INFORMATION PROCESSING DEVICE, INFORMATION PROCESSING METHOD AND PROGRAM

Abstract

This invention enables flexible connection with a wide variety of core networks even without changing, for example, equipment and/or operating systems related to existing base stations. This invention serves as at least one of (i) an interface via which a base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, and includes: a first stateful communication section (**51**) carrying out communication with the base station according to a stateful protocol; and a stateless communication section (**52**) carrying out communication with the first core network according to a stateless protocol.

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Background/Summary

TECHNICAL FIELD

[0001] The present invention relates to an information processing device, an information processing method, and a program, specifically, to an information processing device, an information processing method, and a program each enabling flexible connection with a wide variety of core networks even without changing, for example, equipment and/or operating systems related to existing base stations.

BACKGROUND ART

[0002] The Third Generation Partnership Project (3GPP) has established, in Release15, the technical specifications for network slicing in mobile communication networks. This makes it possible to construct a large number of core networks according to various purposes, for example.

[0003] In recent years, against this background, many business operators are trying to construct new networks. However, it is not practical for a business operator newly entering the field of mobile communication networks to set its own base station. Thus, there are many discussions about a use mode, such as base station sharing, in which a single base station is connected with a plurality of core networks.

[0004] In such a use mode, the base station needs to be capable of flexibly carrying out communication with a large number of core networks. Furthermore, it is necessary to identify a core network which is a destination of a signal received from a terminal and to transmit the signal to the identified core network.

[0005] Patent Literature 1 discloses switching the destination core network from one to another on the basis of an identifier included in the signal received from the terminal device.

CITATION LIST

Patent Literature

[0006] [Patent Literature 1] [0007] Japanese Patent Application Publication, Tokukai, No. 2022-090476

SUMMARY of INVENTION

Technical Problem

[0008] However, the existing base stations are designed without assuming existence of a large number of core networks. Thus, the number of Access and Mobility Management Functions (AMFs) which are connectable is limited.

[0009] Further, as the idea of Virtual Mobile Network Operator (VMNO) is being practically realized in the future, it is assumed that the communication modes for the core networks will change. However, changing functions and/or the like of the existing base stations according to the specifications of the core networks is a large burden on communication business operators. Thus, it has been expected to realize a technique that enables flexible connection with a wide variety of core networks even without changing, for example, equipment and/or operating systems related to the existing base stations.

[0010] An aspect of the present invention has an object to realize a technique that enables flexible connection with a wide variety of core networks even without changing, for example, equipment and/or operating systems related to the existing base stations.

Solution to Problem

[0011] An information processing device in accordance with an aspect of the present invention is an information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing device including: a first stateful communication section configured to carry out communication with the base station according to a stateful protocol; and a stateless communication section configured to carry out communication with the first core network according to a stateless protocol.

[0012] An information processing method in accordance with an aspect of the present invention is an information processing method for an information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing method including: a first stateful communication step of carrying out communication with the base station according to a stateful protocol; and a stateless communication step of carrying out communication with the first core network according to a stateless protocol.

[0013] The aspects of the present invention may be realized by a computer. In this case, the present invention also includes: a program causing the computer to execute the steps of the above-described method; and a computer-readable storage medium in which the program is stored.

Advantageous Effects of Invention

[0014] According to an aspect of the present invention, it is possible to realize a technique that enables flexible connection with a wide variety of core networks even without changing, for example, equipment and/or operating systems related to the existing base stations.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0015] FIG. **1** is a view illustrating a configuration of a 5G communication network in which base stations are provided by a large number of core networks.

[0016] FIG. **2** is a view illustrating a configuration of a 5G communication system in accordance with the present embodiment.

[0017] FIG. **3** is a view showing an example of a configuration of an N1N2 gateway **41**.

[0018] FIG. **4** is a view illustrating an example of a process related to establishment of a NGAP tunnel between a base station **21** and a CN-1.

[0019] FIG. **5** is a view illustrating an example of a process related to establishment of a NGAP tunnel between the base station **21** and a CN-2.

[0020] FIG. **6** is a view illustrating an example of selecting a core network in response to requests from a plurality of different pieces of UE connected via a single base station.

[0021] FIG. **7** is a view illustrating an example of selecting a core network in response to requests from a plurality of different pieces of UE connected via different base stations.

[0022] FIG. **8** is a view illustrating an example of a configuration of a computer which executes an instruction of a program that is software realizing each function.

DESCRIPTION OF EMBODIMENTS

[0023] The following description will discuss embodiments of the present invention with reference to the drawings. First, a problem of conventional techniques will be described.

[0024] The 3GPP has established, in Release15, the technical specifications for network slicing in

mobile communication networks. The network slicing allows construction of multiple core networks operated by 5G VMNO without being tied to a physical interface, for example. This makes it possible to construct a large number of core networks according to various purposes.

[0025] In recent years, against this background, many business operators are trying to construct new networks. However, it is not practical for a business operator newly entering the field of mobile communication networks to set its own base station. Thus, there are many discussions about a use mode, such as base station sharing, in which a single base station is connected with a plurality of core networks.

[0026] FIG. **1** is a view illustrating a configuration of a 5G communication network in which base stations are provided by a large number of core networks.

[0027] In the example shown in FIG. **1**, a core network **100**I, a core network **100**X, . . . , and a core network **100**Y, which constitute the 5G communication network, are illustrated. The core network **100**I is a core network which is assumed to be used in relation to IoT, and is not used for, e.g., calling between terminals.

[0028] The core network **100**X is, for example, a core network operated by company X, which is a business operator. The core network **100**X serves as a core network in a general 5G communication network.

[0029] The core network **100**Y is, for example, a core network operated by company Y, which is a business operator. The core network **100**Y serves as a core network in a general 5G communication network.

[0030] In the example shown in FIG. **1**, a plurality of base stations **21**, which constitute the 5G communication network, are illustrated. Actually, there exist tens of thousands of base stations **21**. Each of the base stations **21** carries out communication with pieces of User Equipment (UE) **11**, which are a plurality of terminals located within a cell that is indicated by an ellipse shown in FIG. **1** and that is a given radio communication area. For example, a single base station **21** simultaneously carries out communication with several hundred pieces of UE **11**.

[0031] The base station **21** is connected with a core network such that the base station **21** is connected with an AMF, which is one of Network Functions (NFs) in the core network. For example, the core network **100**I is provided with an AMF **110**I, the core network **100**A is provided with an AMF **110**X, . . . and the core network **100**Y is provided with an AMF **110**Y.

[0032] As shown in FIG. **1**, the plurality of base stations **21** are connected with the AMF **110**I, the AMF **110**X, . . . , and the AMF **110**Y. Each of the base stations **21** is connected with the AMFs via an N2 interface defined by TS.23.501, which is one of the 3GPP standards. Each of the pieces of UE **11** is connected with a corresponding one of the AMFs via an N1 interface. With the N2 interface, a Stream Control Transmission Protocol (SCTP) association is established between the base station **21** and the AMF.

[0033] However, the existing base stations **21** are designed without assuming existence of a large number of core networks. Thus, the number of AMFs which are connectable is limited. For example, for each of the existing base stations **21**, the number of SCTP associations which can be held is 32 or 64. Thus, in order to allow each of the base stations **21** to be connected with a large number of core networks, reinforcing the equipment of the base station **21** is considered. However, taking a measure of, e.g., reinforcing the equipment with respect to all of the tens of thousands of base stations **21** provided in a large area will take too much cost.

