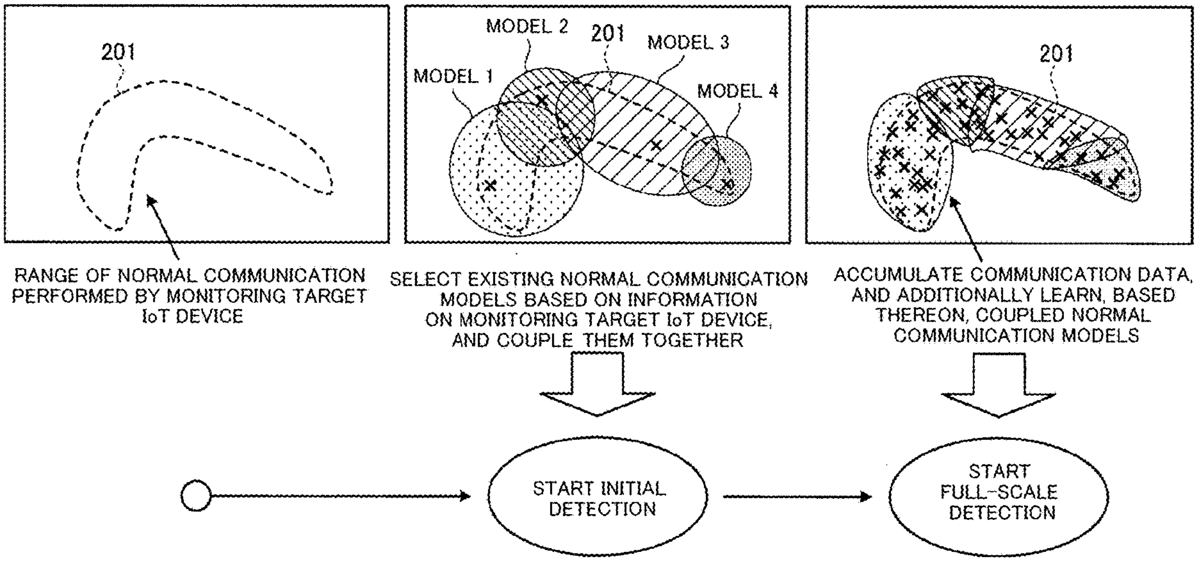

201
MODEL 2
201
MODEL 3
MODEL 1
MODEL 4
201
RANGE OF NORMAL COMMUNICATION PERFORMED BY MONITORING TARGET IoT DEVICE
SELECT EXISTING NORMAL COMMUNICATION MODELS BASED ON INFORMATION ON MONITORING TARGET IoT DEVICE, AND COUPLE THEM TOGETHER
ACCUMULATE COMMUNICATION DATA, AND ADDITIONALLY LEARN, BASED THEREON, COUPLED NORMAL COMMUNICATION MODELS
START INITIAL DETECTION
START FULL-SCALE DETECTION

