Efforts to Solve the Congestion Problems of Mobile Communications Services during Major Natural Disasters

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Abstract

A communications outage may occur as a result of congestion of the mobile communications networks or of multiple and simultaneous physical damages to the transmission lines and communications facilities that comprise the mobile communications networks. Such issues may all be caused by a massive and concentrated occurrence of calls and data transfer from and to mobile phones, especially during major natural disasters happen. It is essential therefore for the congestion issues to be resolved and the networks to be restored.

As a part of the R&D strategy to solve these issues, this paper discusses suitable technologies designed to enhance processing capacity by using virtualization of the communications services, a priority control technology for mobile traffic using OpenFlow and a quality maintenance technology for virtualized communications services.

Keywords

mobile communications network, LTE, OpenFlow, network virtualization, server virtualization

1. Introduction

Because calls and data transfer from and to mobile phones take place massively and concentratedly in the case of a major natural disaster, a huge demand for the services of mobile communications networks is generated. This causes congestion conditions in which the connectivity ratio is decreased by exceeding the communications service processing capacity. Moreover, there may be simultaneous and multiple occurrences of physical damages to transmission lines and communications facilities that comprise the mobile communications networks, thereby posing the possibility of a serious communications outage.

As a result of the Great East Japan Earthquake in northeastern Japan, for example, the demand for communications services reached about 60 times that of normal. This demand surge resulted in major difficulties in providing stable communications services. On the other hand, in areas away from the disaster-stricken areas, no large-scale communications congestion was reported to have happened.

Should such abnormal conditions occur, it is essential that the events are promptly detected and that appropriate countermeasures are taken to solve the congestion conditions and restore the networks. At such a time, the traffic with higher priority such as voice calls and emails need to be processed flexibly.

To solve the above-mentioned issues, the authors of this paper are engaged in R&D for the enhancement of the anti-disaster capabilities of communications services by using the network and server virtualization technology, while focusing on the communications services for LTE (Long Term Evolution) networks [1]. The technologies listed below are chosen as suitable R&D for discussion in this paper.

- **Processing capacity enhancement technology by virtualizing communications services**
  In virtualizing communications services in order to enable their flexible deployment, the processing capacities of the communications services, including the voice calls, which are critical in a disaster, are enhanced by utilizing the available hardware resources.
- **Priority control technology for mobile traffic using OpenFlow**
  By dynamically controlling networks using OpenFlow [2], the data (traffic) of the voice calls that are critical in a disaster are transmitted as high priority data.
- **Quality maintenance technology for virtualized communications services**
  In order that a virtualized communications service may be used for a practical communications system, the sta-

bility of the processing time of the virtual machines (VMs) themselves is improved, so the quality of their responsiveness can be improved.

2. Processing Capacity Enhancement Technology by Virtualizing Communications Services

The VoLTE (Voice over LTE) 'voice call service of the LTE network' is achieved by the linkage of two systems, one is the EPC (Evolved Packet Core,) which is a packet service network and the other is the IMS (IP Multi-media Subsystem,) which provides voice call services. Performances within certain assumed ranges are required for EPC and IMS in order to ensure the quality of the voice calls.

In communications services that have these features, it was conventionally difficult to share the same hardware for different services, since an individual service system was achieved via dedicated hardware. Moreover, it was necessary to operate using static configurations that had been thoroughly verified in advance. This made it difficult to change the configurations dynamically.

Now the authors have solved the above-mentioned problems in dynamic configuration changes of communications services by using the server virtualization technology. In other words, virtualization of EPC and IMS has made it possible to change the processing capability flexibly during congestion.

Here the first objective is to flexibly change the configuration of communications services within each site while the second one is to establish a technology that enables a flexible change of configurations via the linkage of the communications services between sites.

2.1 Technology to Change the Communications Service Configuration within Each Site

In order to change the communications service configuration flexibly within each site, R&D is underway to achieve a technology to appropriately control changes in the configuration of the virtualized communications services. The processing capacity of important communications services can then be enhanced (**Fig. 1**), by using excess resources within the site as well as the resources of other services of lower priority. This process comprises the following technologies.

- **The communications service deployment technology**
  Judges whether or not multiple communications services can be deployed on multiple servers installed in the sites on a per virtual machine basis while taking account of the characteristics of communications services such as their real-time properties.
- **The communications service execution control technology**
  Controls the execution of the communications services, such as start-up and shut-down as well as the settings of the virtual networks. They are all carried out by considering the dependencies between the components that comprise the communications services and also by referring the network configuration restrictions.
- **The communications service status monitoring technology**
  Judges the congestion conditions and failures of the communications services by collecting output log data to monitor the status of the communications services.

