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COMMUNICATION SYSTEM, INTEGRATED CONTROLLER, CONTROL APPARATUS AND SWITCHING METHOD

Abstract

A communication system that includes a plurality of cloud resources, and a plurality of communication devices provided on a path for using any one of the plurality of cloud resources, the communication system including: a cloud controller that collects cloud information regarding the plurality of cloud resources from each of the plurality of cloud resources and performs setting change of the plurality of cloud resources; a network controller that collects NW information regarding the plurality of communication devices and a network formed by the plurality of communication devices from each of the plurality of communication devices and gives an instruction for path switching in the plurality of communication devices; and an integrated controller that collects the cloud information from the cloud controller, collects the NW information from the network controller, and gives at least one of an instruction for setting change of the cloud resources to the cloud controller or an instruction for path switching to the network controller on the basis of the cloud information and the NW information collected.

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Background/Summary

[0001] The present application claims priority on the basis of PCT/JP2022/006351 filed in Japan on Feb. 17, 2022, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a communication system, an integrated controller, a control device, and a switching method.

BACKGROUND ART

[0003] FIG. 10 is a diagram illustrating a configuration example of a conventional communication system 1. The communication system 1 includes a terminal device 2, a plurality of communication devices 3-1 to 3-4, and a plurality of cloud resources 4-1 to 4-2. The terminal device 2 is a user terminal used by a user. The plurality of communication devices 3-1 to 3-4 are relay devices that transfer signals between the terminal device 2 and the cloud resources 4-1 to 4-2. The cloud resource 4-1 is a resource for providing a cloud service. For example, the cloud resource 4-1 may be a server, a database, or a storage. The cloud resource 4-2 is a spare resource used in a case where the cloud resource 4-1 cannot be used due to a failure or the like.

[0004] In the communication system 1 illustrated in FIG. 10, in a case where the user uses the cloud resource 4-1, it is necessary to secure a network from a use base (for example, the terminal device 2) to the cloud resource 4-1 separately from securing the cloud resource 4-1. It is assumed that a failure occurs in a section between the communication device 3-1 and the communication device 3-2 in a situation where the user uses a cloud resource via a path indicated by a dotted line 5 (the terminal device 2 ⇔ the communication device 3-1 ⇔ the communication device 3-2 ⇔ the cloud resource 4-1). Since this is a failure of the network, in this case, it is conceivable to search for a detour path and secure a path of the terminal device 2 ⇔ the communication device 3-1 ⇔ the communication device 3-4 ⇔ the communication device 3-3 ⇔ the communication device 3-2 ⇔ the cloud resource 4-1 as a new communication path to restore communication. However, there is a risk that a path delay increases in some cases.

[0005] In a case where the communication device 3-2 fails, a path to the cloud resource 4-1 cannot be secured, and the user cannot use the cloud resource 4-1. Further, in a case where a large-scale failure occurs in the cloud resource 4-1 and another resource in the base cannot be used, switching is performed to the cloud resource 4-2 provided in another base. However, in that case, resetting of the path is required separately from switching of the cloud resources.

CITATION LIST

Patent Literature

[0006] Patent Literature 1: JP 2010-68139 A

SUMMARY OF INVENTION

Technical Problem

[0007] In a conventional technology, since a redundancy function of a cloud resource and a redundancy configuration of a network are independent of each other, optimization is achieved for

the cloud resource or the network alone. For that reason, in a case where it is necessary to change a configuration depending on occurrence of a failure or a change in a facility or a user usage status, it is necessary to perform switching of cloud resources and networks by a cloud controller that performs setting change of the cloud resource and a network controller that performs setting change of the network in conjunction with each other. However, in the conventional method, since the controllers are not in conjunction with each other, there has been a case where a delay is increased or continuous provision of a service becomes difficult.

[0008] In view of the above circumstances, an object of the present invention is to provide a technology capable of achieving continuous provision of a service while suppressing a delay.

Solution to Problem

[0009] An aspect of the present invention is a communication system that includes a plurality of cloud resources, and a plurality of communication devices provided on a path for using any one of the plurality of cloud resources, the communication system including: a cloud controller that collects cloud information regarding the plurality of cloud resources from each of the plurality of cloud resources and performs setting change of the plurality of cloud resources; a network controller that collects NW information regarding the plurality of communication devices and a network formed by the plurality of communication devices from each of the plurality of communication devices and gives an instruction for path switching in the plurality of communication devices; and an integrated controller that collects the cloud information from the cloud controller, collects the NW information from the network controller, and gives at least one of an instruction for setting change of the cloud resources to the cloud controller or an instruction for path switching to the network controller on the basis of the cloud information and the NW information collected.

[0010] An aspect of the present invention is an integrated controller including: a first information collection unit that collects cloud information from a cloud controller that collects the cloud information regarding a plurality of cloud resources from each of the plurality of cloud resources and performs setting change of the plurality of cloud resources; a second information collection unit that collects NW information from a network controller that collects the NW information regarding a plurality of communication devices provided on a path for using any one of the plurality of cloud resources and a network formed by the plurality of communication devices from each of the plurality of communication devices and gives an instruction for path switching in the plurality of communication devices; and a switching instruction unit that gives at least one of an instruction for setting change of the cloud resources to the cloud controller or an instruction for path switching to the network controller on the basis of the cloud information collected by the first information collection unit and the NW information collected by the second information collection unit.

[0011] An aspect of the present invention is a control device including: a switching determination unit that determines whether or not switching of at least one of cloud resources or communication paths is necessary on the basis of both cloud information regarding a plurality of cloud resources and NW information regarding a plurality of communication devices provided on a path for using any one of the plurality of cloud resources and a network formed by the plurality of communication devices; a switching destination determination unit that determines an optimal switching destination on the basis of a determination result by the switching determination unit, the cloud information, and the NW information; and a switching instruction unit that gives at least one of an instruction for setting change of the cloud resources or an instruction for switching of the communication paths to perform switching to the optimal switching destination determined by the switching destination determination unit.

[0012] An aspect of the present invention is a switching method in a communication system that includes a plurality of cloud resources, and a plurality of communication devices provided on a path for using any one of the plurality of cloud resources, the switching method including:

collecting cloud information regarding the plurality of cloud resources from each of the plurality of cloud resources and performing setting change of the plurality of cloud resources; collecting NW information regarding the plurality of communication devices and a network formed by the plurality of communication devices from each of the plurality of communication devices and giving an instruction for path switching in the plurality of communication devices; and collecting the cloud information and the NW information, and giving at least one of an instruction for setting change of the cloud resources or an instruction for path switching on the basis of the cloud information and the NW information collected.

Advantageous Effects of Invention

[0013] According to the present invention, it is possible to achieve continuous provision of a service while suppressing a delay.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0014] FIG. 1 is a diagram illustrating a configuration example of a communication system in a first embodiment.

[0015] FIG. 2 is a diagram illustrating an example of functional configurations of a cloud controller, a network controller, and an integrated controller in the first embodiment.

[0016] FIG. 3 is a sequence diagram illustrating a flow of processing performed by the communication system in the first embodiment.

[0017] FIG. 4 is a diagram illustrating a configuration example of a communication system in a modification.

[0018] FIG. 5 is a diagram illustrating an example of functional configurations of a cloud controller, a network controller, and an integrated controller in a second embodiment.

[0019] FIG. 6 is a sequence diagram illustrating a flow of processing performed by a communication system in the second embodiment.

[0020] FIG. 7 is a flowchart illustrating a flow of switching destination determination processing performed by the integrated controller in the second embodiment.

[0021] FIG. 8 is a diagram illustrating an example of functional configurations of a cloud controller and a network controller in a third embodiment.

[0022] FIG. 9 is a diagram illustrating an example of functional configurations of a cloud controller and a network controller in a fourth embodiment.

[0023] FIG. 10 is a diagram illustrating a configuration example of a conventional communication system.

DESCRIPTION OF EMBODIMENTS

[0024] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

First Embodiment

[0025] FIG. 1 is a diagram illustrating a configuration example of a communication system **100** in a first embodiment. The communication system **100** includes a terminal device **10**, a plurality of communication devices **20-1** to **20-4**, a plurality of cloud resources **30-1** to **30-2**, a cloud controller **40**, a network controller **50**, and an integrated controller **60**. Note that, in the following description, the communication devices **20-1** to **20-4** will be referred to as communication devices **20** unless otherwise distinguished, and the cloud resources **30-1** to **30-2** will be referred to as cloud resources **30** unless otherwise distinguished. The numbers of pieces of the terminal device **10**, the communication devices **20**, and the cloud resources **30** included in the communication system **100** are not limited to the numbers of pieces illustrated in FIG. 1.

[0026] In the communication system **100** illustrated in FIG. 1, an example is illustrated in which

the communication devices **20-1** to **20-4** form a ring network, the terminal device **10** is connected to the communication device **20-1**, the cloud resource **30-1** is connected to the communication device **20-2**, and the cloud resource **30-2** is connected to the communication device **20-4**. Further, in the communication system **100**, each cloud resource **30** is connected to the cloud controller **40**, the network controller **50** is connected to each communication device **20**, and the integrated controller **60** is connected to the cloud controller **40** and the network controller **50**.

