Method for visualizing information from large-scale carrier networks

Naoki Tateishi, Mitsuho Tahara, Naoyuki Tanji and Hikaru Seshake

Abstract— **With the increase in services, such as telephone, video on demand, and internet connection, networks now consist of various elements, such as routers, switches, and a wide variety of servers. The structure of a network has become more complicated. Therefore, failuare diagnosis and the affected area by using many alarms tends to be more difficult and the time required detecting the causal point of failure also becomes longer. However, to improve quality of services, reducing diagnosis time is essential. Alarm browsers and graphs are used to display the collected data from a networkto determine the network's status. An operator manages a network by envisioning the network structure. However, the larger the network becomes, the more difficult it is for operators to do this. Therefore, a topology view with geographical information and a topology view with hierarchical information of equipment are used. However, these views degrade if the scale of the network is even larger and more complex. We propose a method for visualizing network information on space and time axes. This method can support network operators to recognize causal points of failure and affected areas. We also explain a prototype software implementation of this visualization method .**

Index Terms— **Analyzing causal point, Large-scale network、Time and space axes, Visualization**

I. Introduction

On a large-scale IP network, various services, such as telephone, video on demand, and internet connection, are provided. Routers and switches to forwarding packets are required to provide these services. Application servers, databases, web servers, and authentication servers are also required to provide various kinds of services. Therefore,, the hierarchical structure of networks is becoming more complicated.

For providing high-quality services, detecting failure instantaneously and diagnosing the causal point accuracy are imperative. However, many equipment alarms are necessary to detect failure and diagnose the causal point in complicated large-scale networks. Such analysis requires a long time.

To solve these problems, methods using machine analysis of many alarms and logs based on cause and effect models of each failure have been proposed[1][2]. However, these models must be modified when new services or equipment are applied.

On the other hand, people can presume a relationship between the figures and unwritten other information when people recognize some objects. For example, people can determine the affected area information from failure point information on geographical maps. In our research, we aimed to shorten detecting and analyzing time by visualizing a large amount of network information by using time and space axes to help operators recall. these points.

In Section II, we review conventional visualizing methods and problems with them, and we propose a method for visualizing information by using time and space axes in Section III. In section IV, we introduce prototype inplementaion of this method. In Section V, we discuss future work, and conclude the paper in Section VI

II. Conventional methods and problems

In telecom carrier networks, a wide variety of equipment is used to provide services. The normality of services is evaluated by using text data, such as SYSLOG, and numeric data such as resource usage.

The measures for displaying such data, alarm browsers for text data and time-axis graphs for numeric data, are typically used in network management systems (NMSs) [3] [4]. Operators evaluate these data by envisioning network topology.

If a network expands and becomes complicated, it is difficult to envision such network topology. Therefore, some NMSs are required to visualize the network topology and superimpose network information on this topology.

Visualizing methods of network topology can be loosely classified into three groups. The first group is based on a spring model [5]. These methods can arrange network nodes and links with fewer crossovers. Caida otter [6] can display topology in a 2-D view, and Caida Walrus [7] can display it in a 3-D view. The second group is based on geographical information. Caida geoplot [8] and many NMSs, such as zabbix [9], nagios [10], cariden [11], and HP openview [12] display a geographical view. The third group is based on a hierarchical view to improve the hierarchical structure by using functions and role of equipments. Many NMSs can display this view.

However, as networks become larger and more complicated, many nodes and links are allocated to one view; therefore, the amount of nodes and links exceeds the capacity of humans to envision the strucutre. HP openview [12] can diplay a large area view with brief information and a small area view with detailed information.