Fig. 1

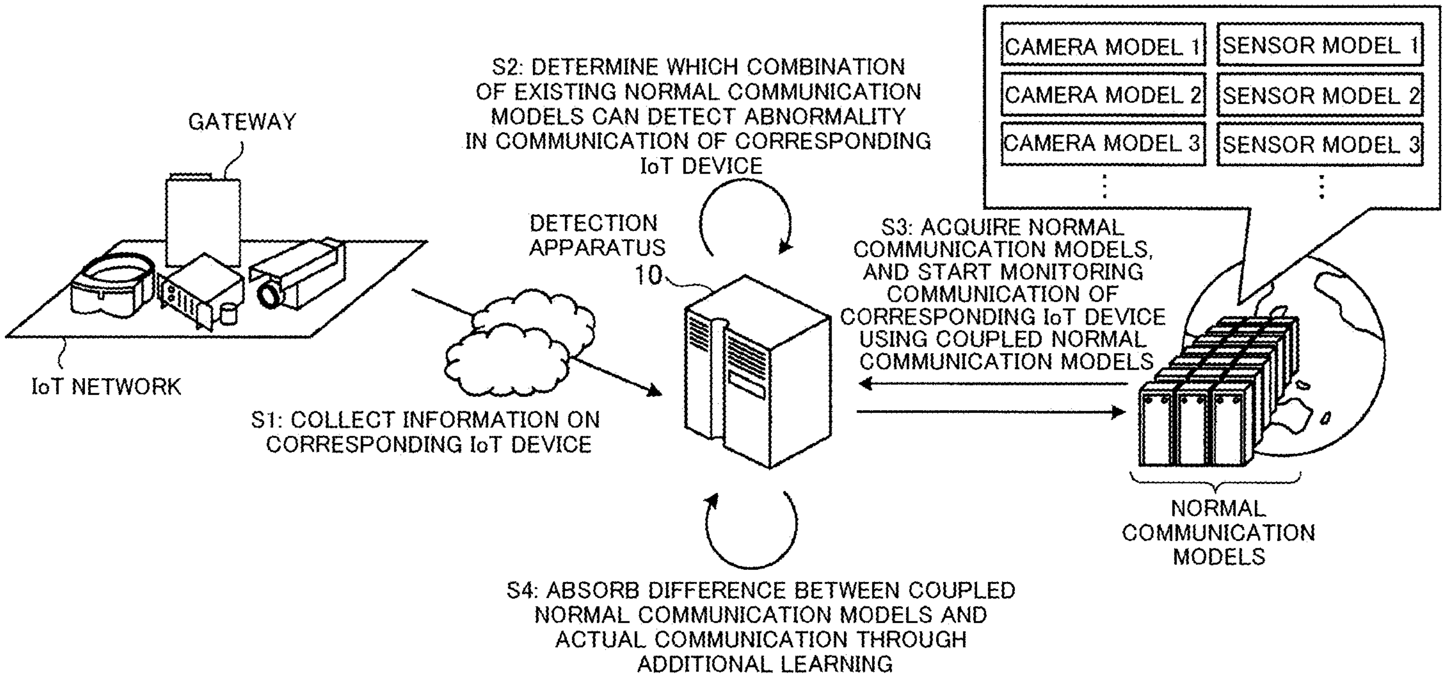

GATEWAY
IoT NETWORK
S1: COLLECT INFORMATION ON CORRESPONDING IoT DEVICE
S2: DETERMINE WHICH COMBINATION OF EXISTING NORMAL COMMUNICATION MODELS CAN DETECT ABNORMALITY IN COMMUNICATION OF CORRESPONDING IoT DEVICE
DETECTION APPARATUS
10
S3: ACQUIRE NORMAL COMMUNICATION MODELS, AND START MONITORING COMMUNICATION OF CORRESPONDING IoT DEVICE USING COUPLED NORMAL COMMUNICATION MODELS
S4: ABSORB DIFFERENCE BETWEEN COUPLED NORMAL COMMUNICATION MODELS AND ACTUAL COMMUNICATION THROUGH ADDITIONAL LEARNING
CAMERA MODEL 1
CAMERA MODEL 2
CAMERA MODEL 3
SENSOR MODEL 1
SENSOR MODEL 2
SENSOR MODEL 3
NORMAL COMMUNICATION MODELS

Fig. 2

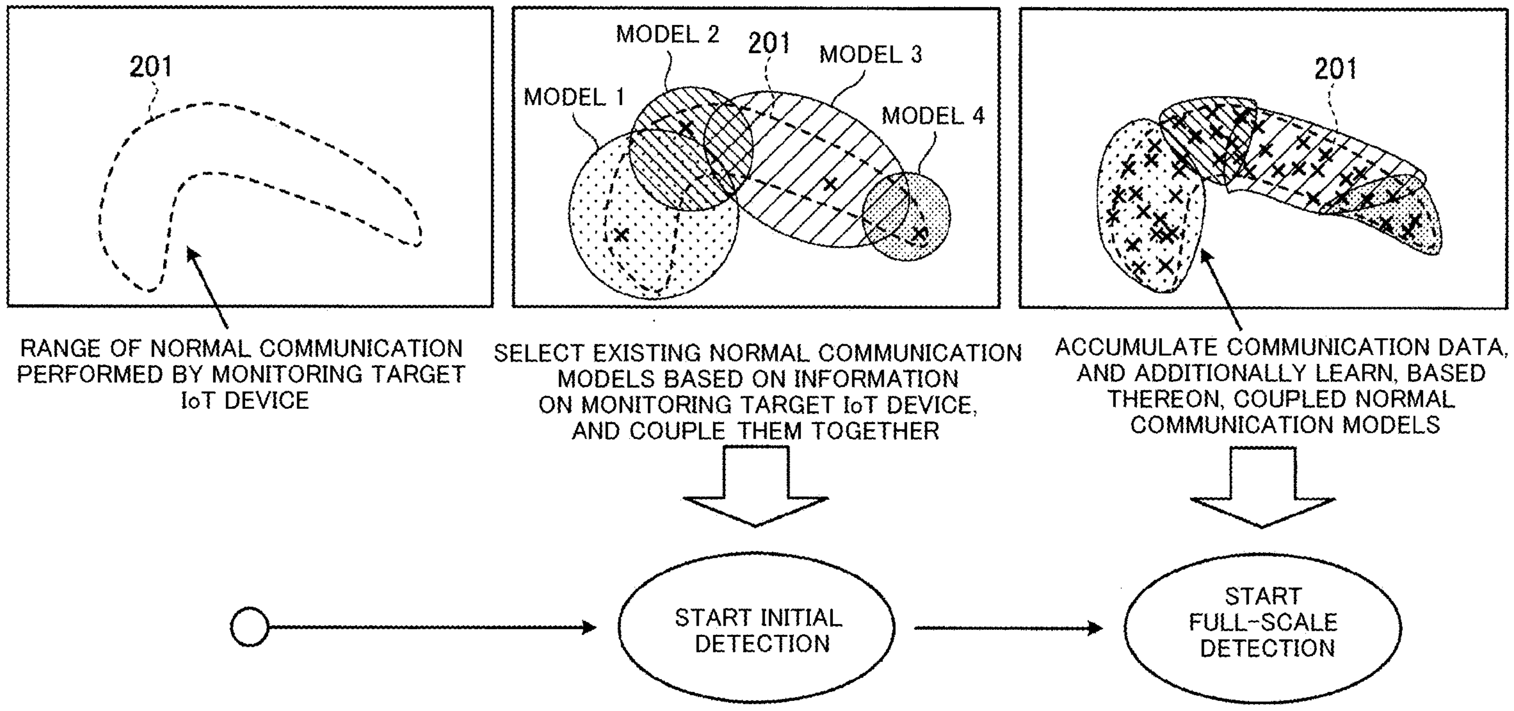

201
MODEL 2
201
MODEL 3
MODEL 1
MODEL 4
201
RANGE OF NORMAL COMMUNICATION PERFORMED BY MONITORING TARGET IoT DEVICE
SELECT EXISTING NORMAL COMMUNICATION MODELS BASED ON INFORMATION ON MONITORING TARGET IoT DEVICE, AND COUPLE THEM TOGETHER
ACCUMULATE COMMUNICATION DATA, AND ADDITIONALLY LEARN, BASED THEREON, COUPLED NORMAL COMMUNICATION MODELS
START INITIAL DETECTION
START FULL-SCALE DETECTION