[0027] The terminal device **10** is a user terminal used by a user, and is, for example, a device that receives provision of a service by the cloud resource **30-1** or **30-2**.

[0028] The communication device **20** is a relay device that transfers a signal between the terminal device **10** and the cloud resources **30**. The communication device **20** changes settings of a signal transfer path and the like in response to an instruction from the network controller **50**. Changing the setting of the signal transfer path means, for example, switching signal transfer paths.

[0029] The cloud resource **30-1** is a resource for providing a cloud service. The cloud resource **30-1** may be, for example, a server including at least one of a central processing unit (CPU), a graphics processing unit (GPU), a field programmable gate array (FPGA), or the like, or may be a database or a storage having a memory. The cloud resource **30-1** is only required to be a resource that performs some processing on the communication data of the user. The cloud resource **30-1** changes a setting of a resource to be allocated to the terminal device **10** in response to an instruction from the cloud controller **40**. Changing the setting of resource allocation means, for example, changing an amount of resource allocation.

[0030] The cloud resource **30-2** is a spare resource used instead of the cloud resource **30-1**. A case of being used instead of the cloud resource **30-1** is, for example, a case where a condition of setting change of the cloud resources **30** is satisfied, such as a case where the cloud resource **30-1** fails, a case where a failure (in FIG. 1, for example, a failure of the communication device **20-2**, disconnection of a path to the communication device **20-2**, or the like) occurs in a path for using the cloud resource **30-1**, a case where a delay is less in using the cloud resource **30-2** than in using the cloud resource **30-1**, or a case where a CPU usage rate is greater than or equal to a threshold. The condition of setting change of the cloud resources **30** is a condition for switching a cloud resource **30** used by the terminal device **10** to another cloud resource **30** or changing the amount of resource allocation. The cloud resource **30-2** may be, for example, a server, a database, or a storage. The cloud resource **30-2** changes a setting of a resource to be allocated to the terminal device **10** in response to an instruction from the cloud controller **40**.

[0031] The cloud controller **40** is a control device that sets and monitors the cloud resources **30**. The cloud controller **40** collects information regarding the cloud resources **30** and notifies the integrated controller **60** of the collected information. A trigger for the cloud controller **40** to transmit the information regarding the cloud resources **30** to the integrated controller **60** may be periodic or only in a case where a predetermined condition is satisfied. In a case where an instruction to change the cloud resources **30** is obtained from the integrated controller **60**, the cloud controller **40** gives an instruction for setting change to the cloud resources **30**. For example, in a case where an instruction to change a cloud resource **30** to be used by the terminal device **10** is obtained, the cloud controller **40** performs setting of a resource to be allocated to the terminal device **10** for the cloud resource **30** to be used by the terminal device **10**.

[0032] The network controller **50** sets and monitors the communication devices **20** and monitors the network. Setting the communication devices **20** is setting signal transfer paths. Monitoring the communication devices **20** is monitoring whether or not failures occur in the communication devices **20** and usage statuses of the communication devices **20**. Monitoring the network is monitoring whether a failure (for example, disconnection or the like) or congestion occurs in the network or monitoring a band usage rate, a transfer delay, or the like. The network controller **50** collects information regarding the communication devices **20** and the network, and notifies the integrated controller **60** of the collected information. A trigger for the network controller **50** to

transmit the information regarding the network to the integrated controller **60** may be periodic or only in a case where a predetermined condition is satisfied. In a case where an instruction for path switching is obtained from the integrated controller **60**, the network controller **50** gives an instruction for switching of the paths to a communication device **20** for which switching of the paths is necessary.

[0033] Depending on the information obtained from the cloud controller **40** and the network controller **50**, the integrated controller **60** determines optimal cloud resource arrangement and network path in consideration of usage statuses of the cloud resources **30** and a usage status of the network. The integrated controller **60** instructs at least one of the cloud controller **40** or the network controller **50** to perform switching depending on the determined cloud resource arrangement and network path.

[0034] The communication system **100** in the first embodiment is a system for performing total delay guarantee in a case where the user uses a cloud resource via a network. Specifically, in the communication system **100**, in a situation where the cloud resource and the network are used in conjunction with each other, the cloud controller **40** and the network controller **50** perform switching of the cloud resources **30** and networks in conjunction with each other when a configuration change is necessary depending on occurrence of a failure or a change in a facility or user usage status.

[0035] Here, for example, the following three patterns are assumed as situations in which the configuration change is necessary. A first pattern is a case where it is necessary to change the cloud resource to another base. A second pattern is a case where it is necessary to switch network paths. A third pattern is a case where a communication device to be used is changed, for example, a user terminal (for example, the terminal device **10**) is connected in a wireless environment. In other words, the third pattern is a case where the communication device used (connected) by the user terminal is changed in an environment such as where the user terminal is connected in a wireless environment.

[0036] In the communication system **100** in the first embodiment, in the case of the first pattern (due to the cloud resource), the cloud controller **40** notifies the integrated controller **60** of an event, and the integrated controller **60** instructs the cloud controller **40** to change the cloud resources and instructs the network controller **50** to switch the paths, whereby linked switching is performed. Here, the first pattern (due to the cloud resource) is a case where an event due to the cloud resource **30-1** occurs, such as a case where the CPU usage rate of the cloud resources **30-1** is greater than or equal to the threshold.

[0037] In the communication system **100** in the first embodiment, in the case of the second pattern (due to the network), the network controller **50** notifies the integrated controller **60** of an event, and the integrated controller **60** instructs the cloud controller **40** to change the cloud resources and instructs the network controller **50** to switch the paths, whereby linked switching is performed. Here, the second pattern (due to the network) is a case where an event due to the network path occurs, such as a failure of the communication device **20** (for example, a failure of the communication device **20-2**), an increase in delay in the path due to network congestion, or a disconnection of the path (for example, failure of the path to the communication device **20-2**).

[0038] In the communication system **100** in the first embodiment, in the case of the third pattern (due to the user), the network controller **50** notifies the integrated controller **60** of an event, and the integrated controller **60** instructs the cloud controller **40** to change the cloud resources and instructs the network controller **50** to switch the paths, whereby linked switching is performed. Here, the third pattern (due to the user) is a case where an event due to the user occurs, such as a case where the communication device to which the terminal device **10** is connected by wireless communication is changed from the communication device **20-1** to the communication device **20-4**.

[0039] As described above, the integrated controller **60** gives an instruction for switching to the cloud controller **40** and the network controller **50**, whereby the cloud controller **40** and the network

controller **50** can operate in conjunction with each other. As a result, the delay can be minimized. Note that, in a case where it is not necessary to perform switching by either the cloud controller **40** or the network controller **50**, the integrated controller **60** is only required to give an instruction for switching only to a controller for which switching is necessary.

[0040] Hereinafter, a description will be given of a specific configuration of the communication system **100** for achieving the above operation.

[0041] FIG. **2** is a diagram illustrating an example of functional configurations of the cloud controller **40**, the network controller **50**, and the integrated controller **60** in the first embodiment. First, the functional configuration of the cloud controller **40** will be described.

[0042] The cloud controller **40** includes a cloud information collection unit **41** and a switching instruction unit **42**. The cloud information collection unit **41** collects, from each cloud resource **30**, cloud information such as a cloud usage status (whether or not the cloud is being used), a CPU usage rate, an amount of free resources, and a processing delay time.

[0043] The switching instruction unit **42** instructs the cloud resource **30** to change the setting in response to an instruction transmitted from integrated controller **60**.

[0044] Next, the functional configuration of the network controller **50** will be described.

[0045] The network controller **50** includes an NW information collection unit **51** and a switching instruction unit **52**. The NW information collection unit **51** collects NW information from each communication device **20**. The NW information is information regarding the communication devices **20** and a network formed by the communication devices **20-1** to **20-4**, and includes, for example, information such as a usage status of each device, a band usage rate, and a transfer delay. Note that the NW information collection unit **51** may collect an end-to-end delay time including a network delay and a cloud delay measured by the terminal device **10** via the communication devices **20**. The switching instruction unit **52** instructs the communication devices **20** to change the setting in response to an instruction transmitted from the integrated controller **60**.

[0046] Next, the functional configuration of the integrated controller **60** will be described.

[0047] The integrated controller **60** includes an information collection unit **61**, a switching determination unit **62**, an information collection unit **63**, a switching determination unit **64**, a switching destination determination unit **65**, and a switching instruction unit **66**.

[0048] The information collection unit **61** collects cloud information from the cloud controller **40**. The information collection unit **61** outputs, to the switching determination unit **62**, determination information (for example, failure information on the cloud resource **30**, delay information in the cloud resource **30**, and a CPU usage rate of the cloud resource **30**) necessary for determination of switching in the collected cloud information, and outputs, to the switching destination determination unit **65**, other information (for example, setting information on the cloud resource **30** and resource information on a redundant facility (cloud resource **30-2**)).