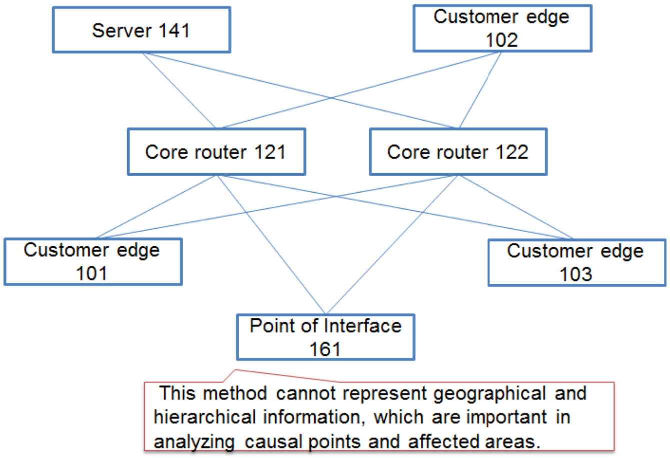

Fig. 1. Automatic placement by using spring model

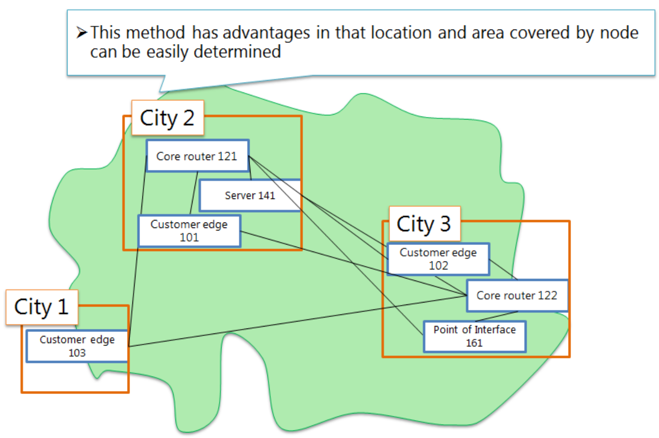

Fig. 2. Placement using geographical information

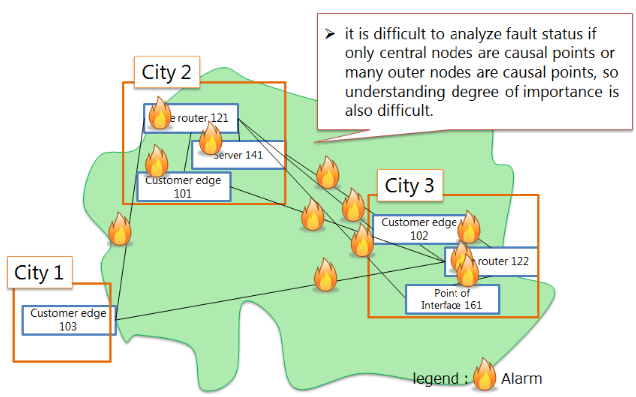

Fig. 3. Problem with placement by using geographical information

Some visualizing methods are based on the status of specific traffic and of end-to-end communication. NICTER [13] is focused on attack traffic on the network, and CAIDA: IPv4 AS core [14] is focused on the AS, where network traffic goes through. NICTER allocates end-to-end malicious nodes and attack nodes, and CAIDA: IPv4 AS core allocates each node in a circle by longitude to visualize the connection of each area.

A. *Visualizing method of network structure*

In this section, we explain three methods for visualizing network structures and problems.

1) *Method of automatic placement algorithm*

Network visualization tools, such as CAIDA Otter [6] and CAIDA walrus [7], can place nodes and links automatically by using a spring model [5] or other algorithms. Nodes are assumed as rings and links as springs in the spring model, and this model calculates node placement by minimizing the sum of forces acting on the rings. An example of placement is shown Fig. 1. However, this method cannot represent geographical and hierarchical information, which are important in analyzing causal points and affected areas.

2) *Method with geographical information*

This method visualization nodes corresponding to the geographical information of each node (Fig. 2). This method has advantages in that the location and area covered by the node can be easily recognized. However, it is difficult to represent the hierarchy of nodes, so it is also difficult to distinguish the cause of failure with many alerts, as shown in Fig. 3. In this case, it is difficult to analyze the failure status; whether only the central nodes are causal points or many outer nodes are causal points, so understanding the degree of importance is also difficult.