Fig. 3

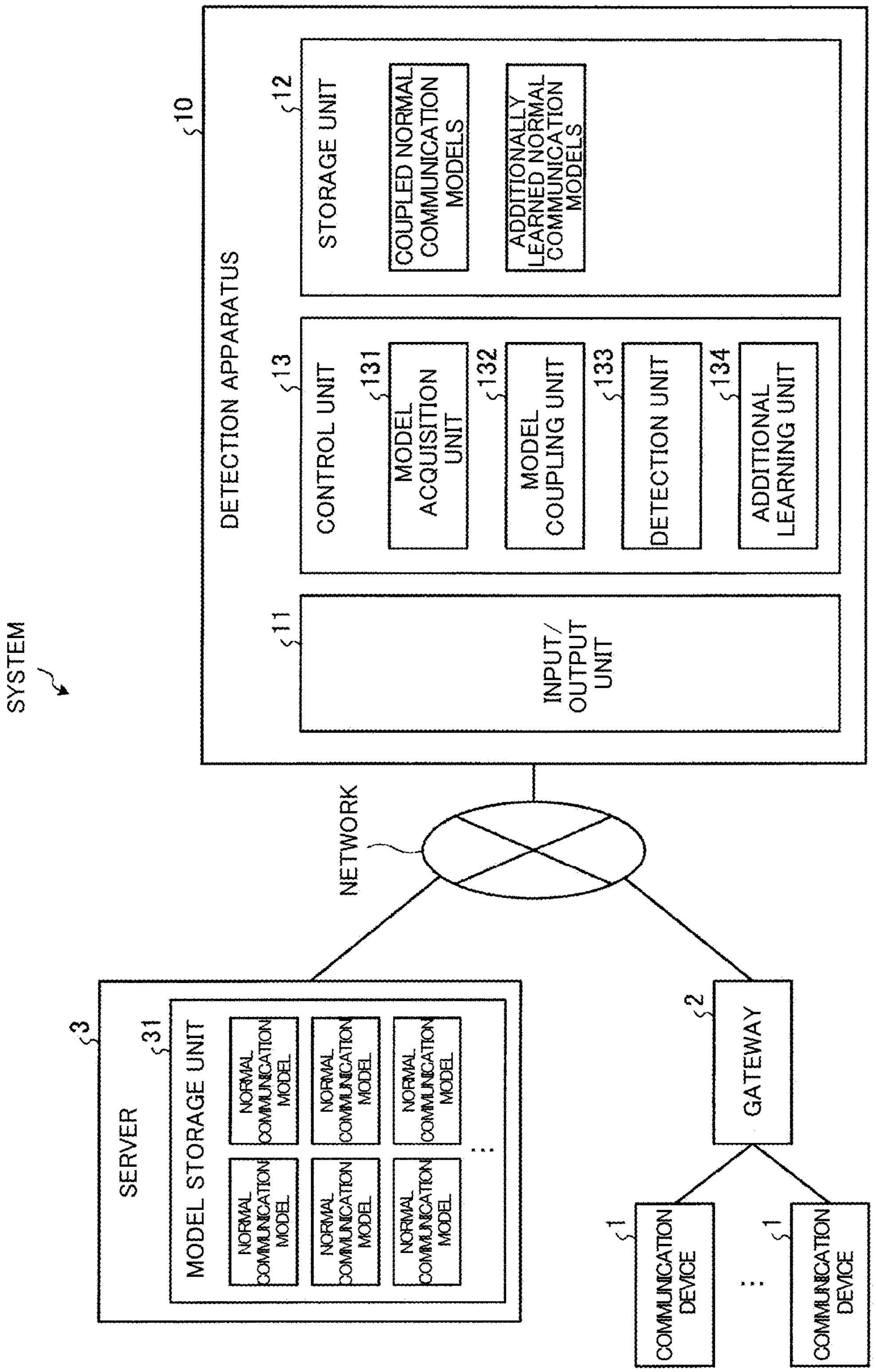

SYSTEM
10
DETECTION APPARATUS
11
INPUT/ OUTPUT UNIT
13
CONTROL UNIT
131
MODEL ACQUISITION UNIT
132
MODEL COUPLING UNIT
133
DETECTION UNIT
134
ADDITIONAL LEARNING UNIT
12
STORAGE UNIT
COUPLED NORMAL COMMUNICATION MODELS
ADDITIONALLY LEARNED NORMAL COMMUNICATION MODELS
NETWORK
3
SERVER
31
MODEL STORAGE UNIT
NORMAL COMMUNICATION MODEL
NORMAL COMMUNICATION MODEL
NORMAL COMMUNICATION MODEL
NORMAL COMMUNICATION MODEL
NORMAL COMMUNICATION MODEL
NORMAL COMMUNICATION MODEL
...
2
GATEWAY
1
COMMUNICATION DEVICE
...
1
COMMUNICATION DEVICE

Fig. 4

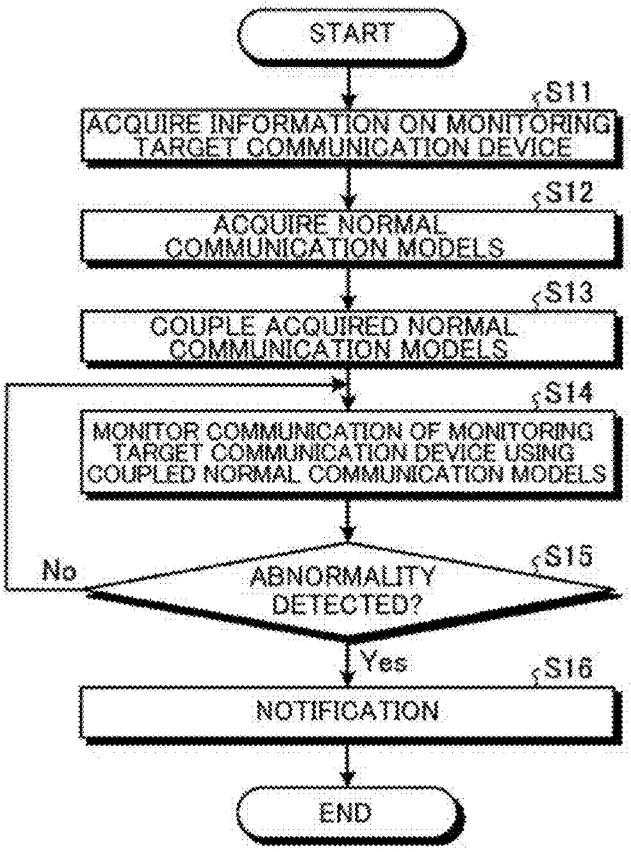

START
S11
ACQUIRE INFORMATION ON MONITORING TARGET COMMUNICATION DEVICE
S12
ACQUIRE NORMAL COMMUNICATION MODELS
S13
COUPLE ACQUIRED NORMAL COMMUNICATION MODELS
S14
MONITOR COMMUNICATION OF MONITORING TARGET COMMUNICATION DEVICE USING COUPLED NORMAL COMMUNICATION MODELS
S15
ABNORMALITY DETECTED?
No
Yes
S16
NOTIFICATION
END