[0049] The switching determination unit **62** determines whether or not switching is necessary on the basis of the determination information output from the information collection unit **61**. In a case where it is determined that switching is necessary, the switching determination unit **62** notifies the switching destination determination unit **65** that switching of the cloud resources **30** is necessary. The switching determination unit **62** is an aspect of a cloud switching determination unit.

[0050] The information collection unit **63** collects NW information from the network controller **50**. The information collection unit **63** outputs, to the switching determination unit **64**, determination information (for example, failure information on the communication devices **20** or the network, delay information on the network, and CPU usage rates of the communication devices **20**) necessary for determination of switching in the collected NW information, and outputs, to the switching destination determination unit **65**, other information (for example, setting information on the communication devices **20**).

[0051] The switching determination unit **64** determines whether or not switching is necessary on the basis of the determination information output from the information collection unit **63**. In a case

where it is determined that switching is necessary, the switching determination unit **64** notifies the switching destination determination unit **65** that setting of the communication devices **20** and switching of the paths are necessary. The switching determination unit **64** is an aspect of a path switching determination unit.

[0052] The switching destination determination unit **65** determines an optimal switching destination on the basis of the information obtained from the information collection unit **61**, the switching determination unit **62**, the information collection unit **63**, and the switching determination unit **64**. When determining the optimal switching destination, the switching destination determination unit **65** grasps the usage statuses of the cloud resources and the communication devices **20**, and switches at least one of the cloud resources **30** or the communication paths. The switching destination determination unit **65** is only required to determine the optimal switching destination by using a method of performing measurement by a total delay time, or a method in which resources of the cloud and the communication facility are converted into cost and a value of the cost is minimized.

[0053] The switching instruction unit **66** notifies the cloud controller **40** of new cloud resource information and notifies the network controller **50** of new path information on the basis of information regarding the optimal switching destination determined by the switching destination determination unit **65** (Hereinafter referred to as “switching destination information”).

[0054] FIG. **3** is a sequence diagram illustrating a flow of processing performed by the communication system **100** in the first embodiment.

[0055] The cloud information collection unit **41** of the cloud controller **40** collects cloud information (step **S101**). The cloud information collection unit **41** notifies the integrated controller **60** of the collected cloud information (step **S102**). The NW information collection unit **51** of the network controller **50** collects NW information (step **S103**). The NW information collection unit **51** notifies the integrated controller **60** of the collected NW information (step **S104**).

[0056] The integrated controller **60** collects the information of which notification is performed from each of the cloud controller **40** and the network controller **50** (step **S105**). Specifically, the information collection unit **61** collects the cloud information of which notification is performed from the cloud controller **40**. The information collection unit **63** collects the NW information of which notification is performed from the network controller **50**. The information collection unit **61** outputs determination information in the collected cloud information to the switching determination unit **62**, and outputs other information to the switching destination determination unit **65**. The information collection unit **63** outputs determination information in the collected NW information to the switching determination unit **64**, and outputs other information to the switching destination determination unit **65**.

[0057] The switching determination unit **62** and the switching determination unit **64** determine whether or not switching is necessary on the basis of the determination information (step **S106**). Specifically, the switching determination unit **62** determines whether or not switching of the cloud resources **30** is necessary on the basis of the determination information included in the cloud information obtained from the information collection unit **61**, and the switching determination unit **64** determines whether or not switching of transfer paths is necessary on the basis of the determination information included in the NW information obtained from the information collection unit **63**. Here, it is assumed that the integrated controller **60** determines that switching of both the cloud resources **30** and the paths is necessary.

[0058] In this case, the switching destination determination unit **65** determines an optimal switching destination on the basis of the information output from the information collection unit **61** and the information output from the information collection unit **63** (step **S107**). Specifically, the switching destination determination unit **65** determines an optimal arrangement of a cloud resource and an optimal network path for using the resource as the optimal switching destination. The switching destination determination unit **65** outputs switching destination information to the

switching instruction unit **66**.

[0059] The switching instruction unit **66** generates a switching instruction on the basis of the switching destination information output from the switching destination determination unit **65** (step **S108**). Specifically, the switching instruction unit **66** generates a cloud switching instruction including information regarding the cloud resources **30** and an NW switching instruction including the information regarding the network paths by using information included in the switching destination information. The switching instruction unit **66** notifies the network controller **50** of the NW switching instruction (step **S109**), and notifies the cloud controller **40** of the cloud switching instruction (step **S110**).

[0060] The switching instruction unit **52** of the network controller **50** gives an instruction for switching of the paths of the network to a corresponding communication device **20** in response to the NW switching instruction of which notification is performed from the integrated controller **60** (step **S111**). The switching instruction unit **42** of the cloud controller **40** gives an instruction for switching of the amount of resource allocation to the cloud resource **30** in response to the cloud switching instruction of which notification is performed from the integrated controller **60** (step **S112**).

[0061] Note that, in the processing of step **S106**, a case has been described where the integrated controller **60** determines that switching of both the cloud resources **30** and the paths is necessary, as an example; however, the integrated controller **60** may determine that switching of either the cloud resources **30** or the paths is necessary. Even in a case where the integrated controller **60** determines that switching of either the cloud resources **30** or the paths is necessary, there is a case where both the cloud resources **30** and the paths are switched as a result depending on the optimal switching destination. An example thereof will be described later.

[0062] In a case where it is determined that switching of both the cloud resources **30** and the paths is not necessary, the integrated controller **60** ends the processing of FIG. **3**.

[0063] As an example of the processing of the sequence diagram illustrated in FIG. **3**, a description will be given of processing in the case of each of the first pattern to the third pattern described above. Here, as a premise, it is assumed that the terminal device **10** uses the cloud resource **30-1** with a path via the communication device **20-1** and the communication device **20-2**.

(Example of First Pattern: Case where it is Necessary to Change Cloud Resource to Another Base)

[0064] In a case where an event due to the cloud resource **30-1** occurs, such as a case where the CPU usage rate of the cloud resource **30-1** is greater than or equal to the threshold, the switching determination unit **62** of the integrated controller **60** can specify the event due to the cloud resource **30-1** on the basis of the cloud information collected by the information collection unit **61**, and thus, determines that the switching of the cloud resources **30** is necessary. On the other hand, since the event due to the cloud resource **30-1** cannot be specified with the NW information collected by the information collection unit **63**, the switching determination unit **64** of the integrated controller **60** determines that the setting of the communication devices **20** and the switching of the paths are not necessary.

[0065] In this case, the switching destination determination unit **65** determines the following switching destination as the optimal switching destination on the basis of the information obtained from the information collection unit **61**, the switching determination unit **62**, the information collection unit **63**, and the switching determination unit **64**. For example, the switching destination determination unit **65** determines the cloud resource **30-2** as the optimal switching destination for the cloud resource **30** to be used by the terminal device **10**. In this case, the switching destination determination unit **65** determines that a path via the communication devices **20-1** and **20-4** is an optimal path as a path for the terminal device **10** to use the cloud resource **30-2**. Then, the switching destination determination unit **65** outputs, to the switching instruction unit **66**, information on the cloud resource **30-2** as the switching destination cloud resource **30**, and switching destination information including information on the communication devices **20-1** and

20-4 as the switching destination path.

[0066] The switching instruction unit **66** notifies the cloud controller **40** of new cloud resource information and notifies the network controller **50** of new path information on the basis of the switching destination information output from the switching destination determination unit **65**. The switching instruction unit **42** of the cloud controller **40** changes the setting for the cloud resource **30-2** depending on the cloud resource information of which notification is performed. The switching instruction unit **52** of the network controller **50** changes the settings for the communication devices **20-1** and **20-4** depending on the path information of which notification is performed.

[0067] As described above, information obtained from the cloud controller **40** and the network controller **50** is considered in the integrated controller **60**, whereby the cloud resources and the paths can be switched in conjunction with each other even in a case where it is determined that switching is not necessary in one of them. As a result, the terminal device **10** can receive service provision by the cloud resource **30-2** while reducing the delay.

(Example of Second Pattern: Case where it is Necessary to Switch Network Paths)

[0068] In a case where an event due to a network path occurs, such as a failure of the communication device **20** (for example, a failure of the communication device **20-2**), an increase in delay in a path due to network congestion, or a disconnection of a path (for example, failure of a path to the communication device **20-2**), the switching determination unit **62** of the integrated controller **60** determines that there is no switching of the cloud resources **30** since the event due to the network path cannot be specified with the cloud information collected by the information collection unit **61**. On the other hand, since the switching determination unit **64** of the integrated controller **60** can specify the event due to the network path on the basis of the NW information collected by the information collection unit **63**, it is determined that setting of the communication devices **20** and switching of the paths are necessary.