3) *Method with hierarchical information*

In a large-scale network, various equipment, such as routers, customer edge and servers, are used and the network structure is based on the hierarchical information of the equipment. This method visualization nodes from this information.

This method has advantages in that the role and hierarchy of nodes can be easily determined. However, geographic information is not represented, so understanding affected failure areas is difficult. Figure 5 represents the same failure as in Fig. 3, and it is difficult to understand the affected area from Fig. 5.

B. *Problems in network operations*

In network operations, geographic information and hierarchical information views are required, so switchover of both views and checking information is necessary. Brief wide-area and detailed narrow-area views are also necessary a network expands. If operators also check logical connections,

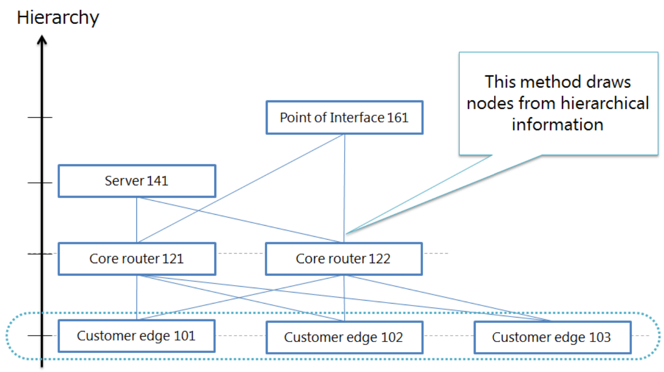

Fig. 4. Placement using hierarchical information

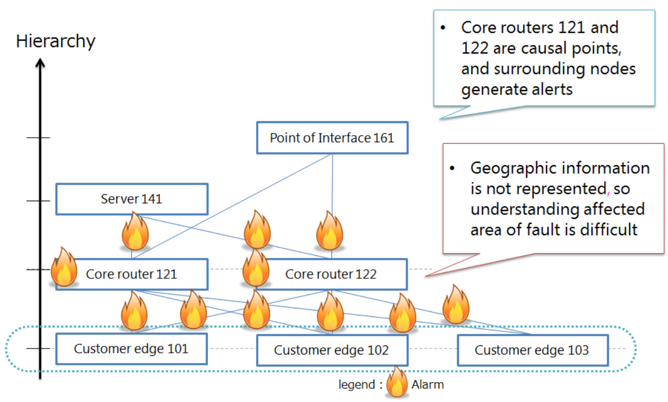

Fig. 5. Problem of placement by using hierarchic information

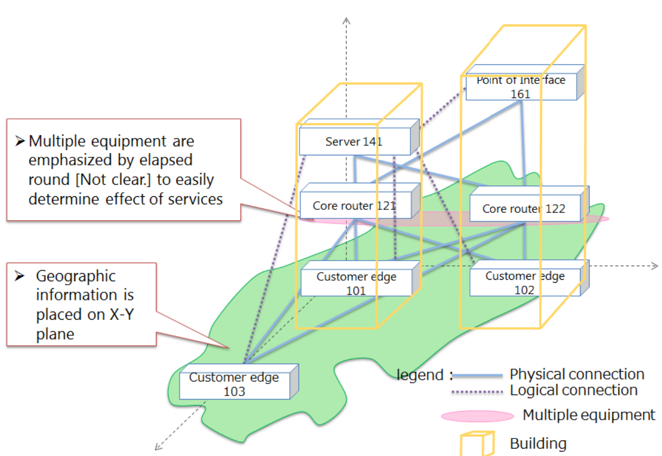

Fig. 6. Displaying network on 3-D space axis

such as sessions and authentication, many views and

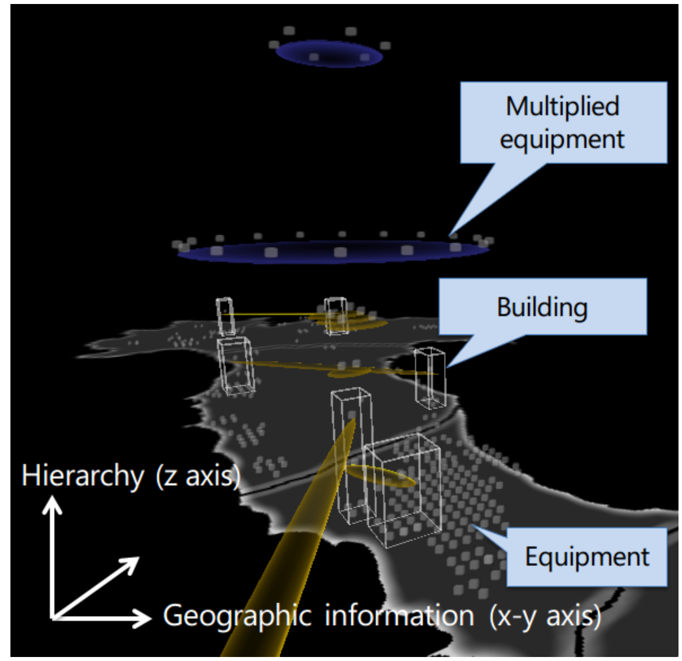

Fig. 7. Example view of network (physical and logical connections are not displayed)

switchover sequences are required.

In addition, to detect the causal point and affected area of a large failure, understanding temporal expansion of the failure is important. However, these views can only show a snapshot of the network at an instant, so they cannot visualize the temporal variance of the failure.

III. PROPOSAL

In a large-scale network with various equipment, it is important to understand the physical and logical connections, hierarchy of equipment, geographical information, and temporal variance of the network to analyze the effect of equipment failure on other equipment and the affected area. To easily understand the network status, we propose a visualizing method with 3-D space axis and time axes to explain geographic information, hierarchical information, physical and logical connections, and time variance of a network.

A. Visualizing network structure on 3-dimensional space axis

Geographical information is displayed on a X-Y plane, and equipment is placed at the X-Y coordinate corresponding to the geographical information. For this visualization, the operator can easily recall. not only the placement of equipment but also the affected area and the number of affected users. The Z-axis is used to display the hierarchy of network equipment, but representing other information, such as link speed, is also possible. Equipment that belongs to the same class are placed at the same height. Therefore, it is easy to determine the concentration and class of the causal point and affected area (Fig.6). Figure 7 is an example view from our method.