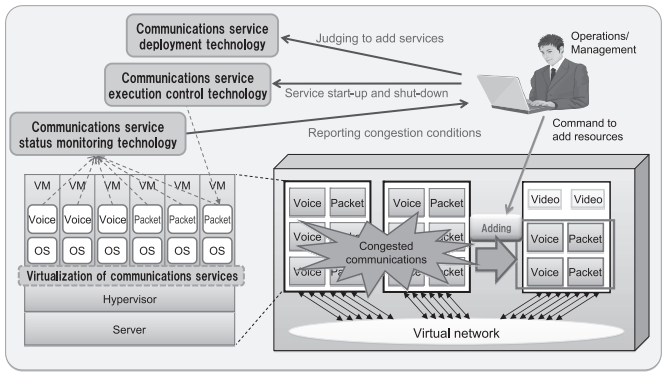

Fig. 1 Overall scheme of technology to change the communications service configurations of each site.

Among these technologies, the communications service deployment technology estimates the processing capability of communications services by using the performance conversion method applied with the system configuration evaluation algorithm. This is based on operation models that take account of the characteristics of communication services so that the performance of the services even during congested period can be ensured.

2.2 Linkage Control Technology of Communications Services between Sites

There might be occurred large communication congestion with which the above mentioned technology to change the communication services configuration within one site cannot cope. In such a case a technology that enables linkage of the

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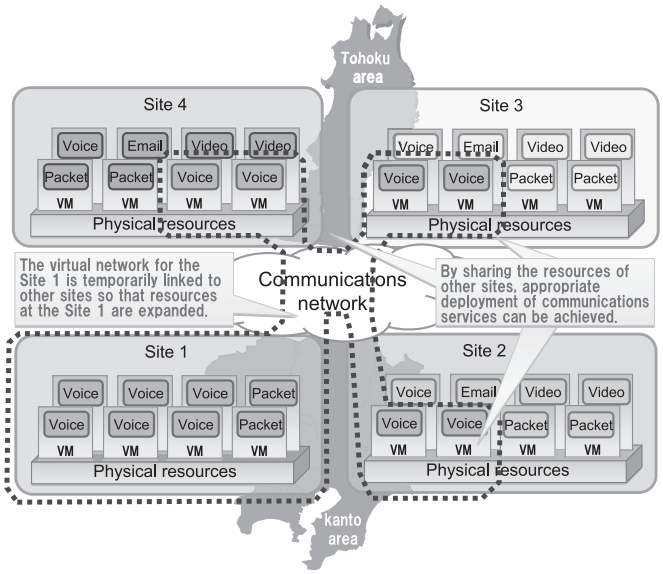

Fig. 2 Overall scheme of the linkage control technology of communications services between sites.

communications services between sites will be applied. This will enable sharing of the communications processing resources that are dispersed in different sites (**Fig. 2**). Sharing is achieved by organically linking such resources from different sites via networks; such as those between sites that need to have their communications capacities enhanced due to the occurrence of communications congestion, and those of sites that have surplus processing capacities. To achieve such linkages between the various communications services, efforts are in hand to advance the following technologies.

- **Linkage control technology for communications services between virtual resources sites**
  To allow conventional communications services to operate between sites without making any changes in them, the virtual resources are linked and controlled so that communications processing services operate between sites as if they were in the same site.
- **Inter-site deployment determination technology for communications services**
  To cope with communications congestion conditions for which processing capacities cannot be ensured by the resources of a single site, the deployment of communications services that fulfill the required processing capacity is determined by using the available communications processing resources that exist at multiple sites.

As one of the linkage control systems between virtual resource sites, efforts are now being made to develop a technology to link and control virtual networks to enable networks to be used as if they are in the same site even if they are located in multiple sites. Inter-site operation is thereby possible without changing conventional communications services. In this system, which links and controls virtual networks, the networks are dynamically deployed using a tunneling technology to arrange physical networks between the sites. This strategy will permit communications networks installed in a single site to be linked to other external sites while keeping pace with the planned expansion of services in order to solve a congestion issue within the site.

Moreover, the inter-site deployment determination system for communications services determines the deployment destinations of the communications services, so that the required performance for multiple communications services may be ensured while meeting two requirements. These are the restriction of communications performance in each communications service such as regarding delay and bandwidth, and the distribution of limited communications resources.