[0069] In this case, the switching destination determination unit **65** determines the following switching destination as the optimal switching destination on the basis of the information obtained from the information collection unit **61**, the switching determination unit **62**, the information collection unit **63**, and the switching determination unit **64**. For example, the switching destination determination unit **65** determines the cloud resource **30-2** as the optimal switching destination for the cloud resource **30** to be used by the terminal device **10**. In this case, the switching destination determination unit **65** determines that a path via the communication devices **20-1** and **20-4** is an optimal path as a path for the terminal device **10** to use the cloud resource **30-2**. Then, the switching destination determination unit **65** outputs, to the switching instruction unit **66**, information on the cloud resource **30-2** as the switching destination cloud resource **30**, and switching destination information including information on the communication devices **20-1** and **20-4** as the switching destination path.

[0070] The switching instruction unit **66** notifies the cloud controller **40** of new cloud resource information and notifies the network controller **50** of new path information on the basis of the switching destination information output from the switching destination determination unit **65**. The switching instruction unit **42** of the cloud controller **40** changes the setting for the cloud resource **30-2** depending on the cloud resource information of which notification is performed. The switching instruction unit **52** of the network controller **50** changes the settings for the communication devices **20-1** and **20-4** depending on the path information of which notification is performed.

[0071] As described above, information obtained from the cloud controller **40** and the network controller **50** is considered in the integrated controller **60**, whereby the cloud resources and the paths can be switched in conjunction with each other even in a case where it is determined that switching is not necessary in one of them. As a result, the terminal device **10** can receive service provision by the cloud resource **30-2** while reducing the delay.

(Example of Third Pattern: Case where Communication Device to be Used is Changed)

[0072] In a case where an event due to the user occurs, such as a case where the communication device to which the terminal device **10** is connected by wireless communication is changed from the communication device **20-1** to the communication device **20-4**, the switching determination unit **62** of the integrated controller **60** determines that there is no switching of the cloud resources **30** since the event due to the network path cannot be specified with the cloud information collected by the information collection unit **61**. On the other hand, since the switching determination unit **64** of the integrated controller **60** can specify the event due to the user on the basis of the NW information collected by the information collection unit **63**, it is determined that setting of the communication devices **20** and switching of the paths are necessary.

[0073] In this case, the switching destination determination unit **65** determines the following switching destination as the optimal switching destination on the basis of the information obtained from the information collection unit **61**, the switching determination unit **62**, the information collection unit **63**, and the switching determination unit **64**. For example, the switching destination determination unit **65** determines the cloud resource **30-2** closest to the communication device **20-4** as the optimal switching destination for the cloud resource **30** to be used by the terminal device **10**. In this case, the switching destination determination unit **65** determines that a path via the communication device **20-4** is the optimal path for the terminal device **10** to use the cloud resource **30-2**. Then, the switching destination determination unit **65** outputs, to the switching instruction unit **66**, information on the cloud resource **30-2** as the switching destination cloud resource **30**, and switching destination information including information on the communication device **20-4** as the switching destination path.

[0074] The switching instruction unit **66** notifies the cloud controller **40** of new cloud resource information and notifies the network controller **50** of new path information on the basis of the switching destination information output from the switching destination determination unit **65**. The switching instruction unit **42** of the cloud controller **40** changes the setting for the cloud resource **30-2** depending on the cloud resource information of which notification is performed. The switching instruction unit **52** of the network controller **50** changes the setting for the communication device **20-4** depending on the path information of which notification is performed.

[0075] As described above, information obtained from the cloud controller **40** and the network controller **50** is considered in the integrated controller **60**, whereby the cloud resources and the paths can be switched in conjunction with each other even in a case where it is determined that switching is not necessary in one of them. As a result, the terminal device **10** can receive service provision by the cloud resource **30-2** while reducing the delay.

[0076] According to the communication system **100** configured as described above, switching of the cloud resources and switching of the paths of the network that are conventionally managed separately are determined in the integrated controller **60** so that optimal switching destinations are obtained. As a result, in a case where there is a change in the cloud resource, network, and user usage statuses, or the facility status, it is possible to perform optimal resource arrangement and path selection. For that reason, minimization of delay and continuation of communication are achieved, and continuous provision of services can be achieved.

[0077] Hereinafter, a modification of the communication system **100** will be described.

Modification 1

[0078] In the above-described embodiment, a configuration has been described in which the cloud resource **30** is used in one base (for example, the terminal device **10**). On the other hand, as illustrated in FIG. 4, the cloud controller **40**, the network controller **50**, and the integrated controller **60** in the first embodiment may perform similar processing even under a situation where the cloud resource **30** is used in the middle of passing information from one base (for example, the terminal device **10**) to another base (for example, a terminal device **70**). FIG. 4 is a diagram illustrating a configuration example of a communication system **100a** in a modification. The communication

system **100a** includes the terminal device **10**, the plurality of communication devices **20-1** to **20-4**, the plurality of cloud resources **30-1** to **30-2**, the cloud controller **40**, the network controller **50**, the integrated controller **60**, and the terminal device **70**. The communication system **100a** is similar to the communication system **100** in terms of a system configuration except that the terminal device **70** is added. Hereinafter, differences will be described. The terminal device **70** is a device to be a communication partner of the terminal device **10**.

Second Embodiment

[0079] In the first embodiment, the integrated controller determines whether or not switching of the cloud resources is necessary on the basis of the cloud information obtained from the cloud resources, and determines whether or not switching of the networks is necessary on the basis of the NW information obtained from the network controller. In a second embodiment, a description will be given of a configuration in which the integrated controller determines whether or not switching is necessary in consideration of both the cloud information and the NW information in addition to the above configuration.

[0080] FIG. **5** is a diagram illustrating an example of functional configurations of the cloud controller **40**, the network controller **50**, and an integrated controller **60b** in the second embodiment. Note that the configurations of the cloud controller **40** and the network controller **50** are similar to those of the first embodiment, and thus description thereof is omitted.

[0081] Depending on at least one or both of the cloud information obtained from the cloud controller **40** and the NW information obtained from the network controller **50**, the integrated controller **60b** determines optimal cloud resource arrangement and network path in consideration of usage statuses of the cloud resources **30** and a usage status of the network. The integrated controller **60b** instructs at least one of the cloud controller **40** or the network controller **50** to perform switching depending on the determined cloud resource arrangement and network path. The integrated controller **60b** is an aspect of a control device.

[0082] The communication system **100** in the second embodiment is a system for performing total delay guarantee in a case where the user uses a cloud resource via a network. Specifically, in the communication system **100** in the second embodiment, in a situation where the cloud resource and the network are used in conjunction with each other, the cloud controller **40** and the network controller **50** perform switching of the cloud resources **30** and networks in conjunction with each other when a configuration change is necessary depending on occurrence of a failure or a change in a facility or user usage status.

[0083] In the communication system **100** in the second embodiment, in the case of the first pattern (due to the cloud resource) or the second pattern (due to the network) described above, the integrated controller **60b** monitors states of the cloud resources and the network via the cloud controller **40** and the network controller **50**, and in a case where it is necessary to perform switching, instructs the cloud controller **40** to change the cloud resources and instructs the network controller **50** to switch the paths, whereby linked switching is performed.

[0084] In the communication system **100** in the second embodiment, in the case of the third pattern (due to the user) described above, the network controller **50** notifies the integrated controller **60b** of an event, and the integrated controller **60b** instructs the cloud controller **40** to change the cloud resources and instructs the network controller **50** to switch the paths, whereby linked switching is performed.

[0085] As described above, the integrated controller **60b** gives an instruction for switching to the cloud controller **40** and the network controller **50**, whereby the cloud controller **40** and the network controller **50** can operate in conjunction with each other. Further, the integrated controller **60b** grasps each event occurring with respect to the cloud resource **30** and the signal transfer path by using both the collected cloud information and NW information, and then integrally determines whether or not switching is necessary, and gives an instruction for switching in a case where it is determined that switching is necessary. Here, “integrally determines” means determination across

the cloud resource **30** and the network, for example, determination by comparison of a sum of an amount of processing delay in the cloud resource **30** and a transfer delay in the network with a predetermined condition, or the like. As a result, the delay can be minimized. Note that, in a case where it is not necessary to perform switching by either the cloud controller **40** or the network controller **50**, the integrated controller **60b** is only required to give an instruction for switching only to a controller for which switching is necessary.

[0086] Hereinafter, a description will be given of a specific configuration of the integrated controller **60b** for achieving the above operation.

[0087] The integrated controller **60b** includes an information collection unit **61b**, the switching determination unit **62**, an information collection unit **63b**, the switching determination unit **64**, a switching destination determination unit **65b**, the switching instruction unit **66**, and the switching determination unit **67b**. The integrated controller **60b** has a configuration different from that of the integrated controller **60** in that the information collection unit **61b**, the information collection unit **63b**, and the switching destination determination unit **65b** are included instead of the information collection unit **61**, the information collection unit **63**, and the switching destination determination unit **65**, and a switching determination unit **67b** is newly included. The configuration of the integrated controller **60b** other than the above is similar to that of the integrated controller **60**.

Hereinafter, differences from the integrated controller **60** will be mainly described.

[0088] The information collection unit **61b** collects cloud information from the cloud controller **40**. The information collection unit **61b** outputs, to the switching determination unit **62** and the switching determination unit **67b**, determination information (for example, failure information on the cloud resource **30**, delay information in the cloud resource **30**, and a CPU usage rate of the cloud resource **30**) necessary for determination of switching in the collected cloud information, and outputs, to the switching destination determination unit **65b**, other information (for example, setting information on the cloud resource **30** and resource information on a redundant facility (cloud resource **30-2**)).