[0034] A SCTP specified in the N2 interface is a stateful protocol, and therefore session management needs to be carried out. For example, a process related to a given system procedure and/or the like needs to be completed within a predetermined period. In a case where the session management such as the above-described one is carried out, congestion is likely to occur, e.g., due to concentration of access to a single AMF which may occur when a natural disaster or the like occurs. Thus, development of a technique has been expected that enables more scalable communication between the base station and the core network.

[0035] As discussed above, as the idea of VMNO is being realized, it is assumed that the communication modes for the core networks will change. In such a situation, it has been expected to realize a technique that enables the existing base stations to be connected with a wide variety of core networks.

First Embodiment

Configuration of Network

[0036] FIG. **2** is a view illustrating a configuration of a 5G communication system in accordance with the present embodiment. In the example shown in FIG. **2**, a core network **100**I, a core network **100**A, . . . , and a core network **100**B, which constitute a 5G communication network, are illustrated.

[0037] As described with reference to FIG. **1**, the core network **100**I is a core network which is assumed to be used in relation to IoT, and is not used for, e.g., calling between terminals. The core network **100**I is provided with an AMF **110**I.

[0038] As described with reference to FIG. **1**, the core network **100**A is, for example, a core network operated by company A, which is a business operator. The core network **100**A serves as a core network in a general 5G communication network. The core network **100**A is provided with an AMF **110**A.

[0039] The core network **100**B is, for example, a core network operated by company B, which is a business operator. The core network **100**B serves as, for example, a core network which is available at a quite low communication charge. In order to reduce the operation cost, the core network **100**B partially employs, for example, a unique communication mode which is different from the mode specified in the 3GPP standards. In one example, in the core network **100**B, a NF specified by TS.23.501 is not provided and processes related to respective system procedures specified by TS.23.502 are executed according to the unique mode.

[0040] Further, in one example, the core network **100**B employs a stateless protocol instead of the SCTP specified in the N2 interface. Thus, the core network **100**B is provided with an Application Programming Interface (API) gateway **120**B instead of the AMF. In one example, the API gateway **120**B is constituted by software using an API which is created by company B; and the API gateway **120**B starts processes related to respective system procedures specified by TS.23.502 in response to a request, without establishing a SCTP association. It is assumed here that an API created by company B is available in public.

[0041] In the example shown in FIG. **2**, only the core network **100**B is illustrated as a core network having an API gateway. Not only this, other core network(s) having API gateway may exist. For example, a core network **100**J having an API gateway **120**J constituted by software using an API created by company J, a core network **100**K having an API gateway **120**K constituted by software using an API created by company K, and/or the like may exist.

[0042] Note that, in a case where the core network **100**I, the core network **100**A, the core network **100**B, . . . , and the like do not need to be distinguished from each other, these core networks will collectively be referred to as "core networks **100**" as appropriate. Similarly, the AMFs will collectively be referred to as "AMFs **110**" as appropriate. Also, the API gateways will collectively be referred to as "API gateways **120**" as appropriate.

[0043] Similarly to FIG. **1**, FIG. **2** illustrates a plurality of base stations **21**, which constitute the 5G communication network. Actually, there exist tens of thousands of base stations **21**. The base stations **21** carry out communication with pieces of UE **11**, which are a plurality of terminals located within a cell that is indicated by an ellipse shown in FIG. **2** and that is a given radio communication area. For example, a single base station **21** simultaneously carries out communication with several hundred pieces of UE **11**.

[0044] Unlike in the case of FIG. **1**, the base stations **21** are connected with the core networks via N1N2 gateways **41** in the example shown in FIG. **2**. Each of the N1N2 gateways **41** is a device which relays communication carried out via the N1 interface and the N2 interface. That is, the

pieces of UE **11** are connected with the core networks **100** via the base stations **21**, and the base stations **21** are connected with the core networks via the N1N2 gateways **41**.

[0045] As compared with the base station **21**, the N1N2 gateway **41** can hold a far more number of SCTP associations. The N1N2 gateway **41** is configured to be capable of holding several hundreds of SCTP associations, for example.

[0046] Unlike in the case shown in FIG. **1**, each of the N1N2 gateways **41** provided for the plurality of base stations **21** is connected with the AMF **110**I, the AMF **110**A, . . . , and the API gateway **120**B, in the case shown in FIG. **2**. Each of the base stations **21** is connected with the N1N2 gateways **41** via the N2 interface specified by TS.23.501, which is one of the 3GPP standards. Each of the pieces of UE **11** is connected with a corresponding one of the AMFs or the API gateway via the N1 interface.

[0047] In the example illustrated in FIG. **2**, a single N1N2 gateway **41** is provided for a single base station **21**. Alternatively, provided that a given condition is satisfied, a single N1N2 gateway **41** may be provided for a plurality of base stations **21**.

Configuration of N1N2 Gateway

[0048] FIG. **3** is a view showing an example of a configuration of the N1N2 gateway **41**. As shown in FIG. **3**, the N1N2 gateway **41** includes a first stateful communication section **51**, a stateless communication section **52**, a second stateful communication section **53**, a control section **54**, and a storage section **55**.

[0049] The N1N2 gateway **41** is an information processing device connected with the base station **21**, serves as at least one of (i) the N2 interface via which the base station **21** and the core network **100**B are connected with each other and (ii) the N1 interface via which the UE connected with the core network **100**B via the base station and the core network **100**B are connected with each other, and includes: the first stateful communication section **51** configured to carry out communication with the base station **21** according to the stateful protocol; and the stateless communication section **52** configured to carry out communication with the core network **100**B according to the stateless protocol.

[0050] The N1N2 gateway **41** further includes the second stateful communication section **53** configured to carry out communication with the core network **100**I or the core network **100**A according to the stateful protocol, and serves as at least one of (i) an interface via which the base station **21** and the core network **100**I or the core network **100**A are connected with each other and (ii) an interface via which the UE **11** connected with the core network **100**I or the core network **100**A via the base station **21** and the core network **100**I or the core network **100**A are connected with each other.

[0051] The stateful protocol is a SCTP, for example. The stateless protocol is a communication protocol in which every request is dealt with as a transaction isolated from a previous request so that communication is constituted by an independent set of a request and a response. That is, it is possible to employ any communication protocol in which information related to sessions is not held and state management is not carried out. To be more specific, the stateless protocol may be, for example, a Remote Procedure Call (RPC) or a Message Queue (MQ). Alternatively, the stateless protocol may be a Hypertext Transfer Protocol (HTTP).

First Stateful Communication Section

[0052] In order to carry out communication with the base station **21**, the N1N2 gateway **41** uses the first stateful communication section **51** for the communication. Consequently, a SCTP association is established between the base station **21** and the AMF, and the base station **21** carry out transmission and reception of messages via the N2 interface. The pieces of UE **11** which carry out communication with the core networks via the base stations **21** carry out transmission and reception of messages via the N1 interface.

[0053] In a case where a single N1N2 gateway **41** is provided for a plurality of base stations **21**, the first stateful communication section **51** carries out communication with the plurality of base

stations.