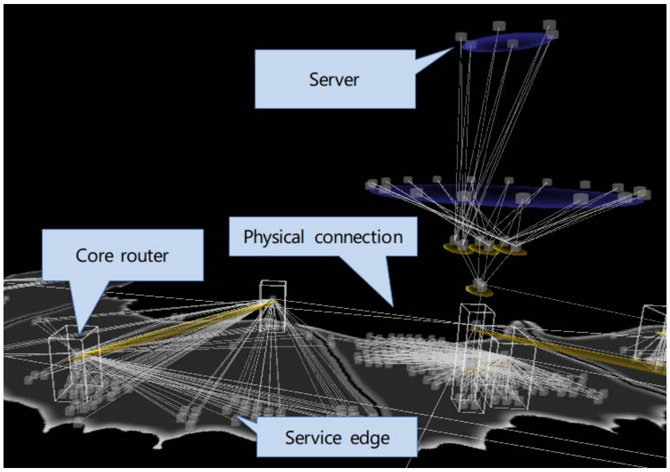

Fig. 8. Example of displaying physical connections

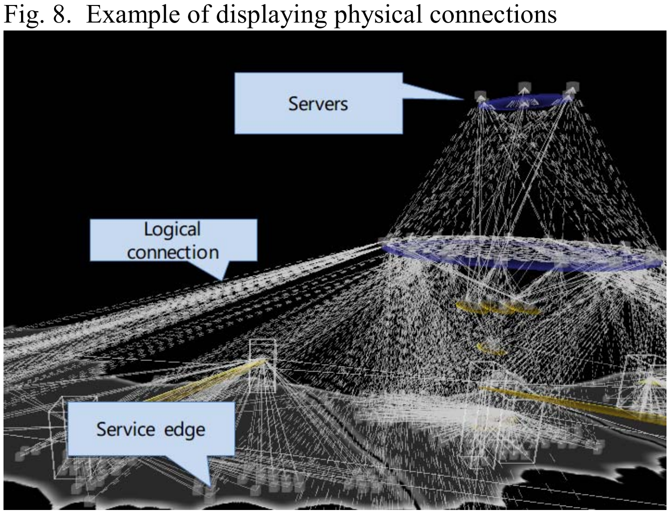

Fig. 9. Example of displaying logical connections

The placed equipment is connected using connection information. The connection is represented as a link (line). Physical connections are shown by solid lines, and logical connections are shown by dotted lines in order to determine the state of each connection(Fig.8 and Fig.9).

The viewpoint and direction can be freely selected in a 3-D view. This enables us to focus on specific equipment and links and to look down over the entire network. Therefore, it is easy to check states in a complicated space.

In addition, to easily determine the effect of services, multiple equipment are emphasized by elapsed round.

.

B. *Benefit of 3-D view*

The nodes and link alarms overlap the nodes and links. If a failure occurs at the nodes and it affects the surrounding nodes and links, alarms overlap the causal point and nearby nodes and links. In the example shown in Fig. 11, the central node of the island went down and this failure set off other link alarms. As a result, many alarms were generated in the island network. If there are overlapping alarms on the 3-D view, they are placed near the causal point. Therefore, operators can determine the failure point and affected area at a glance.

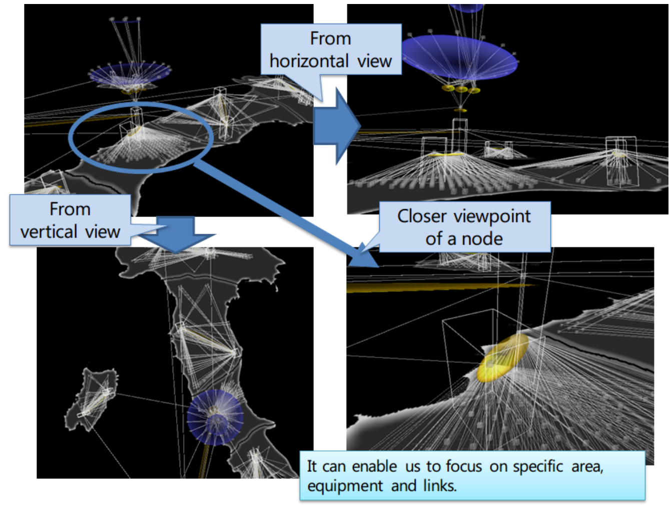

Fig. 10. Viewpoint selection and zooming

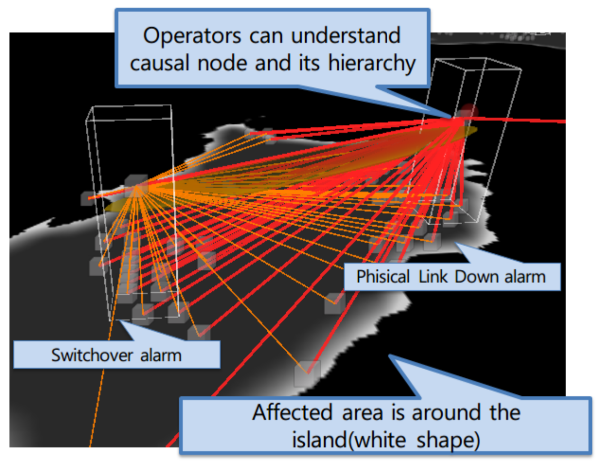

Fig. 11. Displaying pseudo failure data from skew view

C. *Benefit of reproducing network status*

By replaying network status from the time before failure to the present with a 3-D view, the sequence from occurance to expansion becomes clear even if many alarms are shown in the view. Therefore, this reproducing view can help operators analyze the causal point(Fig12,13).