[0089] The information collection unit **63b** collects NW information from the network controller **50**. The information collection unit **63b** outputs, to the switching determination unit **64** and the switching determination unit **67b**, determination information (for example, failure information on the communication devices **20** or the network, delay information on the network, and CPU usage rates of the communication devices **20**) necessary for determination of switching in the collected NW information, and outputs, to the switching destination determination unit **65b**, other information (for example, setting information on the communication devices **20**).

[0090] The switching determination unit **67b** integrally determines whether or not switching is necessary on the basis of the determination information output from the information collection unit **61b** and the determination information output from the information collection unit **63b**. In a case where it is determined that switching is necessary, the switching determination unit **67b** notifies the switching destination determination unit **65b** that switching is necessary. As described above, in comparison with the switching determination units **62** and **64**, the switching determination unit **67b** determines whether or not switching is necessary on the basis of a plurality of determination materials (for example, the determination information necessary for determination of switching in the cloud information and the determination information necessary for determination of switching in the NW information) rather than one determination material.

[0091] The switching destination determination unit **65b** determines an optimal switching destination on the basis of the information obtained from the information collection unit **61b**, the switching determination unit **62**, the information collection unit **63b**, the switching determination unit **64**, and the switching determination unit **67b**. When determining the optimal switching destination, the switching destination determination unit **65b** grasps the usage statuses of the cloud resources and the communication devices **20**, and switches at least one of the cloud resources **30** or the communication paths.

[0092] The switching destination determination unit **65b** selects a switching destination that minimizes an influence range due to switching by switching destination determination processing to be described later. In the switching destination determination processing, the optimal switching destination is determined by three steps of a network switching search, a cloud resource switching search, and a network and cloud resource switching search. Note that the order of the three steps of searching for the switching destination candidate may be any order. In a case where it is intended to minimize the influence of the switching, in a case where switching of the paths of the network is performed faster than switching of the cloud resources **30**, the network switching search, the cloud resource switching search, and the network and cloud resource switching search may be performed in this order. In a case where the switching of the cloud resources **30** is performed faster than the switching of the paths of the network, the cloud resource switching search, the network switching search, and the network and cloud resource switching search may be performed in this order.

[0093] The network switching search is processing of searching for whether or not there is a switching destination candidate suitable for continuous provision of a service by switching only the paths of the network without switching the cloud resources **30**. For example, in a case where there is a switching destination candidate in the network switching search, the switching destination determination unit **65b** determines the switching destination candidate as the optimal switching destination. Note that, in a case where there is a plurality of switching destination candidates, the switching destination determination unit **65b** determines a switching destination candidate having a minimum transfer distance to the cloud resource **30** used by the terminal device **10** as the optimal switching destination. In a case where there is a plurality of switching destination candidates having the minimum transfer distance to the cloud resource **30** used by the terminal device **10**, the switching destination determination unit **65b** may select any of the switching destination candidates.

[0094] The cloud resource switching search is processing of searching for whether or not there is a switching destination candidate suitable for continuous provision of a service by switching only the cloud resources **30** without switching the paths of the network. Here, switching only the cloud resources **30** is, for example, a case where switching is performed between a plurality of cloud resources **30** constructed in the same data center. For example, in a case where there is a switching destination candidate in the cloud resource switching search, the switching destination determination unit **65b** determines the switching destination candidate as the optimal switching destination. Note that, in a case where there is a plurality of switching destination candidates, the switching destination determination unit **65b** may determine a switching destination candidate having a minimum CPU usage rate as the optimal switching destination, or determine a switching destination candidate having a minimum delay as the optimal switching destination.

[0095] The network and cloud resource switching search is processing of searching for whether or not there is a switching destination candidate suitable for continuous provision of a service with both the cloud resources **30** and the paths of the network as switching targets. For example, in a case where there is a switching destination candidate in the network and cloud resource switching search, the switching destination determination unit **65b** determines the switching destination candidate as the optimal switching destination. Note that, in a case where there is a plurality of switching destination candidates, the switching destination determination unit **65b** determines, as the optimal switching destination, a switching destination candidate having a minimum transfer distance to the cloud resource **30** used by the terminal device **10**, a switching destination candidate having a minimum CPU usage rate, or a switching destination candidate having a minimum delay.

[0096] As an index for searching for a switching destination candidate in each step of the cloud resource switching search, the network switching search, and the network and cloud resource switching search, the switching destination determination unit **65b** uses a method of performing evaluation by a total delay time, or a method in which the cloud resources **30** and resources of the communication facility are converted into cost and a value of the cost is minimized. Note that, in a

case where the switching destination candidate is not found even if all the steps are performed, the switching destination determination unit **65b** ends the switching destination determination processing without performing switching. At this time, the switching destination determination unit **65b** may notify a host controller that the switching destination is not found although it is determined that switching is necessary.

[0097] FIG. **6** is a sequence diagram illustrating a flow of processing performed by the communication system **100** in the second embodiment. In FIG. **6**, processing similar to that illustrated in FIG. **3** is denoted by the same reference numeral as that illustrated in FIG. **3**, and description thereof is omitted.

[0098] The integrated controller **60b** collects information of which notification is performed from each of the cloud controller **40** and the network controller **50** (step **S201**). Specifically, the information collection unit **61b** collects the cloud information of which notification is performed from the cloud controller **40**. The information collection unit **63b** collects the NW information of which notification is performed from the network controller **50**. The information collection unit **61b** outputs determination information in the collected cloud information to the switching determination unit **62** and the switching determination unit **67b**, and outputs other information to the switching destination determination unit **65b**. The information collection unit **63b** outputs determination information in the collected NW information to the switching determination unit **64** and the switching determination unit **67b**, and outputs other information to the switching destination determination unit **65b**.

[0099] The switching determination unit **62**, the switching determination unit **64**, and the switching determination unit **67b** determine whether or not switching is necessary on the basis of the determination information (step **S202**). Specifically, the switching determination unit **62** determines whether or not switching of the cloud resources **30** is necessary on the basis of the determination information included in the cloud information obtained from the information collection unit **61**. The switching determination unit **64** determines whether or not switching of the transfer paths is necessary on the basis of the determination information included in the NW information obtained from the information collection unit **63**. The switching determination unit **67b** determines whether or not switching of at least one of the cloud resources **30** or the transfer paths is necessary on the basis of the determination information included in the cloud information obtained from the information collection unit **61** and the determination information included in the NW information obtained from the information collection unit **63**. Here, it is assumed that the integrated controller **60b** determines that switching of both the cloud resources **30** and the paths is necessary.

[0100] In this case, the switching destination determination unit **65b** performs the switching destination determination processing on the basis of the information output from the information collection unit **61b** and the information output from the information collection unit **63b** (step **S203**). As a result, the switching destination determination unit **65b** determines the optimal switching destination. The switching destination determination unit **65b** outputs switching destination information to the switching instruction unit **66**.

[0101] The switching instruction unit **66** generates a switching instruction on the basis of the switching destination information output from the switching destination determination unit **65b** (step **S204**). Specifically, the switching instruction unit **66** generates a cloud switching instruction including information regarding the cloud resources **30** and an NW switching instruction including the information regarding the network paths by using information included in the switching destination information. After that, the processing in step **S109** and the subsequent steps are executed.

[0102] FIG. **7** is a flowchart illustrating a flow of the switching destination determination processing performed by the integrated controller **60b** in the second embodiment. In the description of FIG. **7**, it is assumed that switching of the paths of the network is performed faster than switching of the cloud resources **30**.

[0103] The switching destination determination unit **65b** performs the network switching search on the basis of the information obtained from the information collection unit **63b**, the switching determination unit **64**, and the switching determination unit **67b** (step **S301**). The switching destination determination unit **65b** determines whether or not there is a switching destination candidate as a result of the network switching search (step **S302**). In a case where it is determined that there is a switching destination candidate (YES in step **S302**), the switching destination determination unit **65b** determines the switching destination candidate as the optimal switching destination (step **S303**).

[0104] On the other hand, in a case where it is determined that there is no switching destination candidate (NO in step **S302**), the switching destination determination unit **65b** performs the cloud resource switching search on the basis of the information obtained from the information collection unit **61b**, the switching determination unit **62**, and the switching determination unit **67b** (step **S304**). The switching destination determination unit **65b** determines whether or not there is a switching destination candidate as a result of the cloud resource switching search (step **S305**). In a case where it is determined that there is a switching destination candidate (YES in step **S305**), the switching destination determination unit **65b** determines the switching destination candidate as the optimal switching destination (step **S303**).