Stateless Communication Section

[0054] In order to carry out communication with the core network **100**B, the N1N2 gateway **41** uses the stateless communication section **52** for the communication. As described above, the core network **100**B is provided with, instead of the AMF, the API gateway **120**B configured to relay communication with the N1N2 gateway **41**. That is, in the API gateway **120**B, the stateless protocol is employed, and thus a SCTP association is not established. Therefore, the N1N2 gateway **41** converts the protocol for communication between the base station **21** and the core network **100**B into the stateless protocol.

Second Stateful Communication Section

[0055] In order to carry out communication with the core network **100**I or the core network **100**A, the N1N2 gateway **41** uses the second stateful communication section **53** for the communication. That is, transmission and reception of messages with respect to the AMF **110**I and the AMF **110**A are carried out via the N2 interface. Thus, the N1N2 gateway **41** establishes a SCTP association with these AMFs.

Storage Section

[0056] The N1N2 gateway **41** identifies, on the basis of a message transmitted from the base station **21**, which of the core network **100**I, the core network **100**A, . . . , and the core network **100**B is a communication destination. In one example, the N1N2 gateway **41** identifies the communication destination on the basis of a Public Land Mobile Network (PLMN)-ID, which is a business operator identifier included in the message transmitted from the base station **21**.

[0057] In the N1N2 gateway **41**, information such as a table in which an address of the communication destination and a PLMN-ID are associated with each other is stored in the storage section **55** in advance. For example, information in which a PLMN-ID of company B and an address of the API gateway **120**B of the core network **100**B are associated with each other is stored in the storage section **55** in advance. Further, for example, information in which a PLMN-ID of company A and an address of the AMF **110**A of the core network **100**A are associated with each other is stored in the storage section **55** in advance.

Control Section

[0058] The control section **54** controls the above-described functional blocks so as to execute a process necessary for communication with the base station **21** or the core networks. For example, the control section **54** controls execution of a process of generating information which is to be stored in the storage section **55** and/or a process of reading out the information stored in the storage section. The control section **54** controls, e.g., execution of a process of identifying a transmission destination of information received via the first stateful communication section **51**, the stateless communication section **52**, or the second stateful communication section **53**.

Flow of Communication Process

[0059] The following description will discuss, with reference to FIGS. **4**, **5**, **6**, and **7**, flows of various communication processes in the 5G communication system in accordance with the present embodiment which has been described with reference to FIG. **2**. In the drawings, a base station is indicated as "gNB". Further, in the drawings, a "CN-1" indicates a core network, such as the core network **100**I or the core network **100**A, which is provided with the AMF **110** configured to carry out transmission and reception of messages via the N2 interface. In the drawings, a "CN-2" indicates a core network, such as the core network **100**B, which is provided with the API gateway **120** employing the stateless protocol.

[0060] In each of FIGS. **4**, **5**, **6**, and **7**, in order that the N1N2 gateway **41** carries out communication with the base station **21**, the first stateful communication section **51** is used for the communication. In order that the N1N2 gateway **41** carries out communication with the AMF **110**, the second stateful communication section **53** is used for the communication. In order that the N1N2 gateway **41** carries out communication with the AMF **110**, the stateless communication

section **52** is used for the communication.

Establishment of NGAP Tunnel With Core Network Having AMF

[0061] FIG. **4** is a view illustrating an example of a process related to establishment of a Next Generation Application Protocol (NGAP) tunnel between the base station **21** and the CN-1 (for example, the core network **100**I, the core network **100**A).

[0062] In step S**2001** and step S**4001**, the base station **21** and the N1N2 gateway **41** establish a SCTP association therebetween. Along with this, the N1N2 gateway **41** stores a port number "3850" of the SCTP.

[0063] In step S**2002**, the base station **21** transmits, to the N1N2 gateway **41**, NGsetupRequest, which is a message for requesting establishment of a NGAP tunnel. In step S**4002**, this message is received.

[0064] In step S**4003**, the N1N2 gateway **41** stores a SCTP endpoint and an identifier (gNB ID) of the base station so that the SCTP endpoint and the identifier are associated with each other. Here, the identifier of the base station **21** included in NGsetupRequest and the port number "3850" of the SCTP, which is an endpoint on the base station side, are associated with each other.

[0065] In step S**4003** and step S**5001**, the N1N2 gateway **41** and the AMF **110** of the CN-1 establish a SCTP association therebetween. Along with this, the N1N2 gateway **41** stores a port number "3860" of the SCTP.

[0066] In step S**4004**, the N1N2 gateway **41** stores a PLMN-ID of the CN-1 and a SCTP endpoint on the CN-1 side so that the PLMN-ID and the SCTP endpoint are associated with each other. Here, a PLMN-ID of a business operator operating the CN-1 included in NGsetupRequest and the port number "3860" of the SCTP, which is an endpoint on the core network side, are associated with each other. Further, the port number "3850" and the port number "3860" of the two endpoints are stored so as to be associated with each other.

[0067] The description here has dealt with the example in which the port number of the SCTP is used as the endpoint. However, the endpoint is not limited to the port number of the SCTP. In short, the endpoint may be any one, provided that it can specify a way to make connection with the base station and with the core network.

[0068] In step S**4005**, the N1N2 gateway **41** transmits NGSetupRequest to the AMF **110**. In step S**5002**, this message is received.

[0069] In step S**5003**, the AMF **110** transmits, to the N1N2 gateway **41**, NGSetupResponse, which is a response message to NGSetupRequest received in step S**5002**. In step S**4006**, this message is received.

[0070] In step S**4007**, the N1N2 gateway **41** transmits, to the base station **21**, NGSetupResponse received in step S**4006**. At this time, for example, NGSetupResponse designating the port number "3850" of the endpoint on the base station side is transmitted. In step S**2003**, this message is received.

[0071] In the above-described manner, the NGAP tunnel between the core network provided with the AMF **110** and the base station **21** is established. In the process previously described with reference to FIG. **4**, transmission and reception of messages related to establishment of the NGAP tunnel between the core network and the base station **21**, having been carried out in the conventional 5G communication system, are relayed by the N1N2 gateway **41**. Thus, from the base station **21** side, it appears as if the NGAP tunnel with the CN-1 were established as conventional.

Establishment of NGAP Tunnel With Core Network Having API Gateway

[0072] FIG. **5** is a view illustrating an example of a process related to establishment of a NGAP tunnel between a base station **21** and the CN-2 (for example, the core network **100**B).

[0073] In step S**2101** and step S**4101**, the base station **21** and **41** establish a SCTP association the N1N2 gateway therebetween.

[0074] In step S**2102**, the base station **21** transmits NGSetupRequest to the N1N2 gateway **41**. In step S**4102**, this message is received.

[0075] In step S**4103**, the N1N2 gateway **41** stores a SCTP endpoint and an identifier of the base station so that the SCTP endpoint and the identifier are associated with each other. Here, the identifier of the base station **21** included in NGsetupRequest and a port number of a SCTP, which is an endpoint on the base station side, are associated with each other.

[0076] The description here has dealt with the example in which the port number of the SCTP is used as the endpoint. However, the endpoint is not limited to the port number of the SCTP. In short, the endpoint may be any one, provided that it can specify a way to make connection with the base station.

[0077] In step S**4104**, the N1N2 gateway **41** transmits, as a response to NGSetupRequest received in step S**4101**, NGSetupResponse to the base station **21**. In step S**2103**, this message is received.