Fig. 5

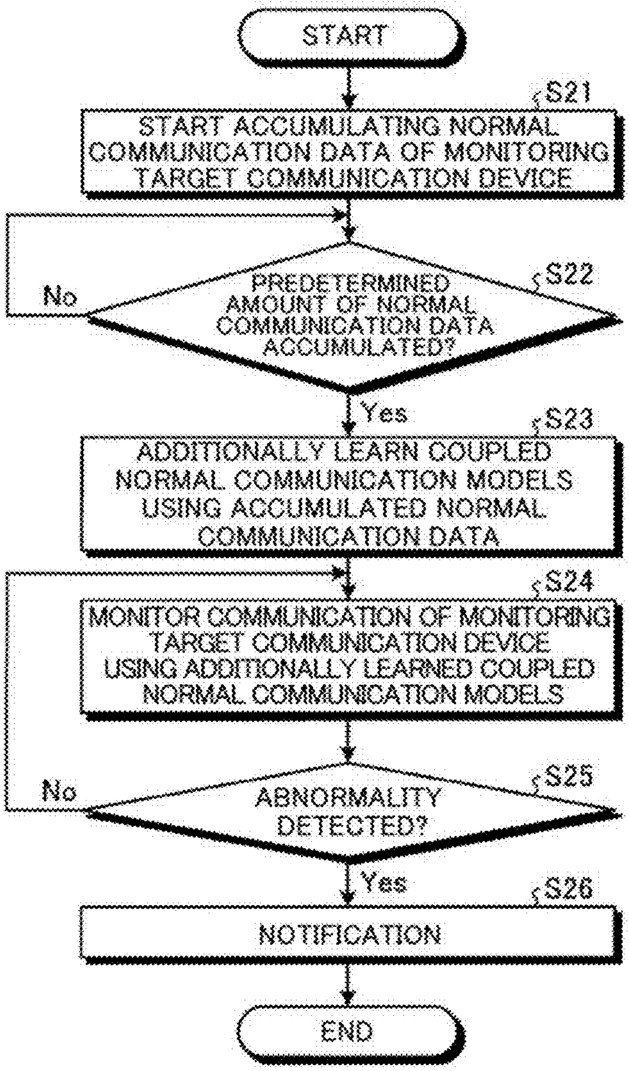
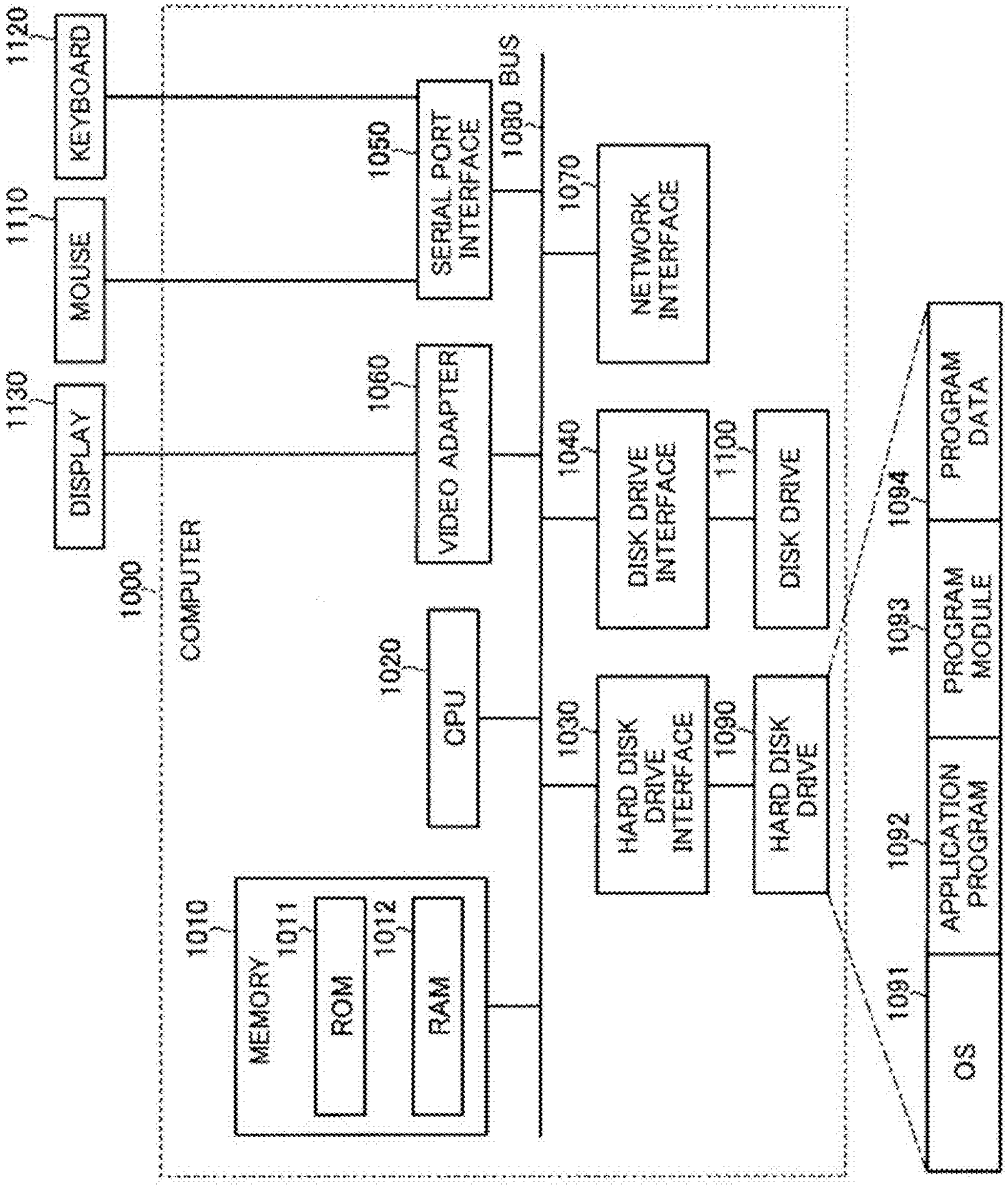