[0105] On the other hand, in a case where it is determined that there is no switching destination candidate (NO in step **S305**), the switching destination determination unit **65b** performs the network and cloud resource switching search on the basis of the information obtained from the information collection unit **61b**, the switching determination unit **62**, the information collection unit **63b**, the switching determination unit **64**, and the switching determination unit **67b** (step **S306**). The switching destination determination unit **65b** determines whether or not there is a switching destination candidate as a result of the network and cloud resource switching search (step **S307**). In a case where it is determined that there is a switching destination candidate (YES in step **S307**), the switching destination determination unit **65b** determines the switching destination candidate as the optimal switching destination (step **S303**).

[0106] On the other hand, in a case where it is determined that there is no switching destination candidate (NO in step **S307**), the switching destination determination unit **65b** determines that there is no switching destination candidate and ends the switching destination determination processing.

[0107] According to the communication system **100** in the second embodiment configured as described above, it is possible to obtain effects similar to those of the first embodiment.

[0108] Further, in the communication system **100** in the second embodiment, whether or not switching is necessary is determined on the basis of a plurality of determination materials (for example, the determination information necessary for determination of switching in the cloud information and the determination information necessary for determination of switching in the NW information.). As a result, control using the end-to-end quality can be performed. For that reason, more accurate switching determination can be performed.

Modification 1

[0109] In the above-described embodiment, the switching determination units **62**, **64**, and **67b** are provided as independent functional units, but functions of the switching determination units **62**, **64**, and **67b** may be configured as one or two functional units. In a case where the functions of the switching determination units **62**, **64**, and **67b** are configured as two functional units, one switching determination unit includes any two functions of the switching determination units **62**, **64**, and **67b**, and the other switching determination unit includes a remaining function among the functions of the switching determination units **62**, **64**, and **67b**.

Third Embodiment

[0110] In the first embodiment and the second embodiment, the integrated controller determines whether or not switching is necessary on the basis of the information collected from the cloud controller and the network controller. In a third embodiment, a description will be given of a

configuration in which a communication system does not include an integrated controller, and a network controller determines whether or not switching is necessary, determines a switching destination, and gives a switching instruction.

[0111] The communication system **100** in the third embodiment includes the terminal device **10**, the plurality of communication devices **20-1** to **20-4**, the plurality of cloud resources **30-1** to **30-2**, a cloud controller **40c**, and a network controller **50c**. The communication system **100** in the third embodiment has a configuration different from that of the communication system **100** in the first embodiment in that the integrated controller **60** is not included, and the cloud controller **40c** and the network controller **50c** are included instead of the cloud controller **40** and the network controller **50**. Hereinafter, differences will be mainly described.

[0112] The cloud controller **40c** is a control device that sets and monitors the cloud resources **30**. The cloud controller **40c** collects information regarding the cloud resources **30** and notifies the network controller **50c** of the collected information. A trigger for the cloud controller **40c** to transmit the information regarding the cloud resources **30** to the network controller **50c** may be periodic or only in a case where a predetermined condition is satisfied. In a case where an instruction to change the cloud resources **30** is obtained from the network controller **50c**, the cloud controller **40c** gives an instruction for setting change to the cloud resources **30**. For example, in a case where an instruction to change the cloud resource **30** to be used by the terminal device **10** is obtained, the cloud controller **40c** performs setting of a resource to be allocated to the terminal device **10** for the cloud resource **30** to be used by the terminal device **10**.

[0113] Further, the cloud controller **40c** determines whether or not switching of the cloud resources **30** is necessary on the basis of the collected cloud information. In a case where it is determined that switching is necessary, the cloud controller **40c** notifies the network controller **50c** that switching of the cloud resources **30** is necessary.

[0114] The network controller **50c** sets and monitors the communication devices **20** and monitors the network. The network controller **50c** collects information regarding the communication devices **20** and the network. In a case where it is determined that path switching is necessary, the network controller **50** gives an instruction for switching of the paths to a communication device **20** for which switching of the paths is necessary.

[0115] Further, the network controller **50c** determines optimal cloud resource arrangement and network path in consideration of usage statuses of the cloud resources **30** and a usage status of the network depending on at least one or both of the cloud information obtained from the cloud controller **40c** and the collected NW information. The network controller **50c** instructs the cloud controller **40c** to perform switching depending on the determined cloud resource arrangement and network path. The network controller **50c** is an aspect of a control device.

[0116] FIG. **8** is a diagram illustrating an example of functional configurations of the cloud controller **40c** and the network controller **50c** in the third embodiment. First, the functional configuration of the cloud controller **40c** will be described.

[0117] The cloud controller **40c** includes a cloud information collection unit **41c**, the switching instruction unit **42**, a switching determination unit **43**, and a switching destination determination unit **44**. The cloud controller **40c** has a configuration different from that of the cloud controller **40** in that the cloud information collection unit **41c** is included instead of the cloud information collection unit **41**, and the switching determination unit **43** and the switching destination determination unit **44** are newly included. Hereinafter, differences will be mainly described.

[0118] The cloud information collection unit **41c** collects cloud information from each cloud resource **30**. The cloud information collection unit **41c** outputs, to the network controller **50c** and the switching determination unit **43**, determination information (for example, failure information on the cloud resource **30**, delay information in the cloud resource **30**, and a CPU usage rate of the cloud resource **30**) necessary for determination of switching in the collected cloud information, and outputs, to the switching destination determination unit **44**, other information (for example, setting

information on the cloud resource **30** and resource information on a redundant facility (cloud resource **30-2**)).

[0119] The switching determination unit **43** determines whether or not switching of the cloud resources **30** is necessary on the basis of the determination information output from the cloud information collection unit **41c**. In a case where it is determined that switching is necessary, the switching determination unit **43** notifies the switching destination determination unit **44** of a switching notification including an effect that switching of the cloud resources **30** is necessary.

[0120] The switching destination determination unit **44** determines an optimal switching destination on the basis of the information obtained from the cloud information collection unit **41c** and the switching determination unit **43**. When determining the optimal switching destination, the switching destination determination unit **44** grasps the usage status of the cloud resource **30** and determines a switching destination of the cloud resource **30**. The switching destination determination unit **44** is only required to determine the optimal switching destination by using a method of performing measurement by a total delay time, or a method in which the cloud resource **30** is converted into cost and a value of the cost is minimized. The switching destination determination unit **44** notifies the network controller **50c** of information on the determined optimal switching destination candidate.

[0121] Note that, in a case where the switching destination candidate suitable for continuous provision of a service is found by switching only the cloud resources **30**, the switching destination determination unit **44** may complete the processing without cooperating with a switching destination determination unit **56** of the network controller **50c**.

[0122] Next, the functional configuration of the network controller **50c** will be described.

[0123] The network controller **50c** includes an NW information collection unit **51c**, the switching instruction unit **52**, an information collection unit **53**, a switching determination unit **54**, a switching determination unit **55**, the switching destination determination unit **56**, and a switching instruction unit **57**. The network controller **50c** has a configuration different from that of the network controller **50** in that the NW information collection unit **51c** is included instead of the NW information collection unit **51**, and the information collection unit **53**, the switching determination unit **54**, the switching determination unit **55**, the switching destination determination unit **56**, and the switching instruction unit **57** are newly included. Hereinafter, differences will be mainly described.

[0124] The NW information collection unit **51c** collects NW information from each communication device **20**. Note that the NW information collection unit **51c** may collect an end-to-end delay time including a network delay and a cloud delay measured by the terminal device **10** via the communication devices **20**. The NW information collection unit **51c** outputs, to the switching determination unit **54** and the switching determination unit **55**, determination information (for example, failure information on the communication devices **20** or the network, delay information on the network, and CPU usage rates of the communication devices **20**) necessary for determination of switching in the collected NW information, and outputs, to the switching destination determination unit **56**, other information (for example, setting information on the communication devices **20**).

[0125] The information collection unit **53** collects the determination information output from the cloud controller **40c**. The information collection unit **53** outputs the collected determination information to the switching determination unit **54**.

[0126] The switching determination unit **54** integrally determines whether or not switching is necessary on the basis of the determination information output from the NW information collection unit **51c** and the determination information output from the information collection unit **53**. In a case where it is determined that switching is necessary, the switching determination unit **54** notifies the switching destination determination unit **56** of a switching notification including an effect that switching is necessary. As described above, in comparison with the switching determination unit

55, the switching determination unit **54** determines whether or not switching is necessary on the basis of a plurality of determination materials (for example, the determination information necessary for determination of switching in the cloud information and the determination information necessary for determination of switching in the NW information) rather than one determination material. That is, the switching determination unit **54** has a function corresponding to the switching determination unit **67b** illustrated in FIG. 5.

[0127] The switching determination unit **55** determines whether or not switching of the paths of the network is necessary on the basis of the determination information output from the NW information collection unit **51c**. In a case where it is determined that switching is necessary, the switching determination unit **55** notifies the switching destination determination unit **56** of a switching notification including an effect that setting of the communication devices **20** and switching of the paths are necessary.