IV. Prototype Implementation

We implemented the proposed method as prototype software to evaluate it by displaying network data. This prototype consists of a data processing server and visualization clients (Fig. 14).

The data processing server consists of construction data, processing blocks and database, alarm data processing block

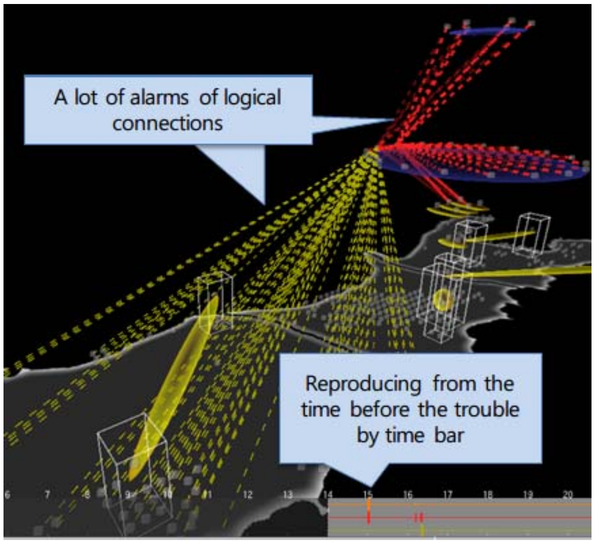

Fig. 12. Benefit of reproducing view (Present time)

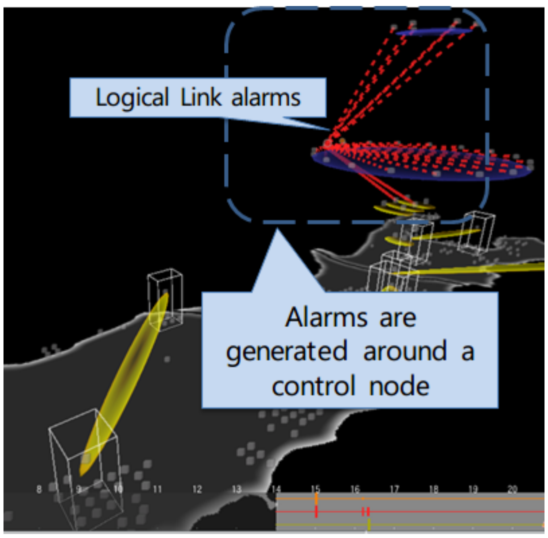

Fig. 13. Benefit of reproducing view (Past time)

and database, and a block for generating viualization data objects. To visualize a huge amount of network alarms during a large failure, the data processing server is directly connected to the NMS and receives alarms in real time. To decrease the delay in displaying alarms, alarms are directly passed to the block for generating visualization data objects. Alarms are also stored in the alarm database to replay past network states. At the block for generating visualization data objects, network objects, such as links and nodes, are generated from construction data, and alarm objects contain generated alarm data that overlap network objects. These objects are sent to clients.

The visualization clients consist of the visualizing network objects block and web browsers. To display a large-scale network that consists of thousands of network links, nodes, and alarms in 3-D, we must ensure the visualizing capability of computers. The visualization capabilitiy of computers has improved dramatically and open source visualization libraries