START
S21
START ACCUMULATING NORMAL COMMUNICATION DATA OF MONITORING TARGET COMMUNICATION DEVICE
S22
PREDETERMINED AMOUNT OF NORMAL COMMUNICATION DATA ACCUMULATED?
No
Yes
S23
ADDITIONALLY LEARN COUPLED NORMAL COMMUNICATION MODELS USING ACCUMULATED NORMAL COMMUNICATION DATA
S24
MONITOR COMMUNICATION OF MONITORING TARGET COMMUNICATION DEVICE USING ADDITIONALLY LEARNED COUPLED NORMAL COMMUNICATION MODELS
S25
ABNORMALITY DETECTED?
No
Yes
S26
NOTIFICATION
END

Fig. 6


1000
COMPUTER
1010
MEMORY
1011
ROM
1012
RAM
1020
CPU
1030
HARD DISK DRIVE INTERFACE
1040
DISK DRIVE INTERFACE
1050
SERIAL PORT INTERFACE
1060
VIDEO ADAPTER
1070
NETWORK INTERFACE
1080 BUS
1090
HARD DISK DRIVE
1100
DISK DRIVE
1110
MOUSE
1120
KEYBOARD
1130
DISPLAY
1091
OS
1092
APPLICATION PROGRAM
1093
PROGRAM MODULE
1094
PROGRAM DATA

DETECTION DEVICE, DETECTION METHOD, AND DETECTION PROGRAM

TECHNICAL FIELD

[0001] The present invention relates to a detection apparatus, a detection method, and a detection program that are used to detect abnormality in communication of a communication device.

BACKGROUND ART

[0002] With the coming of the IoT (Internet of Things) era, IoT device-related traffic session abnormality detection systems and intrusion detection systems (IDS) have been investigated as security measures for various devices.

[0003] Some of the above-described abnormality detection systems use a probability density estimator with unsupervised learning, such as a Variational Auto-Encoder (see Non Patent Literature 1).

[0004] For example, the abnormality detection system learns event probabilities of normal communication patterns of IoT devices, and thereby creates probability density estimators (models) for determining normal communication of the IoT devices. Then, the abnormality detection system calculates, using the above-described models, the event probability of communication of each monitoring target IoT device, and detects communication with a small event probability as non-normal communication (abnormal communication). With this measure, it is possible to detect an abnormality in communication even without the knowledge of an erroneous communication pattern. The above-described method is suitable for detection of a cyberattack against an IoT device that cannot know all types of threat information, for example.

CITATION LIST

Non Patent Literature

[0005] [Non Patent Literature 1] Auto-Encoding Variational Bayes, [searched on Nov. 30, 2018], the Internet <URL: https://arxiv.org/abs/1312.6114>

SUMMARY OF THE INVENTION

Technical Problem

[0006] However, when, as described above, a normal communication pattern of a communication device such as an IoT device is learned and a model is created, it is not possible to detect an abnormality in communication of the communication device during a period of time in which the learning is performed for creating the model, and thus the above-described communication device such as an IoT device enters an unsecured state. Moreover, since learning normal communication patterns requires to cover all of the normal communication patterns, the period of time in which learning is performed for model creation often takes long. Accordingly, a period of time in which the communication device is in the unsecured state may also be long.

[0007] Therefore, an object of the present invention is to solve the aforementioned problems, and prevent, during a period of time in which a model for detecting an abnormality in communication of a communication device is learned, the communication device from entering a state (unsecured state) in which it is not being subjected to abnormality detection.

Means for Solving the Problem

[0008] To solve the above-described object, the present invention includes: a model acquisition unit configured to acquire, from a storage unit having stored therein normal communication models for determining, for each function of a communication device, whether or not communication of the communication device having the function is normal, at least one normal communication model that corresponds to a function of a monitoring target communication device; and a detection unit configured to monitor communication of the monitoring target communication device using the acquired normal communication model, and detect an abnormality in the communication.

Effects of the Invention

[0009] According to the present invention, it is possible to prevent, during a period of time in which a model for detecting an abnormality in communication of a communication device is learned, the communication device from entering a state (unsecured state) in which it is not being subjected to abnormality detection.

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. **1** is a diagram illustrating an overview of a detection apparatus.

[0011] FIG. **2** is a diagram illustrating detection by the detection apparatus using coupled normal communication models, and detection using additionally learned normal communication models.

[0012] FIG. **3** is a diagram illustrating an example of a configuration of a system that includes the detection apparatus.

[0013] FIG. **4** is a flowchart illustrating an example of a procedure in which the detection apparatus monitors communication of a monitoring target communication device using coupled normal communication models.

[0014] FIG. **5** is a flowchart illustrating an example of a procedure in which the detection apparatus additionally learns the coupled normal communication models, and monitors communication of a monitoring target communication device using the additionally learned normal communication models.

[0015] FIG. **6** is a diagram illustrating an example of a computer that executes a detection program.

DESCRIPTION OF EMBODIMENTS

[0016] Hereinafter, an aspect (embodiment) for implementing the present invention will be described with reference to the drawings. The present invention is not limited to the below-described embodiment.

[0017] [Overview]

[0018] First, the overview of the detection apparatus **10** according to the present embodiment will be described with reference to FIG. **1**. Here, the description will be given taking a case where communication devices (monitoring target communication devices) that are subjected to abnormality detection by the detection apparatus **10** are IoT devices, as an example. Also, each of the IoT devices is assumed to be connected to the Internet via a gateway.

