JB: Design and Architecture of Next Generation Internet Infrastructure in Japan

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Abstract

The project "JB" is a joint research project to explore the next generation Internet technologies. The project is run by several network computing research projects, such as the WIDE project, ITRC project and Cyber Kansai Project. We are going to build the nation-wide high performance research test-bed, that is jointly operated by the participating research projects and organizations.

The initial technological targets are IP version 6, quality of service control (e.g., diffserv), realtime high speed stream multicast, reliable multicast and new applications (e.g., School on the Internet). The test-bed is going to integrate all of these functions and protocol stacks into an unified platform based on the PC-UNIX based advanced network stack provided by KAME project. Network operation with the integration of these functions and protocol stacks will disclose some new issues and requirements for the next generation Internet infrastructure. The deployed test-bed internetworks with international research networks, such 6REN and Q-Bone.

1 Introduction

Internet technology provides global, ubiquitous and universal connectivity for all computers and everyone connecting through various datalink platforms. Since connectivity is the Internet's own reward, the Internet has been growing numerically and geographically at a more than exponential rate.

The core technology for the Internet is IP (Internet Protocol) and TCP (Transmission Control Protocol). A network in the Internet contains computers that are interconnected using IP. As well as interconnecting computers within a network using IP, IP further interconnects these networks. This is reason why it is said that the Internet is a network of networks. Reliable data transmission is achieved by the end-to-end TCP control mechanism between source and destination hosts. Therefore, it is said that Internet with TCP/IP is inherently a distributed system.

As the Internet moves forward into the next century, the Internet transits to an information infrastructure for everyone from the information infrastructure only for scientists or professionals. This means that the next generation Internet has to achieve the following features.

- Internet for everyone
- Internet for everything
- Internet everywhere
- Internet at anytime
- Internet any way

Now, what are the technological requirements and challenges for the next generation Internet. It is *"scalability"*. Scalability has various aspects from various quantitative and qualitative view points.

The initial technological target of the "JB" project is IP version 6 (IPv6) [14], quality of service control[13][11][12], multicast [5] and new applications.

- IPv6
  IPv6 provides sufficiently larger address space (128 bits) for the next generation Internet. IPv6 also provides various new functions compared with the legacy of IPv4 (IP version 4). For example, IPv6 enables autoconfigurations for end hosts to accommodate everyone into the Internet.

- Quality of service control
  Each person and each application may require different communication quality levels. Differentiated Service (Diff-Serv), Integrated Service (Int-Serv) and RSVP are the key architecture models and protocol stacks which provide various communication qualities for each particular packet flow over the Internet. The quality of service control must be scalable, regarding the heterogeneity of the required service class and of the condition of the network.

- Multicast
  The unicast based multicast emulation, that is the general solution in the existing Internet environment, may not be numerically scalable to need to multicast capability. Multicast has two different technological challenges. One is for realtime high speed stream data transmission, e.g., digital video data multicasting. The other is for error free data delivery for large number of receivers, i.e., so-called as reliable multicast.

- New applications
  Using the new technologies described above, new applications should be researched and developed. For example, in the "JB" project, the School on the Internet (SOI)[8] applications using the above technologies will be deployed.

We, the "JB" project, will integrate the above mentioned functions and protocol stacks into a unified platform based on the KAME stack[15]. Also, we operates these above mentioned functions over a newly deployed research test-bed, called the "JB" project test-bed.

The "JB" project is a joint research project to explore next generation Internet technologies. The project is organized by several network computing projects, such as the WIDE project[10], ITRC project[4] and Cyber Kansai Project[3]. Therefore, we build a new nation-wide high performance research test-bed, that is jointly operated by the participating research projects and organizations. The deployed test-bed also internetworks with international research networks, such as 6REN (IPv6 Research and Educational Network)[1] and Q-Bone (end-to-end Quality of service backBone)[6]. Network operation with the integration of these functions and protocol stacks described above will disclose some of the new issues and of requirements for the next generation Internet infrastructure.

Section 2 gives brief description for project overview, test-bed topology and its architecture. Section 3, 4 and 5 give an introduction, schedule and work items of each sub-project. Section 6 gives brief conclusion.