[0078] In the above-described manner, a NGAP tunnel between the core network having the API gateway **120** and the base station **21** is established. Since the API gateway **120** employs the stateless protocol, the N1N2 gateway **41** cannot establish a SCTP association with the API gateway **120**. Thus, instead of the API gateway **120**, the N1N2 gateway **41** transmits NGSetupResponse to the base station **21**. Also in this case, from the base station **21** side, it appears as if the NGAP tunnel with the CN-2 were established as conventional.

[0079] For example, in a case where the processes in step S**2001**, step S**4001**, step S**2002**, and step S**4002** in FIG. **4** have been already executed, the processes in step S**2101**, step S**4101**, step S**2102**, step S**4102**, and step S**4103** are not necessary. That is, once a SCTP association is established between the base station **21** and the N1N2 gateway **41**, the base station **21** transmits NGSetupRequest by using the SCTP association. For example, in a case where the base station **21** is to establish a NGAP tunnel with the CN-2, CN-3, . . . after the process related to establishment of the NGAP tunnel with the CN-1 is completed, the base station **21** would not establish a new SCTP association with the N1N2 gateway **41**.

[0080] The description here has dealt with the example in which the NGAP tunnel is terminated by the N1N2 gateway **41** itself. Alternatively, the NGAP tunnel may be terminated by the API gateway **120** and the CN-2. In this case, the N1N2 gateway **41** may simply transfer NGSetupRequest and NGSetupResponse.

Allocation of Radio Link to UE

[0081] Thereafter, a single piece of UE **11** or a plurality of pieces of UE **11** carry out communication with the core network(s) via the base station **21** and the N1N2 gateway **41**. In this process, the base station **21** notifies the UE **11** of a core network(s) (for example, the CN-1, CN-2, CN-3, . . .) with which the base station **21** itself is connectable. In establishment of a radio link with the base station **21**, the UE **11** designates a core network (for example, the CN-1) which is a connection destination.

[0082] A frame of New Radio (NR), which is a radio communication mode in the 5G communication system is provided with a Physical Broadcast Channel (PBCH) serving as a physical broadcast channel which notifies a main radio parameter. When making an initial access, the UE **11** detects information included in the PBCH. Consequently, the UE **11** also obtains a system parameter necessary to receive System Information Block (SIB) 1.

[0083] The base station **21** incorporates, into SIB1, PLMN-IDs of the core networks with which the base station **21** itself is connectable, and transmits a radio signal. Consequently, for example, the UE **11** is notified of the PLMN-IDs of the CN-1, CN-2, CN-3, . . . with which the base station **21** itself is connectable.

[0084] The UE **11** transmits, for example, a PLMN-ID (e.g., 22f640) of the CN-1, which is a core network with which the UE **11** itself should be connected in order to establish a radio link with the base station **21**. In one example, the UE **11** may transmit, to the base station **21**, the PLMN-ID of the CN-1 together with a Physical Random Access Channel (PRACH).

[0085] After the radio link with the UE **11** is established, the base station **21** gives, to the radio link with the UE **11**, a RAN-UE-NGAP-ID, which is a unique ID. For example, UE **11-1**, UE **11-2**, UE

11-3, and UE **11-4**, which are a plurality of pieces of UE, respectively establish a radio link W, a radio link X, a radio link Y, and a radio link Z with the base station **21**. In this case, for example, the radio link W is given "100" as a RAN-UE-NGAP-ID, and the radio link X is given "200" as a RAN-UE-NGAP-ID. The radio link Y and the radio link Z are respectively given "300" and "400" as RAN-UE-NGAP-IDs.

[0086] Actually, the radio links W to Z are identified as respective different frequency bands, for example.

[0087] With this configuration, the base station **21** can identify the pieces of UE according to the RAN-UE-NGAP-IDs. Further, at the time of establishment of the radio links, the base station **21** is notified of the PLMN-IDs of the core networks which are to be connected. Therefore, the base station **21** may store the RAN-UE-NGAP-IDs and the PLMN-IDs so that the RAN-UE-NGAP-IDs and the PLMN-IDs are associated with each other.

[0088] As described above, the radio links are allocated to the pieces of UE. Consequently, the base station **21** can carry out communication with a large number of core networks merely by holding a single SCTP session with the N1N2 gateway **41**. That is, with the configuration in which a RAN-UE-NGAP-ID is included in a message to be transmitted from a core network to UE, the base station **21** can transmit the message to the UE by identifying the radio link. This makes it possible to identify the UE to which the message is to be transmitted even without reference to the port number of the SCTP, thereby making it possible to connect a plurality of pieces of UE with a plurality of core networks by using the single SCTP session.

Selection of Core Network in Response to Request From UE (Version 1)

[0089] As described above, the N1N2 gateway **41** is connected with the plurality of core networks, so that each of the pieces of UE **11** connected with the base station **21** can carry out communication with an appropriate one of the core networks. FIG. **6** is a view illustrating an example of selecting, in response to requests from UE, a core network in the 5G communication system in accordance with the present embodiment, the selection of the core network being carried out in response to requests from a plurality of different pieces of UE connected via a single base station.

[0090] In the case shown in FIG. **6**, a base station **21-1** is connected with a N1N2 gateway **41**, and the CN-1 and the CN-2 commonly use the base station **21-1**. That is, in the example shown in FIG. **6**, a single base station **21-1** is connected with a single N1N2 gateway **41**. Of the plurality of pieces of UE carrying out communication via the base station **21-1**, UE **11-1** is connected with the CN-1, and UE **11-2** is connected with the CN-2. In this example, before messages are transmitted from the pieces of UE, establishment of the NGAP tunnel, which is previously described with reference to FIGS. **3** and **4**, is completed.

Connection Between UE **11-1** and CN-1 Via Base Station **21-1**

[0091] First, the following will describe an example in which selection of the core network (CN-1) is carried out in response to a request from the UE **11-1**.

[0092] In step S**1211**, the UE **11-1** transmits a NAS message to the base station **21-1**. In step S**2201**, the NAS message is received. In this process, transmitted as the NAS message is, for example, a request to initiate a single system procedure among a plurality of system procedures specified by TS.23.502. Note that the transmission of the NAS message is carried out via the radio link W which is established in advance.

[0093] For example, it is requested to initiate a system procedure such as Registration, PDU Session Establishment, or PDU Session Release. Note that the NAS message includes the PLMN-ID (22f640) of the CN-1.

[0094] In step S**2202**, the base station **21-1** generates a NGAP message including the NAS message received in step S**2201**, and transmits the NGAP message to the N1N2 gateway **41**. In step S**4201**, the NGAP message is received. The NGAP message includes the PLMN-ID of the CN-1 and the RAN-UE-NGAP-ID (100) of the radio link W.

[0095] In step S**4202**, the N1N2 gateway **41** identifies a transfer destination. As described above, in

the N1N2 gateway **41**, information such as the table in which an address of the communication destination and a PLMN-ID are associated with each other is stored in the storage section **55** in advance. Thus, an address of an AMF **110** of the CN-1 associated with the PLMN-ID of the CN-1 is identified. The address may be an IP address, for example.

[0096] Further, for example, in a case where a SCTP association with the communication destination is already established, it may be configured such that a SCTP port number can be identified. In this case, a SCTP endpoint on the base station side and a SCTP endpoint on the core network side are also stored so that these SCTP endpoints are associated with each other.

[0097] In step S**4203**, the N1N2 gateway **41** transmits, to the AMF **110**, the NGAP message received in step S**4201**. In step S**5201**, the NGAP message is received.