[0128] The switching destination determination unit **56** determines an optimal switching destination on the basis of the information output from the switching destination determination unit **44** included in the cloud controller **40c**, the switching notification output from the switching determination unit **54**, and the switching notification output from the switching determination unit **55**. In a case where switching of the cloud resources **30** is necessary, the switching destination determination unit **56** determines a final switching destination by cooperating with the switching destination determination unit **44** included in the cloud controller **40c**. In the third embodiment, the switching destination determined by the switching destination determination unit **56** is the optimal switching destination. The switching destination determination unit **56** notifies the switching instruction unit **57** of information on the determined switching destination.

[0129] The switching instruction unit **57** notifies the switching instruction unit **42** of the cloud controller **40c** of new cloud resource information and notifies the switching instruction unit **52** of new path information on the basis of switching destination information determined by the switching destination determination unit **56**. Note that, in a case where the switching destination information determined by the switching destination determination unit **56** includes only information regarding switching of the paths of the network, the switching instruction unit **57** notifies the switching instruction unit **52** of new path information. Note that, in a case where the switching destination information determined by the switching destination determination unit **56** includes only information regarding switching of the cloud resources **30**, the switching instruction unit **57** notifies the cloud controller **40c** of new cloud resource information.

[0130] In the communication system **100** in the third embodiment configured as described above, the network controller **50c** serves as a master, and the cloud controller **40c** serves as a slave. Then, the switching destination finally determined by the network controller **50c** is determined as the optimal switching destination. As a result, it is possible to obtain effects similar to those of the first embodiment and the second embodiment even without including the integrated controllers **60** and **60b** as in the first embodiment and the second embodiment.

Modification 1

[0131] A configuration may be made in which the switching determination unit **43** included in the cloud controller **40c** is included in the network controller **50c**. In a case where such a configuration is made, the switching determination unit **43** determines whether or not switching of the cloud resources **30** is necessary on the basis of the determination information output from the information collection unit **53** included in the network controller **50c**. In a case where it is determined that switching is necessary, the switching determination unit **43** notifies the cloud controller **40c** of a switching notification including an effect that switching of the cloud resources **30** is necessary.

Modification 2

[0132] A configuration may be made in which the switching destination determination unit **44** included in the cloud controller **40c** is included in the network controller **50c**. In a case where such a configuration is made, the cloud controller **40c** notifies the network controller **50c** of setting

information, and resource information on a redundant facility in addition to the switching notification.

Fourth Embodiment

[0133] In a fourth embodiment, a description will be given of a configuration in which a communication system does not include an integrated controller, and a cloud controller determines whether or not switching is necessary, determines a switching destination, and gives a switching instruction. That is, the fourth embodiment has a configuration in which a relationship between the master and the slave is reversed from that of the third embodiment.

[0134] The communication system **100** in the fourth embodiment includes the terminal device **10**, the plurality of communication devices **20-1** to **20-4**, the plurality of cloud resources **30-1** to **30-2**, a cloud controller **40d**, and a network controller **50d**. The communication system **100** in the fourth embodiment has a configuration different from that of the communication system **100** in the first embodiment in that the integrated controller **60** is not included, and the cloud controller **40d** and the network controller **50d** are included instead of the cloud controller **40** and the network controller **50**. Hereinafter, differences will be mainly described.

[0135] The cloud controller **40d** is a control device that sets and monitors the cloud resources **30**. The cloud controller **40d** collects information regarding the cloud resources **30**. In a case where it is determined that switching of the cloud resources **30** is necessary, the cloud controller **40d** performs setting of a resource to be allocated to the terminal device **10** for the cloud resource **30** to be used by the terminal device **10**.

[0136] Further, the cloud controller **40d** determines optimal cloud resource arrangement and network path in consideration of usage statuses of the cloud resources **30** and a usage status of the network depending on at least one or both of NW information obtained from the network controller **50d** and the collected cloud information. The cloud controller **40d** instructs the network controller **50d** to perform switching depending on the determined cloud resource arrangement and network path.

[0137] The network controller **50d** sets and monitors the communication devices **20** and monitors the network. The network controller **50d** collects information regarding the communication devices **20** and the network, and notifies the cloud controller **40d** of the collected information. A trigger for the network controller **50d** to transmit the information regarding the network to the cloud controller **40d** may be periodic or only in a case where a predetermined condition is satisfied. In a case where an instruction for path switching is obtained from the cloud controller **40d**, the network controller **50d** gives an instruction for switching of the paths to a communication device **20** for which switching of the paths is necessary.

[0138] Further, the network controller **50d** determines whether or not switching of the paths of the network is necessary on the basis of the collected NW information. In a case where it is determined that switching is necessary, the network controller **50d** notifies the cloud controller **40d** that setting of the communication devices **20** and switching of the paths are necessary.

[0139] FIG. **9** is a diagram illustrating an example of functional configurations of the cloud controller **40d** and the network controller **50d** in the fourth embodiment. First, the functional configuration of the cloud controller **40d** will be described.

[0140] The cloud controller **40d** includes a cloud information collection unit **41d**, the switching instruction unit **42**, the switching determination unit **43**, an information collection unit **45**, a switching determination unit **46**, a switching destination determination unit **47**, and a switching instruction unit **48**. The cloud controller **40d** has a configuration different from that of the cloud controller **40** in that the cloud information collection unit **41d** is included instead of the cloud information collection unit **41**, and the switching determination unit **43**, the information collection unit **45**, the switching determination unit **46**, the switching destination determination unit **47**, and the switching instruction unit **48** are newly included. Hereinafter, differences will be mainly described.

[0141] The cloud information collection unit **41d** collects cloud information from each cloud resource **30**. The cloud information collection unit **41d** outputs, to the switching determination unit **43** and the switching determination unit **46**, determination information (for example, failure information on the cloud resource **30**, delay information in the cloud resource **30**, and a CPU usage rate of the cloud resource **30**) necessary for determination of switching in the collected cloud information, and outputs, to the switching destination determination unit **47**, other information (for example, setting information on the cloud resource **30** and resource information on a redundant facility (cloud resource **30-2**)).

[0142] The switching determination unit **43** determines whether or not switching of the cloud resources **30** is necessary on the basis of the determination information output from the cloud information collection unit **41d**. In a case where it is determined that switching is necessary, the switching determination unit **43** notifies the switching destination determination unit **47** of a switching notification including an effect that switching of the cloud resources **30** is necessary.

[0143] The information collection unit **45** collects the determination information output from the network controller **50d**. The information collection unit **45** outputs the collected determination information to the switching determination unit **46**.

[0144] The switching determination unit **46** integrally determines whether or not switching is necessary on the basis of the determination information output from the cloud information collection unit **41d** and the determination information output from the information collection unit **45**. In a case where it is determined that switching is necessary, the switching determination unit **46** notifies the switching destination determination unit **47** of a switching notification including an effect that switching is necessary. As described above, in comparison with the switching determination unit **43**, the switching determination unit **46** determines whether or not switching is necessary on the basis of a plurality of determination materials (for example, the determination information necessary for determination of switching in the cloud information and the determination information necessary for determination of switching in the NW information) rather than one determination material. That is, the switching determination unit **46** has a function corresponding to the switching determination unit **67b** illustrated in FIG. 5.

[0145] The switching destination determination unit **47** determines an optimal switching destination on the basis of information output from a switching destination determination unit **58** included in the network controller **50d**, the switching notification output from the switching determination unit **43**, and the switching notification output from the switching determination unit **46**. In a case where switching of the cloud resources **30** is necessary, the switching destination determination unit **47** determines a final switching destination by cooperating with the switching destination determination unit **58** included in the network controller **50d**. In the fourth embodiment, the switching destination determined by the switching destination determination unit **47** is the optimal switching destination. The switching destination determination unit **47** notifies the switching instruction unit **48** of information on the determined switching destination.

[0146] The switching instruction unit **48** notifies the switching instruction unit **42** of new cloud resource information on the basis of the switching destination information determined by the switching destination determination unit **47**, and notifies the switching instruction unit **52** of the network controller **50d** of new path information. Note that, in a case where the switching destination information determined by the switching destination determination unit **47** includes only information regarding switching of the paths of the network, the switching instruction unit **48** notifies the switching instruction unit **52** of the network controller **50d** of new path information. Note that, in a case where the switching destination information determined by the switching destination determination unit **47** includes only information regarding switching of the cloud resources **30**, the switching instruction unit **48** notifies the switching instruction unit **42** of new cloud resource information.

[0147] Next, the functional configuration of the network controller **50d** will be described.

[0148] The network controller **50d** includes an NW information collection unit **51d**, the switching instruction unit **52**, the switching determination unit **55**, and the switching destination determination unit **58**. The network controller **50d** has a configuration different from that of the network controller **50** in that the NW information collection unit **51d** is included instead of the NW information collection unit **51**, and the switching determination unit **55** and the switching destination determination unit **58** are newly included. Hereinafter, differences will be mainly described.

[0149] The NW information collection unit **51d** collects NW information from each communication device **20**. Note that the NW information collection unit **51d** may collect an end-to-end delay time including a network delay and a cloud delay measured by the terminal device **10** via the communication devices **20**. The NW information collection unit **51d** outputs, to the switching determination unit **55** and the cloud controller **40d**, determination information (for example, failure information on the communication devices **20** or the network, delay information on the network, and CPU usage rates of the communication devices **20**) necessary for determination of switching in the collected NW information, and outputs, to the switching destination determination unit **58**, other information (for example, setting information on the communication devices **20**).