[0019] First, a system is provided with, for each element (function) constituting an IoT device, models (normal communication models) for determining whether or not the IoT device having this element performs normal communication. The normal communication models are created, for example, by sorting communication information (such as traffic information) when the IoT device performs normal communication according to the element (for example, a camera or a sensor) constituting the IoT device, and using a probability density estimator. The normal communication models are accumulated in, for example, a server (not shown).

[0020] Then, if a new IoT device is added to a monitoring target IoT network, the detection apparatus **10** acquires information on this IoT device from the gateway or the like (S**1**). Note that the information that is acquired here is preferably information that can be acquired immediately from the IoT device such as information regarding the machine type of this IoT device, and communication data (traffic information) on this IoT device during a predetermined period of time, for example. The detection apparatus **10** determines, based on the acquired information on the IoT device, which combination of existing normal communication models accumulated in the server can detect an abnormality in communication of this IoT device (S**2**).

[0021] After S**2**, the detection apparatus **10** acquires, from the server, the normal communication models that can detect an abnormality in the IoT device, couples them together, and starts monitoring communication of the IoT device using the coupled normal communication models (S**3**). In other words, the detection apparatus **10** uses the coupled normal communication models to monitor communication of the IoT device, and detect an abnormality, if any, in communication of the IoT device.

[0022] After S**3**, the detection apparatus **10** absorbs a difference between the coupled normal communication models and actual communication (actual communication of the IoT device), through additional learning (fine-tuning) (S**4**).

[0023] For example, after the start of monitoring communication of the IoT device in S**3**, if it is determined that normal communication data of the IoT device has been sufficiently accumulated, the detection apparatus **10** additionally learns the coupled normal communication models based on the communication data. That is, the detection apparatus **10** additionally learns the coupled normal communication models, so as to be able to perform accurate determination regarding normal communication of the IoT device.

[0024] A case is considered in which, as shown in FIG. **2** for example, the range of normal communication of an IoT device subjected to monitoring by the detection apparatus **10** is a range denoted by the reference numeral **201**. In this case, the detection apparatus **10** selects, based on information on the monitoring target IoT device, existing normal communication models (models **1** to **4** in FIG. **2**), and couples them together. Then, the detection apparatus **10** starts initial detection for communication of the monitoring target IoT device using the coupled normal communication models.

[0025] Here, there is also a case where the range (indicated by the reference numeral **201**) of normal communication performed by the monitoring target IoT device does not match the range of communication determined as normal communication by a model obtained by coupling the models **1** to **4** together. Accordingly, when normal communication data of the monitoring target IoT device has been accumulated, the detection apparatus **10** additionally learns, using this communication data, the coupled normal communication models (models **1** to **4** in FIG. **2**). Then, the detection apparatus **10** starts full-scale detection for communication of the monitoring target IoT device using the additionally learned normal communication model.

[0026] In this way, the detection apparatus **10** first performs initial detection for communication of a monitoring target IoT device using a combination of existing normal communication models. Then, the detection apparatus **10** additionally learns the existing normal communication models based on normal communication data of the IoT device, and then performs full-scale detection for communication of the IoT device using the additionally learned normal communication models. Accordingly, the detection apparatus **10** can prevent the IoT device from entering a state (unsecured state) in which it is not being subjected to abnormality detection during a period of time in which the detection apparatus **10** learns the normal communication models.

[0027] [Configuration]

[0028] The following will describe an example of a configuration of a system including the detection apparatus **10** with reference to FIG. **3**. As shown in FIG. **3** for example, the system includes one or more communication devices **1**, a gateway **2**, a server **3**, and a detection apparatus **10**.

[0029] Each communication device **1** is an apparatus that has a communication function, and is, for example, an IoT device that connects to the Internet via the gateway **2**, and performs communication. The gateway **2** is an apparatus that connects each communication device **1** to a network such as the Internet.

[0030] The server **3** includes a model storage unit **31** in which one or more normal communication models are stored. The normal communication models are models for determining, for each function of the communication device **1**, whether or not communication of the communication device **1** having this function is normal communication. Each normal communication model is realized by, for example, the above-described probability density estimator.

[0031] Examples of the normal communication models include a normal communication model relating to a video delivery communication function, a normal communication model relating to a DHCP (Dynamic Host Configuration Protocol) communication function, a normal communication model relating to a management HTTP (Hyper Text Transfer Protocol) communication function, a normal communication model relating to an NTP (Network Time Protocol) communication function, and a normal communication model relating to a temperature notification MQTT (Message Queue Telemetry Transport) communication function.

[0032] If, for example, the communication device **1** (monitoring target communication device **1**) that is a monitoring target is a network camera, the detection apparatus **10** can determine whether or not communication of the network camera is normal, by combining the normal communication model relating to a video delivery communication function, the normal communication model relating to a DHCP communication function, the normal communication model relating to a management HTTP communication function, the normal communication model relating to an NTP communication function, and the like, the functions being included in the network camera.

[0033] Also, if the monitoring target communication device **1** is an IoT sensor having a temperature sensor, the detection apparatus **10** can determine whether or not communication of the IoT sensor is normal, by combining the normal communication model relating to a DHCP communication function, the normal communication model relating to an NTP communication function, and the like, the functions being included in the IoT sensor.

[0034] Note that these normal communication models may be provided for each protocol used by the communication device **1**, or for each machine-model number of the communication device **1**, for example. The normal communication models may also be provided for each type of the communication device **1** (such as a network camera or a sensor), or for each combination thereof (for example, each "yy" protocol of a device of a machine-model number "xx").

[0035] The detection apparatus **10** includes an input/output unit **11**, a storage unit **12**, and a control unit **13**. The input/output unit **11** serves as an interface when various types of information are transmitted and received via a network. The storage unit **12** stores various types of information required for the control unit **13** to operate. Also, the storage unit **12** stores normal communication models coupled by the control unit **13**, normal communication models additionally learned by the control unit **13**, and the like.

[0036] The control unit **13** performs overall control of the detection apparatus **10**. This control unit **13** includes a model acquisition unit **131**, a model coupling unit **132**, a detection unit **133**, and an additional learning unit **134**.