[0098] In step S**6201**, NFs **111** of the CN-1 executes a process related to a system procedure corresponding to an initiation request from the UE **11-1**. The NFs **111** includes a plurality of NFs, and these NFs are collectively described as "NFs". For example, in a case where a request to initiate PDU Session Establishment is given in step S**1211**, a process related to PDU Session Establishment is executed by a NF(s) such as a Session Management Function (SMF) and/or a Policy Control Function (PCF) in the NFs **111**.

[0099] Upon completion of the system procedure, in step S**5201**, the AMF **110** generates, as a response to the NGAP message received in step S**5201**, a NGAP message including a NAS message, and transmits the NGAP message to the N1N2 gateway **41**. In step S**4204**, the N1N2 gateway **41** receives the NGAP message. The NGAP message includes the RAN-UE-NGAP-ID (100) of the radio link W.

[0100] In step S**4205**, the N1N2 gateway **41** transmits, to the base station **21**, the NGAP message received in step S**4204**. In step S**2203**, the NGAP message is received.

[0101] In step S**2204**, the base station **21** transmits, to the UE **11-1**, the NAS message included in the NGAP message received in step S**2203**. In this process, the base station **21** refers to the RAN-UE-NGAP-ID included in the NGAP message, and transmits the NAS message to the UE **11-1** via the radio link W.

[0102] In the above-described manner, selection of the core network (CN-1) is carried out in response to the request from UE **11-1**.

Connection Between UE **11-2** and CN-2 Via Base Station **21-1**

[0103] Next, the following will describe an example in which selection of the core network (CN-2) is carried out in response to a request from the UE **11-2**.

[0104] In step S**1221**, the UE **11-2** transmits a NAS message to the base station **21-1**. In step S**2211**, the NAS message is received. In this process, transmitted as the NAS message is, for example, a request to initiate a single system procedure among a plurality of system procedures specified by TS.23.502. Note that the transmission of the NAS message is carried out via the radio link X established in advance and the NAS message includes a PLMN-ID (44f002) of the CN-2.

[0105] In step S**2212**, the base station **21-1** generates a NGAP message including the NAS message received in step S**2211**, and transmits the NGAP message to the N1N2 gateway **41**. In step S**4211**, the NGAP message is received. The NGAP message includes the PLMN-ID (44f002) of the CN-1 and the RAN-UE-NGAP-ID (200) of the radio link X.

[0106] In step S**4212**, the N1N2 gateway **41** identifies a transfer destination. As described above, in the N1N2 gateway **41**, information such as the table in which an address of the communication destination and a PLMN-ID are associated with each other is stored in the storage section **55** in advance. Thus, an address of an API gateway **120** of the CN-2 associated with the PLMN-ID of the CN-2 is identified. The address may be an IP address, for example.

[0107] In step S**4213**, the N1N2 gateway **41** transmits, to the API gateway **120**, the identifier of the base station **21-1** together with the NGAP message received in step S**4211**. In this process, the N1N2 gateway **41** identifies the identifier of the base station **21-1** on the basis of the information in which the SCTP endpoint and the identifier of the base station are associated with each other, the

information having been stored at the time of establishment of the NGAP tunnel (step S**4103** in FIG. **5**).

[0108] Since the CN-2 is the core network employing the stateless protocol, the N1N2 gateway **41** does not store the SCTP endpoint on the core network side. That is, in the conventional 5G communication system, a SCTP association between the base station and the AMF of the core network is constantly maintained. Thus, the core network can identify, according to the SCTP association, the base station to which a message is to be transmitted. However, a SCTP association is not maintained between the N1N2 gateway **41** and the CN-2.

[0109] Thus, in order that the message transmitted from the CN-2 is delivered to the base station **21-1**, the identifier of the base station **21-1** is transmitted together with the message from the base station **21-1**. That is, when the first stateful communication section **51** which carries out communication with the base station **21-1** receives a NGAP message which is to be transmitted from the base station **21-1** to the CN-2, the stateless communication section **52** transmits, to the CN-2, information indicative of the identifier of the base station **21-1** together with the NGAP message. With this, it is possible to provide the 5G communication system without connecting the base station **21** and the CN-2 with each other according to the stateful protocol.

[0110] In step S**7201**, the NGAP message is received by the API gateway **120** of the CN-2.

[0111] In step S**8201**, a backend **121** of the CN-2 executes a process related to a system procedure corresponding to an initiation request from the UE **11-2**. When the request to initiate the system procedure is given from the UE **11-2**, the backend **121** generates, for example, an instance of a program causing a computer to execute processes required from initiation to completion of the system procedure. This program may be a function.

[0112] For example, in a case where a single piece of UE gives a request to start Registration, a single instance fn-1-Reg corresponding to a function of Registration is generated. Then, in a case where another piece of UE gives a request to start Registration, another instance fn-2-Reg corresponding to a function of Registration is generated.

[0113] For example, in a case where a single piece of UE gives a request to initiate PDU Session Establishment, a single instance fn-1-PSE is generated. Then, in a case where another piece of UE **11** gives a request to initiate PDU Session Establishment, another instance fn-2-PSE is generated.

[0114] As described above, for each of the plurality of pieces of UE, an instance for each of the plurality of system procedures is generated.

[0115] Further, in the backend **121** of the CN-2, a computational resource is allocated every time an instance is generated. The "computational resource" herein means a resource related to a processor and a memory of a computer.

[0116] Further, in the backend **121** of the CN-2, a process related to a system procedure is executed with reference to a state of UE stored in a database. In the database, the states of the pieces of UE are stored in advance. Then, when the system procedure is completed, the state of the UE is updated. The updated state of the UE is stored in the database. Then, the instance corresponding to the completed system procedure is deleted, and a computational resource therefor is released.

[0117] As described above, the backend **121** of the CN-2 executes the process related to the system procedure in a mode different from that for the NFs **111** of the CN-1.

[0118] Upon completion of the system procedure, in step S**7202**, the API gateway **120** generates, as a response to the NGAP message received in step S**7201**, a NGAP message including a NAS message, and transmits the NGAP message to the N1N2 gateway **41**. In this process, the identifier of the base station **21-1** received in step S**7201** is transmitted together with the NGAP message. In step S**4214**, the NGAP message is received by the N1N2 gateway **41**. The NGAP message includes the RAN-UE-NGAP-ID (200) of the radio link X.

[0119] In step S**4215**, the N1N2 gateway **41** identifies the endpoint on the base station side. In this process, according to the identifier of the base station **21-1** received together with the NGAP message in step S**4214**, a base station to which the NGAP message is to be transmitted is identified.

Consequently, a SCTP endpoint associated with the identifier is identified. In this process, the N1N2 gateway **41** identifies the SCTP endpoint on the basis of the information in which the SCTP endpoint and the identifier of the base station are associated with each other, the information having been stored at the time of established of the NGAP tunnel.

[0120] In the case of the example shown in FIG. **6**, the single base station **21-1** is connected with the N1N2 gateway **41**. Therefore, it is clear that the base station to which the NGAP message is to be transmitted is the base station **21-1**. In such a case, the process in step S**4215** may be omitted.

[0121] In step S**4216**, the N1N2 gateway **41** transmits, to the base station **21-1**, the NGAP message received in step S**4214**. In step S**2213**, the NGAP message is received.