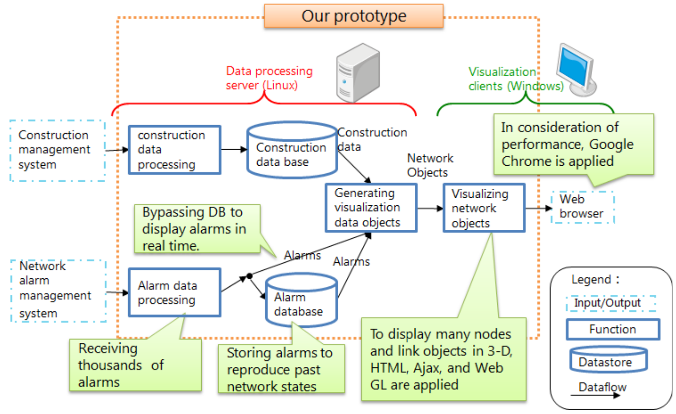

Fig. 14. Implementation of protype software

are also evolving. We choosed visualization techniques, such as HTML5 and Ajax (jQuery [14]), webGL(three.js [15]), and google chrome [16], to make the most use of the visualization capability by checking displaying capability of thousands of network elements.

V. Future Work

A. *Displaying various types of data*

For this study, we explained the visualization of alerts. However, traffic, flow, route information, call data, the results of other analysis engines, and various types of data are used for network operations. Therefore, we will investigate a method for visualizing various types data in a complicated way.

B. *Displaying various cases of network states*

For future work, we will evaluate the proposed visualization method by using this prototype software and network data of various cases of failure.

C. *Accuracy of network topology data*

Various types of data overlap the network topology. Inaccuracy of network topology data leads to misunderstanding of network states. However, the application scope of conventional network presumption methods are limited, so it is difficult to apply them to a carrier network. Hand working on topology data often causes wrongness. Therefore, ensuring accuracy of network topology data is will be quite important.

VI. Conclusions

We proposed a network visualization method by using 3-D space and time axes for determining failure points and affected areas at a glance. We also explained the implementation of prototype software.

Carrier networks consist of various equipment, generating various types of alarms. Therefore, evaluation of real network data is imperative. In the future, we will evaluate the items discussed in Section V and evaluate visibility and operability in terms of a user interface, recognition performance of failure points and affected areas, and processing capacity to evaluate the data of multi-service networks by using the prototype software.

References

[1] S. Kandula, D. Katabi, and J.-P. Vasseur. Shrink: A Tool for Failure Diagnosis in IP Networks. In Proc.MineNet Workshop at SIGCOMM, 2005.

[2] R. R. Kompella, J. Yates, A. Greenberg, and A.Snoeren. IP Fault Localization Via Risk Modeling. In Proc. of NSDI, May 2005.

[3] ITU-T Recommendation Z.371 (2005) Graphic information for telecommunication management objects

[4] ITU-T Recommendation Z.372 (2005) Templates for telecommunications human-machine interfaces

[5] P. Eades, "A heuristic for graph drawing", Congressus numerantium, Vol.42, pp.149-160, 1984 CAIDA Otter, http://www.caida.org/tools/visualization/otter/

[6] CAIDA Walrus http://www.caida.org/tools/visualization/walrus/

[7] CAIDA Geoplot http://www.caida.org/tools/visualization/geoplot/

[8] Zabbix, http://www.zabbix.com/jp/

[9] Nagios, http://www.nagios.org/

[10] Cariden network operations, http://www.cariden.com/solutions/network-operations/

[11] HP OpenView Network node manager guide http://h50146.www5.hp.com/doc/manual/openview/pdf/t2490-99024.pdf

[12] K. Nakao, F. Matsumoto, D. Inoue, et al. , “Visualization Technologies of nicter Incident Analysis System,” IEICE Tech. Rep., vol. 106, no. 176, ISEC2006-51, pp. 83-89, July 2006.

[13] CAIDA The Cooperative Association for Internet Data Analysis, IPv4 and IPv6 AS Core: Visualizing IPv4 and IPv6 Internet Topology at a Macroscopic Scale in 2011 http://www.caida.org/research/topology/as_core_network/

[14] jQuery, http://jquery.com/

[15] three.js - JavaScript 3D library , http://threejs.org/

[16] google chrome, http://www.google.co.jp/intl/ja/chrome/browser/