[0037] The model acquisition unit **131** acquires, from the server **3**, at least one normal communication model that corresponds to the function of the monitoring target communication device **1**. For example, the model acquisition unit **131** acquires, from the monitoring target communication device **1**, information regarding the type and the machine-model number of the communication device **1**, and specifies, based on the information, which functions the communication device **1** has. Then, the model acquisition unit **131** acquires, from the server **3**, a normal communication model that corresponds to each of the specified functions.

[0038] For example, a case is considered in which the monitoring target communication device **1** is a network camera of a machine type A. In this case, the model acquisition unit **131** specifies the video delivery communication function, the DHCP communication function, the management HTTP communication function, and the NTP communication function, as the functions provided for the network camera of the machine type A. From the server **3**, the normal communication models are acquired that relate to the specified functions, namely, the normal communication model relating to the video delivery communication function, the normal communication model relating to the DHCP communication function, the normal communication model relating to the management HTTP communication function, and the normal communication model relating to the NTP communication function are acquired.

[0039] If a plurality of normal communication models are acquired by the model acquisition unit **131**, the model coupling unit **132** will couple these normal communication models together. For example, if as a normal communication model, a probability density function p(x) is used for calculating the probability density that the communication is normal communication with communication (x) by the monitoring target communication device **1** serving as an input, the model coupling unit **132** will add up the probability density functions p(x) of the normal communication models to be coupled together and thereby couple the normal communication models together. For example, the model coupling unit **132** adds up the probability density functions p(x) serving as each normal communication models, using the following Expression (1).

[Math. 1]

$$P_{concat}(x)=1/a+b(ap_1(x)+bp_2(x)),\text{where } a+b=1 \qquad \text{Expression (1)}$$

[0040] The detection unit **133** monitors communication of the monitoring target communication device **1**, and detects an abnormality. For example, the detection unit **133** monitors communication of the monitoring target communication device **1** using normal communication models coupled by the model coupling unit **132**, and detects an abnormality. Note that after the coupled normal communication models have been additionally learned by the additional learning unit **134**, the detection unit **133** monitors communication of the monitoring target communication device **1** using the additionally learned normal communication models, and detects an abnormality.

[0041] The additional learning unit **134** additionally learns the normal communication models using normal communication data of the monitoring target communication device **1**.

[0042] For example, if it is determined that a predetermined amount (an amount for, e.g., one day to one week) of normal communication data of the monitoring target communication device **1** has been accumulated, the additional learning unit **134** additionally learns the coupled normal communication models using the accumulated communication data.

[0043] Note that if a result of analysis of the normal communication data of the monitoring target communication device **1** performed by the additional learning unit **134** shows that the coupled normal communication models include an unnecessary normal communication model, the unnecessary normal communication model may be deleted from the coupled normal communication models.

[0044] With this measure, the additional learning unit **134** can change the coupled normal communication models acquired by the model acquisition unit **131** to a model with a higher detection accuracy.

[0045] The above-described detection apparatus **10** first performs initial detection for communication of a monitoring target IoT device using a combination of existing normal communication models. Then, the detection apparatus **10** additionally learns the existing normal communication models using normal communication data of the IoT device, and then performs full-scale detection for the communication of the IoT device using the additionally learned normal communication models. Accordingly, the detection apparatus **10** can prevent the IoT device from entering a state (unsecured state) in which it is not being subjected to abnormality detection during a period of time in which the detection apparatus **10** learns the normal communication models.

[0046] [Processing Procedure]

[0047] The following will describe an example of a procedure of processing performed by the detection apparatus

10. First, an example of a procedure in which the detection apparatus **10** monitors communication of a monitoring target communication device using coupled normal communication models obtained by coupling normal communication models acquired from the server **3** will be described with reference to FIG. **4**.

[0048] For example, when the model acquisition unit **131** of the detection apparatus **10** acquires information on the monitoring target communication device **1** from the gateway **2** (S**11**), the model acquisition unit **131** acquires, based on the acquired information, normal communication models that correspond to the function of this communication device **1** from among the normal communication models accumulated in the server **3** (S**12**).

[0049] After S**12**, the model coupling unit **132** couples the normal communication models acquired in S**12** (S**13**). Then, the detection unit **133** monitors communication of the monitoring target communication device **1**, using the normal communication models coupled in S**13** (S**14**).

[0050] For example, upon acquiring communication data of the monitoring target communication device **1** from the gateway **2**, the detection unit **133** determines whether or not communication of the communication device **1** is normal, using the above-described coupled normal communication models. Then, if an abnormality in communication of the monitoring target communication device **1** is detected (Yes in S**15**), the detection unit **133** perform notification relating to the detection (S**16**). Also, if no abnormality in communication of the monitoring target communication device **1** is detected by the detection unit **133** (No in S**15**), the procedure returns to S**14**.

[0051] The following will describe an example of a procedure in which, after the processing shown in FIG. **4**, the detection apparatus **10** additionally learns the coupled normal communication models, and monitors communication of the monitoring target communication device using the additionally learned normal communication models, with reference to FIG. **5**.

[0052] After the procedure shown in FIG. **4**, the additional learning unit **134** of the detection apparatus **10** starts accumulating normal communication data of the monitoring target communication device **1** (S**21**), and, if a predetermined amount of normal communication data is accumulated (Yes in S**22**), the additional learning unit **134** additionally learns the coupled normal communication models using the accumulated normal communication data (S**23**).

[0053] After S**24**, the detection unit **133** monitors communication of the monitoring target communication device **1** using the additionally learned coupled normal communication models (S**24**). For example, upon acquiring communication data of the monitoring target communication device **1** from the gateway **2**, the detection unit **133** determines whether or not communication of the communication device **1** is normal, using the additionally learned coupled normal communication models. Then, if an abnormality in communication of the monitoring target communication device **1** is detected (Yes in S**25**), the detection unit **133** performs notification relating to the detection (S**26**). Also, if no abnormality in communication of the monitoring target communication device **1** is detected by the detection unit **133** (No in S**25**), the procedure returns to S**24**.