2 Project overview: design and architecture

The goals of the "JB" project are development new technologies to construct a nation-wide next generation Internet infrastructure and to point out the problems that become aparent through its operation. Furthermore, it has collaborated with international networking research groups, such as Internet2 Project[9], NGI Project[7] and APAN project[2] in IPv6, Reliable Multicasting, QoS area and new applications. Initially, the "JB" project focuses on the following three themes, IPv6, Multicasting and Quality of Service, as three independent sub-projects that collaborate with each other. As an early phase objective of the "JB" project, those sub-projects aim to establish a test-bed network that has integrated these three themes. Then, research and development of new applications will begin after the test-bed is available.

In order to build a high-speed and high-performance test-bed, "JB" has been designed adopting high-speed lines such as ATM and SDH leased line as a datalink.

The rest of this section, will describe the following:

1. Formation of this project
2. Network topology and technologies

2.1 Formation of this project

As stated above, the "JB" project has several sub-projects, such as IPv6, QoS, Multicast and new application, and these are able to increase or decrease depending on the situation. In other words, these sub-projects are able to integrate and divide. As this behavior can be likened to piling up various layers, we designated that each sub-project be called "*plane*" in the "JB" project.

The figure 1 shows that these "planes" will in the end be unified into one single "plane". This is exactly what the next generation Internet infrastructure is all about.

2.2 Network topology and technologies

There are at least 10 NOCs (Network Operation Center), such as KDD Otemachi, University of Tokyo, Keio SFC(Shonan Fujisawa Campus), Osaka University, Kyoto University, NAIST(Nara Advanced Institute of Science and Technology), JAIST(Japan Advanced Institute of Science and Technology), CRL(Communication Research Lab., MPT), Kurashiki and Kyushu University, and at least 20 leaf-sites have connected to the test-bed network.

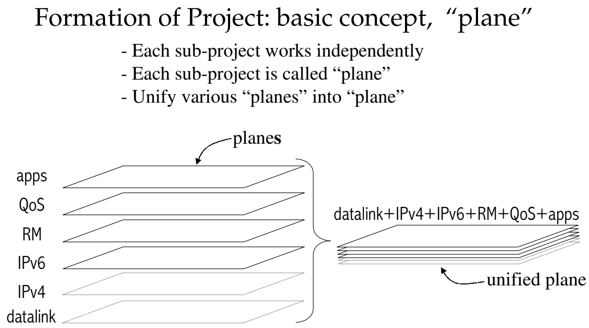

Figure 1: multiple-planes unite into one plane

The figure 2 shows the initial topology of the "JB" test-bed network. Most of connectivity has been provided by ATM links(OC-3 to OC-12), though SDH links have also been used in parts.

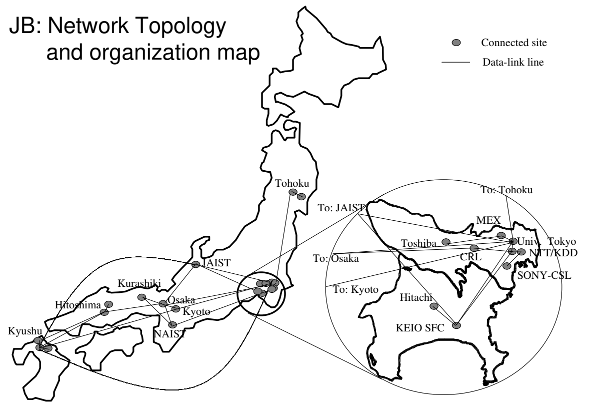

Figure 2: "Japan Backbone": nation-wide backbone

The KAME stack based PC-UNIX boxes have been installed as both hosts and routers to all "JB" sites.

3 JB/6: the "IP version 6" plane

The goal of JB/6 plane is building a IPv6 network environment for next generation Internet infrastructure.

3.1 Introduction

The IPv6 (IP version 6) is a core protocol of the next generation Internet. It has a 128bit address space that is enough to cover all worldwide networks. IPv6 core stacks have already been in development for four years. During these years, a lot of network equipment vendors and research and development organizations have developed IPv6 stacks on various platforms. As a result, most of those stacks are available as products or public domain.