[0122] In step S**2214**, the base station **21** transmits, to the UE **11-2**, the NAS message included in the NGAP message received in step S**2213**. In this process, the base station **21** refers to the RAN-UE-NGAP-ID included in the NGAP message, and transmits the NAS message to the UE **11-2** via the radio link X.

[0123] In the above-described manner, selection of the core network (CN-2) is carried out in response to the request from UE **11-2**.

[0124] As previously described with reference to FIG. **6**, in the 5G communication system in accordance with the present embodiment, each of a plurality of pieces of UE connected with a single base station is allowed to carry out communication with an appropriate core network. In this process, regardless of the number of core networks, the base station may establish only one SCTP association with the N1N2 gateway.

Selection of Core Network in Response to Request From UE (Version 2)

[0125] In a case where all of the core networks connected with the N1N2 gateway **41** are core networks each having an API gateway employing the stateless protocol, it is possible to allow the plurality of base stations to be connected with the single N1N2 gateway **41**. In other words, in a case where the N1N2 gateway **41** is not connected with the core networks according to the stateful protocol, it is possible to allow the plurality of base stations to be connected with the single N1N2 gateway **41**.

[0126] FIG. **7** is a view illustrating an example of selecting a core network in response to requests from UE in the 5G communication system in accordance with the present embodiment, the selection of the core network being carried out in response to requests from a plurality of different pieces of UE connected via different base stations.

[0127] In the case shown in FIG. **7**, the base station **21-1** and the base station **21-2** are connected with the same N1N2 gateway **41**. The UE **11-2** which carries out communication via the base station **21-1** is connected with the CN-2, and the UE **11-3** which carries out communication via the base station **21-2** is also connected with the CN-2. In this example, before messages are transmitted from the pieces of UE, establishment of the NGAP tunnel, which is previously described with reference to FIGS. **3** and **4**, is completed.

Connection Between UE **11-2** and CN-2 Via Base Station **21-1**

[0128] First, the following will describe an example in which selection of the core network (CN-2) is carried out in response to a request from the UE **11-2** connected with the base station **21-1**.

[0129] In step S**1321**, the UE **11-2** transmits a NAS message to the base station **21-1**. In step S**2301**, the NAS message is received. In this process, transmitted as the NAS message is, for example, a request to initiate a single system procedure among a plurality of system procedures specified by TS.23.502. Note that the transmission of the NAS message is carried out via the radio link Y established in advance and the NAS message includes the PLMN-ID (44f002) of the CN-2.

[0130] In step S**2302**, the base station **21-1** generates a NGAP message including a NAS message received in step S**2301**, and transmits the NGAP message to the N1N2 gateway **41**. In step S**4301**, the NGAP message is received. The NGAP message includes the PLMN-ID (44f002) of the CN-2 and the RAN-UE-NGAP-ID (300) of the radio link Y.

[0131] In step S**4302**, the N1N2 gateway **41** identifies a transfer destination. As described above, in

the N1N2 gateway **41**, information such as the table in which an address of the communication destination and a PLMN-ID are associated with each other is stored in the storage section **55** in advance. Thus, an address of an API gateway **120** of the CN-2 associated with the PLMN-ID of the CN-1 is identified. The address may be an IP address, for example.

[0132] In step S**4303**, the N1N2 gateway **41** transmits, to the API gateway **120**, the identifier of the base station **21**-**1** together with the NGAP message received in step S**4301**. In this process, the N1N2 gateway **41** identifies the identifier of the base station **21**-**1** on the basis of the information in which the SCTP endpoint and the identifier of the base station are associated with each other, the information having been stored at the time of establishment of the NGAP tunnel.

[0133] In step S**7301**, the NGAP message is received by the API gateway **120** of the CN-2.

[0134] In step S**8301**, the backend **121** of the CN-2 executes a process related to a system procedure corresponding to an initiation request from the UE **11**-**2**. As described above, the backend **121** of the CN-2 executes the process related to the system procedure in a mode different from that for the NFs **111** of the CN-1.

[0135] Upon completion of the system procedure, in step S**7302**, the API gateway **120** generates, as a response to the NGAP message received in step S**7301**, a NGAP message including a NAS message, and transmits the NGAP message to the N1N2 gateway **41**. In this process, the identifier of the base station **21**-**1** received in step S**7301** is transmitted together with the NGAP message. In step S**4304**, the NGAP message is received by the N1N2 gateway **41**. The NGAP message includes the RAN-UE-NGAP-ID (300) of the radio link Y.

[0136] In step S**4305**, the N1N2 gateway **41** identifies the endpoint on the base station side. In this process, according to the identifier of the base station **21**-**1** received together with the NGAP message in step S**4304**, a base station to which the NGAP message is to be transmitted is identified. Consequently, a SCTP endpoint associated with the identifier is identified. In this process, the N1N2 gateway **41** identifies the SCTP endpoint on the basis of the information in which the SCTP endpoint and the identifier of the base station are associated with each other, the information having been stored at the time of established of the NGAP tunnel.

[0137] In step S**4306**, the N1N2 gateway **41** transmits, to the base station **21**-**1**, the NGAP message received in step S**4304**. In step S**2303**, the NGAP message is received.

[0138] In step S**2304**, the base station **21**-**1** transmits, to the UE **11**-**2**, the NAS message included in the NGAP message received in step S**2302**. In this process, the base station **21**-**1** refers to the RAN-UE-NGAP-ID included in the NGAP message, and transmits the NAS message to the UE **11**-**2** via the radio link Y.

[0139] In the above-described manner, selection of the core network (CN-2) is carried out in response to the request from the UE **11**-**2**.

Connection Between UE **11**-**3** and CN-2 Via Base Station **21**-**2**

[0140] Next, the following will describe an example in which selection of the core network (CN-2) is carried out in response to a request from the UE **11**-**3** connected with the base station **21**-**2**.

[0141] In step S**1331**, the UE **11**-**3** transmits a NAS message to the base station **21**-**2**. In step S**2321**, the NAS message is received. In this process, transmitted as the NAS message is, for example, a request to initiate a single system procedure among a plurality of system procedures specified by TS.23.502. Note that the transmission of the NAS message is carried out via the radio link Z established in advance and the NAS message includes the PLMN-ID (44f002) of the CN-2.

[0142] In step S**2322**, the base station **21**-**2** generates a NGAP message including a NAS message received in step S**2321**, and transmits the NGAP message to the N1N2 gateway **41**. In step S**4321**, the NGAP message is received. The NGAP message includes the PLMN-ID (44f002) of the CN-2 and the RAN-UE-NGAP-ID (400) of the radio link Z.

[0143] In step S**4322**, the N1N2 gateway **41** identifies a transfer destination. As described above, in the N1N2 gateway **41**, information such as the table in which an address of the communication destination and a PLMN-ID are associated with each other is stored in the storage section **55** in

advance. Thus, an address of an API gateway **120** of the CN-2 associated with the PLMN-ID (44f002) of the CN-1 is identified. The address may be an IP address, for example.

[0144] In step S**4323**, the N1N2 gateway **41** transmits, to the API gateway **120**, the identifier of the base station **21-2** together with the NGAP message received in step S**4321**. In this process, the N1N2 gateway **41** identifies the identifier of the base station **21-2** on the basis of the information in which the SCTP endpoint and the identifier of the base station are associated with each other, the information having been stored at the time of establishment of the NGAP tunnel.