3. Priority Control Technology for Mobile Traffic Using OpenFlow

In order to specify the communications service that is the most important at given time among communications services such as voice calls and emails when a major disaster occurs and to transfer that service preferentially, it is necessary to control the traffic based on the dynamic priority allocation of the communications services. To control the traffic according to the priority of the communications services, it is essential that all traffic priorities are clearly defined. Traffic exchanged between core networks and base stations in current mobile communications networks does not, nevertheless, have the functionality to differentiate important communications such as voice calls and emails. Consequently, the controls to prioritize important communications during a disaster cannot be performed. In addition, it is also necessary to perform route controls according not only to the events generated in the networks, but also to suit the priority of the traffic, to set up pathways that can flexibly cope with phenomena that has been generated by the occurrence of failures. Such pathway controls are however impossible to perform currently, since current route controls use only IP addresses.

For this reason, it is necessary to undertake the dynamic reconfiguration of network resources available for basic

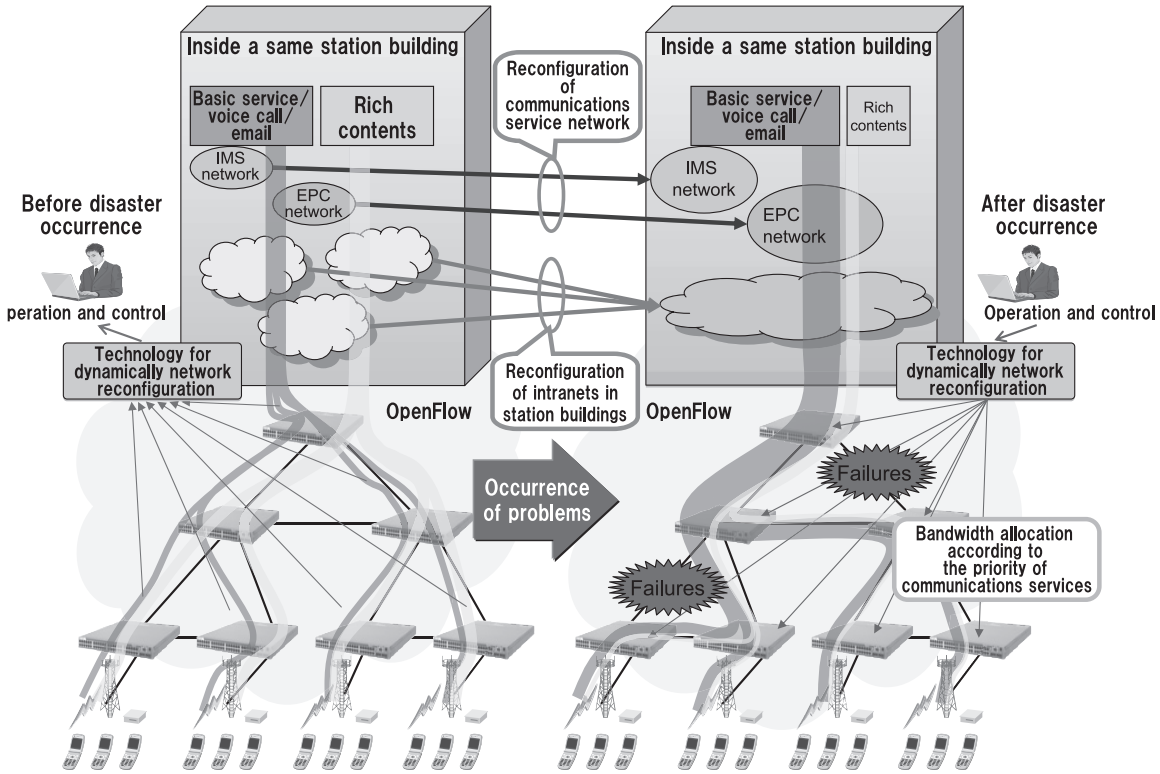

Fig. 3 Priority control technology for mobile traffic using OpenFlow.

communications services that have a higher priority. This is achieved by collecting various events such as disconnection of links and connection of new nodes that have occurred in the network and by controlling the routes using the traffic classes and characteristics including QoS (Quality of Service) as individual flows. At the same time the control of low-priority traffic is enabled according to the priority of the service.

The present authors are engaged in the R&D of a system to apply OpenFlow to mobile communications networks in order to process the traffic according to the priority of the communications services. OpenFlow enables the definition of flow by flexibly combining fields in Layers 1 to 4 of the IP packets, making it effective for the achievement of flexible processing according to the traffic priority. OpenFlow also enables achievement of virtual networks that are completely separate per port of the switches that correspond to Layer 1 even when the communications services of voice calls and packets that function on virtual machines are operated separately in virtual networks.

The introduction of OpenFlow switches to the applications from the base stations of mobile communications networks to the networks of communications services at large will help achieve: 1) reconfiguration of intranets in station buildings, 2) reconfiguration of communications service networks, and 3) bandwidth allocation according to the priority of communications services (**Fig. 3**).