[0054] With this measure, the detection apparatus **10** can prevent the communication device **1** from entering the state (unsecured state) in which it is not being subjected to abnormality detection while the detection apparatus **10** learns normal communication models relating to communication of the monitoring target communication device **1**.

[0055] Note that the above-described embodiment has described a case where the detection apparatus **10** acquires a plurality of normal communication models from the server **3**, but the number of normal communication models that are acquired may be one. In this case, the detection apparatus **10** does not couple the normal communication model, and the detection unit **133** performs initial detection using the normal communication model acquired from the server **3**. Also, the additional learning unit **134** performs additional learning of the normal communication model acquired from the server **3**. Then, after the above-described additional learning, the detection unit **133** performs full-scale detection using the additionally learned normal communication model.

[0056] [Program]

[0057] Also, a program for realizing the functions of the detection apparatus **10** that have been described in the foregoing embodiment can be implemented by being installed in a desired information processing apparatus (computer). For example, the information processing apparatus can function as the detection apparatus **10** by executing the above-described program provided as package software or online software. The "information processing apparatus" in this context includes a desktop or notebook personal computer, a rack mount server computer, and the like. In addition thereto, the category of the information processing apparatus also includes, for example, a mobile communication terminal such as a smartphone, a cellular phone, and a PHS (Personal Handyphone System), as well as a PDA (Personal Digital Assistant). Also, the detection apparatus **10** may also be implemented on a cloud server.

[0058] The following will describe an example of a computer that executes the above-described program (detection program), with reference to FIG. **6**. As shown in FIG. **6**, the computer **1000** includes, for example, a memory **1010**, a CPU **1020**, a hard disk drive interface **1030**, a disk drive interface **1040**, a serial port interface **1050**, a video adapter **1060**, and a network interface **1070**. These components are connected to each other via a bus **1080**.

[0059] The memory **1010** includes a ROM (Read Only Memory) **1011** and a RAM (Random Access Memory) **1012**. The ROM **1011** stores, for example, a boot program such as a BIOS (Basic Input Output System). The hard disk drive interface **1030** is connected to a hard disk drive **1090**. The disk drive interface **1040** is connected to a disk drive **1100**. For example, a detachable storage medium such as a magnetic disk or an optical disc is inserted into the disk drive **1100**. For example, a mouse **1110** and a keyboard **1120** are connected to the serial port interface **1050**. For example, a display **1130** is connected to the video adapter **1060**.

[0060] Here, as shown in FIG. **6**, the hard disk drive **1090** stores, for example, an OS **1091**, an application program **1092**, a program module **1093**, and program data **1094**. Various types of data and information described in the foregoing embodiment are stored in the hard disk drive **1090** or the memory **1010**, for example.

[0061] Also, the CPU **1020** reads the program module **1093** or the program data **1094** stored in the hard disk drive **1090** onto the RAM **1012** as needed, and executes the above-described procedures.

[0062] Note that the present invention is not limited to the case where the program module **1093** and the program data **1094** according to the above-described detection program are stored in the hard disk drive **1090**, but the program module **1093** and the program data **1094** may be stored in, for example, a detachable storage medium, and read by the CPU **1020** via the disk drive **1100** or the like. Alternatively, the program module **1093** and the program data **1094** according to the above-described program may also be stored in another computer connected via a network such as a LAN or a WAN (Wide Area Network), and read by the CPU **1020** via the network interface **1070**.

REFERENCE SIGNS LIST

[0063] **1** Communication device
[0064] **2** Gateway
[0065] **3** Server
[0066] **10** Detection apparatus
[0067] **11** Input/output unit
[0068] **12** Storage unit
[0069] **13** Control unit
[0070] **131** Model acquisition unit
[0071] **132** Model coupling unit
[0072] **133** Detection unit
[0073] **134** Additional learning unit

1. A detection apparatus comprising:

processing circuitry configured to:

acquire, from a storage having stored therein normal communication models for determining, for each function of a communication device, whether or not communication of the communication device having the function is normal, at least one normal communication model that corresponds to a function of a monitoring target communication device; and

monitor communication of the monitoring target communication device using the acquired normal communication model, and detect an abnormality in the communication.

2. The detection apparatus according to claim **1**, wherein the processing circuitry is further configured to:

additionally learn the acquired normal communication model using communication data on normal communication of the monitoring target communication device, and

monitor communication of the monitoring target communication device using the additionally learned normal communication model, and detect the abnormality in the communication.

3. The detection apparatus according to claim **1**, wherein the processing circuitry is further configured to:

couple, if a plurality of normal communication models are acquired, the plurality of acquired normal communication models, and

monitor communication of the monitoring target communication device using the coupled normal communication models, and detect the abnormality in the communication.

4. The detection apparatus according to claim **3**, wherein

the normal communication models each include a probability density function of calculating a probability density that communication of the communication device having the function is normal communication, and

the processing circuitry is further configured to couple the normal communication models by adding up the probability density functions respectively included in the acquired normal communication models.

5. The detection apparatus according to claim **3**, wherein the processing circuitry is further configured to:

additionally learn the coupled normal communication models using communication data on normal communication of the monitoring target communication device, and

monitor communication of the monitoring target communication device using the additionally learned coupled normal communication models, and detect the abnormality in the communication.

6. A detection method comprising:

acquiring, from a storage having stored therein normal communication models for determining, for each function of a communication device, whether or not communication of the communication device having the function is normal, at least one normal communication model that corresponds to a function of a monitoring target communication device; and

monitoring communication of the monitoring target communication device using the acquired normal communication model, and detecting an abnormality in the communication, by processing circuitry.

7. A non-transitory computer-readable recording medium storing therein a detection program that causes a computer to execute a process comprising:

acquiring, from a storage having stored therein normal communication models for determining, for each function of a communication device, whether or not communication of the communication device having the function is normal, at least one normal communication model that corresponds to a function of a monitoring target communication device; and

monitoring communication of the monitoring target communication device using the acquired normal communication model, and detecting an abnormality in the communication.

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