[0145] In step S**7311**, the NGAP message is received by the API gateway **120** of the CN-2.

[0146] In step S**8311**, the backend **121** of the CN-2 executes a process related to a system procedure corresponding to an initiation request from the UE **11-2**. As described above, the backend **121** of the CN-2 executes the process related to the system procedure in a mode different from that for the NFs **111** of the CN-1.

[0147] Upon completion of the system procedure, in step S**7312**, the API gateway **120** generates, as a response to the NGAP message received in step S**7311**, a NGAP message including a NAS message, and transmits the NGAP message to the N1N2 gateway **41**. In this process, the identifier of the base station **21-2** received in step S**7311** is transmitted together with the NGAP message. In step S**4324**, the NGAP message is received by the N1N2 gateway **41**. The NGAP message includes the RAN-UE-NGAP-ID (400) of the radio link Z.

[0148] In step S**4325**, the N1N2 gateway **41** identifies the endpoint on the base station side. In this process, according to the identifier of the base station **21-2** received together with the NGAP message in step S**4324**, a base station to which the NGAP message is to be transmitted is identified. Consequently, a SCTP endpoint associated with the identifier is identified. In this process, the N1N2 gateway **41** identifies the SCTP endpoint on the basis of the information in which the SCTP endpoint and the identifier of the base station are associated with each other, the information having been stored at the time of established of the NGAP tunnel.

[0149] In step S**4326**, the N1N2 gateway **41** transmits, to the base station **21-2**, the NGAP message received in step S**4324**. In step S**2323**, the NGAP message is received.

[0150] In step S**2324**, the base station **21-2** transmits, to the UE **11-3**, the NAS message included in the NGAP message received in step S**2322**. In this process, the base station **21-2** refers to the RAN-UE-NGAP-ID included in the NGAP message, and transmits the NAS message to the UE **11-3** via the radio link Z.

[0151] In the above-described manner, selection of the core network (CN-2) is carried out in response to the request from UE **11-3**.

Effects of First Embodiment

[0152] As described above, introduction of the N1N2 gateway enables connection with a wide variety of core networks by using the existing base stations. That is, with the configuration in which communication is carried out with core networks via the N1N2 gateway, it is possible to carry out communication with a core network employing the stateless protocol, for example.

[0153] Further, it is difficult to predict all specifications of core networks that can be employed in the future. Introduction of the N1N2 gateway also makes it possible to flexibly change the specifications of the core networks even without changing equipment or functions of the base stations. That is, introduction of the N1N2 gateway enables connection with a large number of core networks even without increasing the number of SCTP associations to be held in the existing base stations **21**.

[0154] Furthermore, in session management by the N1N2 gateway and the API gateway, SCTP session management carried out between the base station and the AMF is not necessary. That is, it is possible to realize communication as if it were a WEB application in which the API gateway serves as a server and the N1N2 gateway serves as a client. In the WEB application, the number of access endpoints to the WEB server is logically one, and the server and the client maintain TCP sessions only while communication is carried out. Introduction of the N1N2 gateway makes it

possible to allow connection between the base stations and the core networks to be in a mode having high extensibility like the WEB application.

[0155] As described above, according to the present embodiment, it is possible to provide a technique that enables flexible connection with a large number of core networks even without changing, for example, equipment and/or operating systems related to the existing base stations.

Second Embodiment

Variations of API Gateway

[0156] As described above, the API gateway **120**B is constituted by, for example, software using API created by a communication business operator (company B) of the core network **100**B, and does not establish a SCTP association.

[0157] For example, in a case where the core network **100**B and the N1N2 gateway **41** shown in FIG. **2** carry out communication by a MQ, the API gateway **120** may be configured to have two queues. For example, an upLinkMQ 151 in which messages transmitted from the N1N2 gateway **41** are accumulated and a downLinkMQ 161 in which messages which are to be transmitted to the N1N2 gateway **41** are accumulated may be provided to the API gateway **120**.

[0158] Note that the upLinkMQ 151 and the downLinkMQ 161 will be respectively referred as "MQ 151" and "MQ 161" as appropriate. That is, the core network **100** causes messages transmitted from the N1N2 gateway **41** to be accumulated in a first message queue (MQ 151) and asynchronously processes the messages, and the core network **100** causes messages which are to be transmitted to the N1N2 gateway **41** to be accumulated in a second message queue (MQ 161) and asynchronously processes the messages.

[0159] In this case, in the storage section **55** of the N1N2 gateway **41**, information in which a PLMN-ID and IP addresses of the upLinkMQ 151 and the downLinkMQ 161 are associated with each other is stored.

[0160] With such a configuration, it is possible to decentralize process loads at a peak in the core network, for example. Therefore, for example, it is possible to reduce occurrence of congestion even without increasing the computational resource.

[0161] Further, the API gateway **120** may be provided with upLinkMQs 151 and downLinkMQs 161 such that the upLinkMQs 151 and the downLinkMQs 161 are associated with their corresponding system procedures. For example, MQs may be provided such that an upLinkMQ 151-1 and a downLinkMQ 161-1 are provided for registration and an upLinkMQ 151-2 and a downLinkMQ 161-2 are provided for PDU session establishment, ...

[0162] For example, in a case where, among system procedures processed in the core network, a specific system procedure is intended to be processed preferentially, the upLinkMQs 151 and the downLinkMQs 161 may be provided for corresponding system procedure. With such a configuration, it is possible to easily set priority levels of the system procedures, for example.

[0163] Furthermore, the API gateway **120** may be configured by adding a function to the existing AMF **110**, for example.

Third Embodiment

Variations of N1N2 Gateway Connection

[0164] In the examples explained in the foregoing embodiments, the base station **21** is constantly connected with the core networks via the N1N2 gateway **41**. Alternatively, for example, connection with the core network having the AMF **110** may be made not via the N1N2 gateway **41**.

[0165] For example, in order to carry out communication with the core network **100**I and the core network **100**A shown in FIG. **2**, the base station **21** may directly carry out the communication with the core network **100**I and the core network **100**A, not via the N1N2 gateway **41**. With such a configuration, it is possible to more effectively utilize the existing equipment.

Software Implementation Example

[0166] The N1N2 gateway **41** described above can be realized by a program installed on a computer, the program causing the computer to function as the N1N2 gateway **41**. In this case, the

N1N2 gateway **41** includes, as hardware for executing the program, a computer which includes (i) at least one control device (e.g., processor) and (ii) at least one storage device (e.g., memory). An example of such a computer is illustrated in FIG. **8**.

[0167] A computer **500** includes at least one processor **501** and at least one memory **502**. In the memory **502**, a program **520** for causing the computer **500** to function as the N1N2 gateway **41** is stored. In the computer **500**, the processor **501** reads the program **520** from the memory **502** and executes the program **520**, so that the functions of the N1N2 gateway **41** are realized.

[0168] The processor **501** can be, for example, a Central Processing Unit (CPU), a Graphic Processing Unit (GPU), a Digital Signal Processor (DSP), a Micro Processing Unit (MPU), a Floating point number Processing Unit (FPU), a Physics Processing Unit (PPU), a microcontroller, or a combination of any of them.

[0169] The memory **502** can be, for example, a flash memory, a Hard Disk Drive (HDD), a Solid State Drive (SSD), or a combination of any of them.