4. Quality Maintenance Technology for Communications Services

When the technology for flexible configuration change is to be applied to actual communications services by using the server virtualization technology as mentioned above, it will be necessary to consider and solve the issues accompanied by the virtualization, including any deviation from the expected

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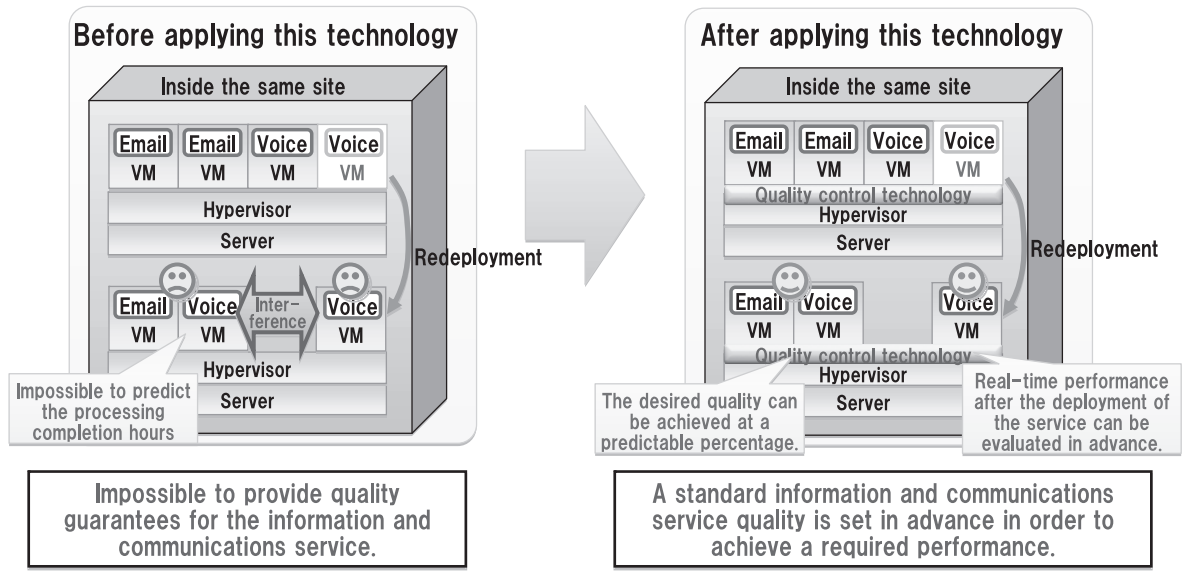

Fig. 4 Quality maintenance technology for communications services.

processing time or any extra time needed to process overheads. Therefore, the present authors are developing the following technologies in order to allow the processing of communications services to maintain constant quality in the processing on the servers. It is thus that the quality maintenance of processing of communications services can be achieved (**Fig. 4**).

- **Evaluation technology for the real-time performance of communications service deployment**
  Evaluates the real-time performance of deployment in order to avoid as much as possible the deployment of communications services that cause resource competition at a single physical server.
- **Quality maintenance technology for communications service processing**
  Allocates appropriate resources for communications services so that the communications services implemented on the server can maintain a desired quality.

Of these technologies, the quality assurance technology for communications service processing has achieved a scheduling system that stabilizes the processing time of the communications services. This is achieved by separating the computational resources allocated for the communications services from those for other processing operations such as the interruption processing that may affect the communications service processing time.

5. Conclusion

The present paper discusses technologies for the enhancement of the anti-disaster capabilities of communications services by using a technology for the virtualization of networks and servers while focusing on the communications services of LTE networks. The system effectiveness remains to be verified via its implementation and evaluation. Efforts will be made to achieve superior communications services by establishing this technology, so that “connectability” will be ensured even during major natural disasters.

Additionally, this research is now being implemented as projects commissioned by the Ministry of Internal Affairs and Communications.

The projects are: (1) “Experimental challenges for dynamic virtualized networking resource control over an evolved mobile core network - a new approach to reduce massive traffic congestion after a devastating disaster (FY2011’s General Account Revised Budget [No. 3])” and (2) “Research and development of network conversion of communication process-

ing functions in large-scale communication congestion (FY2012's General Account Budget) ” .

*LTE is a registered trademark of European Telecommunications Standards Institute(ETSI).

*OpenFlow is a trademark of registered trademark of Open Networking Foundation.

References

1) 3GPP-Keywords&Acronyms-LTE
http://www.3gpp.org/article/lte

2) N. McKeown et al, “OpenFlow: enabling innovation in campus networks”, SIGCOMM Comput. Commun. Vol.38, No.2, pp69-74, 2008.
http://www.sigcomm.org/sites/default/files/ccr/papers/2008/April/1355734-1355746.pdf

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