[0150] The switching determination unit **55** determines whether or not switching of the paths of the network is necessary on the basis of the determination information output from the NW information collection unit **51d**. In a case where it is determined that switching is necessary, the switching determination unit **55** notifies the switching destination determination unit **58** of a switching notification including an effect that switching of the paths of the network is necessary.

[0151] The switching destination determination unit **58** determines an optimal switching destination on the basis of the information obtained from the NW information collection unit **51d** and the switching determination unit **55**. When determining the optimal switching destination, the switching destination determination unit **58** grasps the usage statuses of the communication devices **20** and determines a switching destination of the communication path. The switching destination determination unit **58** is only required to determine the optimal switching destination by using a method of performing measurement by a total delay time, or a method in which the cloud resource **30** is converted into cost and a value of the cost is minimized. The switching destination determination unit **58** notifies the cloud controller **40d** of information on the determined optimal switching destination candidate.

[0152] In a case where the switching destination candidate suitable for continuous provision of a service is found by switching only the paths of the network, the switching destination determination unit **58** may complete the processing without cooperating with the switching destination determination unit **47** of the cloud controller **40d**.

[0153] In the communication system **100** in the fourth embodiment configured as described above, the cloud controller **40d** serves as a master, and the network controller **50d** serves as a slave. Then, the switching destination finally determined by the cloud controller **40d** is determined as the optimal switching destination. As a result, it is possible to obtain effects similar to those of the first embodiment and the second embodiment even without including the integrated controllers **60** and **60b** as in the first embodiment and the second embodiment.

Modification 1

[0154] A configuration may be made in which the switching determination unit **55** included in the network controller **50d** is included in the cloud controller **40d**. In a case where such a configuration is made, the switching determination unit **55** determines whether or not switching of the paths of the network is necessary on the basis of the determination information output from the information collection unit **45** included in the cloud controller **40d**. In a case where it is determined that switching is necessary, the switching determination unit **55** notifies the network controller **50d** of a switching notification including an effect that switching of the paths of the network is necessary.

Modification 2

[0155] A configuration may be made in which the switching destination determination unit **58** included in the network controller **50d** is included in the cloud controller **40d**. In a case where such a configuration is made, the network controller **50d** notifies the cloud controller **40d** of setting information, and resource information on a redundant facility in addition to the switching notification.

Modification 1 Common to Each Embodiment

[0156] In each of the above embodiments, a case has been described where the cloud controllers **40**, **40c**, and **40d**, the network controllers **50**, **50c**, and **50d**, and the integrated controllers **60** and **60b** are configured as different devices, as an example; however, the cloud controllers **40**, **40c**, and **40d**, the network controllers **50**, **50c**, and **50d**, and the integrated controllers **60** and **60b** may be mounted on the same device using a virtualization technology. In a case where such a configuration is made, in the first embodiment, the cloud controller **40**, the network controller **50**, and the integrated controller **60** are mounted on the same device. In the second embodiment, the cloud controller **40**, the network controller **50**, and the integrated controller **60b** are mounted on the same device. In the third embodiment, the cloud controller **40c** and the network controller **50c** are mounted on the same device. In the fourth embodiment, the cloud controller **40d** and the network controller **50d** are mounted on the same device.

[0157] Some functional units of the cloud controllers **40**, **40c**, and **40d**, the network controllers **50**, **50c**, and **50d**, and the integrated controllers **60** and **60b** in the above-described embodiments may be implemented by a computer. In that case, a program for implementing functions thereof may be recorded in a computer-readable recording medium, and the program recorded in the recording medium may be read and executed by a computer system to implement the functions. Note that the “computer system” mentioned herein includes an OS and hardware such as peripheral devices.

[0158] In addition, the “computer-readable recording medium” refers to a portable medium such as a flexible disk, a magneto-optical disk, a read only memory (ROM), or a CD-ROM, or a storage device such as a hard disk included in the computer system. Further, the “computer-readable recording medium” may include a medium that dynamically holds the program for a short time, such as a communication wire in a case where the program is transmitted via a network such as the Internet or a communication line such as a telephone line, and a medium that holds the program for a certain period of time, such as a volatile memory inside the computer system serving as a server or a client in that case. In addition, the program may be for implementing some of the functions described above, may be implemented in a combination of the functions described above and a program already recorded in the computer system, or may be implemented with a programmable logic device such as a field programmable gate array (FPGA).

[0159] As described above, the embodiments of the present invention have been described in detail with reference to the drawings; however, the specific configuration is not limited to the embodiments and includes design and the like within the scope of the present invention.

INDUSTRIAL APPLICABILITY

[0160] The present invention can be applied to a communication system that uses cloud resources via a network.

REFERENCE SIGNS LIST

[0161] **10** Terminal device [0162] **20**, **20-1** to **20-4** Communication device [0163] **30** Cloud resource [0164] **40**, **40c**, **40d** Cloud controller [0165] **50**, **50c**, **50d** Network controller [0166] **60**, **60b** Integrated controller [0167] **45**, **53**, **61**, **61b**, **63**, **63b** Information collection unit [0168] **43**, **46**, **54**, **55**, **62**, **64**, **67b** Switching destination determination unit [0169] **44**, **47**, **56**, **58**, **65**, **65b** Switching destination determination unit [0170] **66** Switching instruction unit [0171] **48**, **57** Switching instruction unit [0172] **41**, **41c**, **41d** Cloud information collection unit [0173] **42** Switching instruction unit [0174] **51**, **51c**, **51d** NW information collection unit [0175] **52** Switching instruction unit

Claims

1. A communication system that includes a plurality of cloud resources, and a plurality of communication devices provided on a path for using any one of the plurality of cloud resources, the communication system comprising: a cloud controller configured to collect cloud information regarding the plurality of cloud resources from each of the plurality of cloud resources and performs setting change of the plurality of cloud resources; a network controller configured to collect NW information regarding the plurality of communication devices and a network formed by the plurality of communication devices from each of the plurality of communication devices and gives an instruction for path switching in the plurality of communication devices; and an integrated controller configured to collect the cloud information from the cloud controller, collects the NW information from the network controller, and gives at least one of an instruction for setting change of the cloud resources to the cloud controller or an instruction for path switching to the network controller on a basis of the cloud information and the NW information collected.
2. The communication system according to claim 1, wherein the integrated controller determines, as an optimal switching destination in a case where a user uses a cloud resource, one of the plurality of cloud resources and a path for using the one of the cloud resources on the basis of the cloud information and the NW information.
3. The communication system according to claim 2, wherein the integrated controller determines whether or not switching of the cloud resources is necessary on the basis of the cloud information collected, determines whether or not path switching is necessary on the basis of the NW information collected, and determines the optimal switching destination in a case where it is determined that switching is necessary in any of determination results.
4. An integrated controller comprising: a first information collector configured to collect cloud information from a cloud controller that collects the cloud information regarding a plurality of cloud resources from each of the plurality of cloud resources and performs setting change of the plurality of cloud resources; a second information collector configured to collect NW information from a network controller that collects the NW information regarding a plurality of communication devices provided on a path for using any one of the plurality of cloud resources and a network formed by the plurality of communication devices from each of the plurality of communication devices and gives an instruction for path switching in the plurality of communication devices; and a switching instructor configured to give at least one of an instruction for setting change of the cloud resources to the cloud controller or an instruction for path switching to the network controller on a basis of the cloud information collected by the first information collector and the NW information collected by the second information collector.
5. A control device comprising: a switching determiner configured to determine whether or not switching of at least one of cloud resources or communication paths is necessary on a basis of both cloud information regarding a plurality of cloud resources and NW information regarding a plurality of communication devices provided on a path for using any one of the plurality of cloud resources and a network formed by the plurality of communication devices; a switching destination determiner configured to determine an optimal switching destination on a basis of a determination result by the switching determiner, the cloud information, and the NW information; and a switching instructor configured to give at least one of an instruction for setting change of the cloud resources or an instruction for switching of the communication paths to perform switching to the optimal switching destination determined by the switching destination determiner.
6. The control device according to claim 5, further comprising: a cloud switching determiner configured to determine whether or not switching of the cloud resources is necessary on the basis of the cloud information; and a path switching determiner configured to determine whether or not switching of the communication paths is necessary on the basis of the NW information, wherein the

switching destination determiner determines the optimal switching destination further on a basis of a determination result by the cloud switching determiner and a determination result by the path switching determiner.

7. The control device according to claim 5, wherein the switching destination determiner determines the optimal switching destination by performing, in order based on a predetermined condition, first processing of searching for whether or not there is a switching destination candidate suitable for continuous provision of a service by switching only the communication paths, second processing of searching for whether or not there is a switching destination candidate suitable for continuous provision of a service by switching only the cloud resources, and third processing of searching for whether or not there is a switching destination candidate suitable for continuous provision of a service with both the communication paths and the cloud resources as switching targets.

8. (canceled)