[0170] Note that the computer **500** can further include a Random Access Memory (RAM) in which the program **520** is loaded when the program **520** is executed and in which various kinds of data are temporarily stored. The computer **500** can further include a communication interface for carrying out transmission and reception of data with other apparatuses. The computer **500** can further include an input-output interface for connecting input-output apparatuses such as a keyboard, a mouse, a display, and/or a printer.

[0171] The program **520** for causing the computer **500** to operate as the N1N2 gateway **41** can be stored in a non-transitory tangible storage medium **530** which is readable by the computer **500**. The storage medium **530** can be, for example, a tape, a disk, a card, a semiconductor memory, a programmable logic circuit, or the like. The computer **500** can obtain the program **520** via the storage medium **530**.

[0172] The program **520** for causing the computer **500** to operate as the N1N2 gateway **41** can be transmitted via a transmission medium. The transmission medium can be, for example, a communications network, a broadcast wave, or the like. The computer **500** can obtain the program **520** also via such a transmission medium.

[0173] A part of or all of the functions of the N1N2 gateway **41** can also be realized by a logical circuit. For example, an integrated circuit on which a logical circuit functioning as the control blocks is formed may also be encompassed in the present invention. Further, the functions of the control blocks can also be realized by a quantum computer, for example.

[0174] Further, since the above-described aspects of the present invention give the foregoing effects, it is possible to contribute to achievement of Goal 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation." of Sustainable Development Goals (SDGs).

[0175] The present invention is not limited to the embodiments, but can be altered by a skilled person in the art within the scope of the claims. The present invention also encompasses, in its technical scope, any embodiment derived by combining technical means disclosed in differing embodiments.

[0176] Aspects of the present invention can also be expressed as follows:

[0177] An information processing device in accordance with a first aspect of the present invention is an information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing device including: a first stateful communication section configured to carry out communication with the base station according to a stateful protocol; and a stateless communication section configured to carry out communication with the first core network according to a stateless protocol.

[0178] An information processing device in accordance with a second aspect of the present invention is configured such that, in the first aspect, the first core network includes a relay section configured to relay the communication with the information processing device, and the information processing device further includes a storage section configured to store therein information in which an address of the relay section and a business operator identifier of the first core network are associated with each other.

[0179] An information processing device in accordance with a third aspect of the present invention is configured such that, in the second aspect, the relay section causes messages transmitted from the information processing device to be accumulated in a first message queue and asynchronously processes the messages; and the relay section causes messages which are to be transmitted to the information processing device to be accumulated in a second message queue and asynchronously processes the messages.

[0180] An information processing device in accordance with a fourth aspect of the present invention is configured such that, in the second or third aspect, the relay section is constituted by software which uses an API provided by a communication business operator of the first core network.

[0181] An information processing device in accordance with a fifth aspect of the present invention is configured such that, in any one of the first to fourth aspects, the first stateful communication section carries out communication with a plurality of base stations.

[0182] An information processing device in accordance with a sixth aspect of the present invention is configured such that, in the fifth aspect, in a case where the first stateful communication section receives a NGAP message which is transmitted from the base station to the first core network, the stateless communication section transmits, to the first core network, information indicative of an identifier of the base station together with the NGAP message.

[0183] An information processing device in accordance with a seventh aspect of the present invention is configured such that, in any of the second to fourth aspects, the information processing device further includes a second stateful communication section configured to carry out communication with a second core network according to a stateful protocol, wherein the information processing device further serves as at least one of (i) an interface via which the base station and the second core network are connected with each other and (ii) an interface via which a terminal device connected with the second core network via the base station and the second core network are connected with each other.

[0184] An information processing device in accordance with an eighth aspect of the present invention is configured such that, in the seventh aspect, the storage section is further configured to store therein information in which an address of an AMF of the second core network and a business operator identifier of the second core network are associated with each other.

[0185] An information processing device in accordance with a ninth aspect of the present invention is configured such that, in any of the first to eighth aspects, the stateful protocol is a SCTP; and the stateless protocol is a RPC or a MQ.

[0186] An information processing method in accordance with a tenth aspect of the present invention is an information processing method for an information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing method including: a first stateful communication step of carrying out communication with the base station according to a stateful protocol; and a stateless communication step of carrying out communication with the first core network according to a stateless protocol.

[0187] A program in accordance with an eleventh aspect of the present invention is a program causing a computer to function as an information processing device which is connected with a base

station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing device including: a first stateful communication section configured to carry out communication with the base station according to a stateful protocol; and a stateless communication section configured to carry out communication with the first core network according to a stateless protocol.

REFERENCE SIGNS LIST

[0188] **11**: UE [0189] **21**: base station [0190] **41**: N1N2 gateway [0191] **51**: first stateful communication section [0192] **52**: stateless communication section [0193] **53**: second stateful communication section [0194] **54**: control section [0195] **55**: storage section [0196] **100**: core network [0197] **110**: AMF [0198] **120**: API gateway

Claims

1. An information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing device comprising: a first stateful communication section configured to carry out communication with the base station according to a stateful protocol; and a stateless communication section configured to carry out communication with the first core network according to a stateless protocol.

2. The information processing device according to claim 1, wherein: the first core network includes a relay section configured to relay the communication with the information processing device, and the information processing device further comprises a storage section configured to store therein information in which an address of the relay section and a business operator identifier of the first core network are associated with each other.

3. The information processing device according to claim 2, wherein: the relay section causes messages transmitted from the information processing device to be accumulated in a first message queue and asynchronously processes the messages; and the relay section causes messages which are to be transmitted to the information processing device to be accumulated in a second message queue and asynchronously processes the messages.

4. The information processing device according to claim 2, wherein: the relay section is constituted by software which uses an Application Programming Interface (API) provided by a communication business operator of the first core network.

5. The information processing device according to claim 1, wherein: the first stateful communication section carries out communication with a plurality of base stations.

6. The information processing device according to claim 5, wherein: in a case where the first stateful communication section receives a Next Generation Application Protocol (NGAP) message which is transmitted from the base station to the first core network, the stateless communication section transmits, to the first core network, information indicative of an identifier of the base station together with the NGAP message.

7. The information processing device according to claim 2, further comprising: a second stateful communication section configured to carry out communication with a second core network according to a stateful protocol, wherein the information processing device further serves as at least one of (i) an interface via which the base station and the second core network are connected with each other and (ii) an interface via which a terminal device connected with the second core network via the base station and the second core network are connected with each other.

8. The information processing device according to claim 7, wherein: the storage section is further

configured to store therein information in which an address of an Access and Mobility Management Function (AMF) of the second core network and a business operator identifier of the second core network are associated with each other.

9. The information processing device according to claim 1, wherein: the stateful protocol is a Stream Control Transmission Protocol (SCTP); and the stateless protocol is a Remote Procedure Call (RPC) or a Message Queue (MQ).

10. An information processing method for an information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing method comprising: a first stateful communication step of carrying out communication with the base station according to a stateful protocol; and a stateless communication step of carrying out communication with the first core network according to a stateless protocol.

11. A computer-readable non-transitory recording medium having recorded thereon a program causing a computer to function as an information processing device which is connected with a base station and which serves as at least one of (i) an interface via which the base station and a first core network are connected with each other and (ii) an interface via which a terminal device connected with the first core network via the base station and the first core network are connected with each other, the information processing device including: a first stateful communication section configured to carry out communication with the base station according to a stateful protocol; and a stateless communication section configured to carry out communication with the first core network according to a stateless protocol.