Likewise, three years have passed since the significant test bed for IPv6 stack evolution, development and deployment, known as the 6bone, has started operation. As a result of the 6bone, we have developed important technologies such as dynamic routing, source address selection and multihoming as well as having acquired operational tips and experience.

However, if those technologies are not deployed generally throughout the world, IPv6 can not be called "Internet Protocol for Next Generation"in its true sense. Therefore, JB/6 is going to focus on a establishment of a network environment using these technologies as commodity operation.

3.2 JB/6 Roadmap

Through the constructing and operating of a test-bed network for IPv6, that is the next generation core protocol for the Internet, on"JB", the "JB/6" project is going to tackle the following technical issues:

- Establishment of transition technologies from IPv4 to IPv6
- Verification of interconnectivity among various IPv6 products
- Verification of IPv6 unicast routing
- Building up applications for IPv6

Furthermore, these issues are also applicable to the deployment of IPv6 in the worldwide Internet. Especially with the IPv4-IPv6 transition issues, through actively providing an IPv4 and IPv6 coexisting environment for all "JB" sites, we will positively find out and solve new problems, and provide feed back to the IETF ngtrans working group.

Finally, we believe that the current 6bone-jp should be replaced with "JB" as its successor, in order to change it from a simple test-bed to a IPv6 nationwide, general and commodity infrastructure. This is because for the most part, it consists of complex and ad hoc IPv6 over IPv4 tunnels.

At present, we are going to install KAME stacks, as both of router and end-host, Toshiba CSR, that has been improved based on KAME stack, and Hitachi GR as routers to all "JB" sites.

3.2.1 Schedule

1999/3	tested the KAME project and the others protocol stack capabilities (both host and router)
1999/4	test and operate IPv4 - IPv6 translation
1999/5	begin IPv6 network operation on the "JB" using KAME based stack
1999/6	early deployment of IPv6 capable commercial routers such as Toshiba CSR, Hitachi GR and so on
1999/7	implement and deployment simple OSPF version 3 for IPv6
1999/9	transit a role of test-bed for IPv6 in Japan from the 6bone-jp to the "JB"
1999/11	second implementation of OSPF for IPv6 begin implementation of new application for IPv6
2000/3	begin operation of OSPF for IPv6

Table 1: Table of JB/6 schedule

3.2.2 Work items

Starting from May 1999, we will focus on whether these three individual research planes, IPv6, Multicasting and Quality of Service are able to work with each other on the same network. In other words, JB/6 has to provide IPv6 connectivity in order that the other planes can work on IPv6.

We will cooperate with operation experiments for commercial IPv6 products by allowing them deployment as soon as they are ready for use. Our initial plans for experiment are for the Toshiba CSR and Hitachi GR which are compatible with high-speed lines such as OC-3 and OC-12.

Several OSPF version 3 implementations are in progress. They will be tested starting from September 1999. At present, there are two candidates for developing platform, one is "gated", the other is "zebra". As both of them are available in the public domain, we will also make available results of development, such as codes and documents.

As the Internet will have to go through the same transition in near future, the transition of the main IPv6 test-bed of Japan from 6bone-jp to "JB" is a most interesting event, not only for us, but also for IPv6 researchers all over the world. Therefore, we will have to feed back our experience to the IETF community.

4 JB/M: the "Multicast" plane

The goal of JB/M plane is establishment of reliable technologies at a worldwide scale. For example, to provide multicast communication capabilities for high-quality multimedia streaming such as video and audio, and for guarantee of reliability.

4.1 Background

The most suitable situation to make use of the striking features of multicast such as "reduction of redundant traffic" and "similarity to existing broadcasting media" is high band width communication within a widely distributed area. Therefore, development of IP multicast technology on super high-speed networks is necessary for the deployment of multicast communication in general.

The MBone, which is a worldwide test-bed for IP multicasting, has long supported the development of a lot of IP multicasting technologies such as "DVMRP" which is a multicast routing protocol based on "distance vector" algorithms, "RTP" which is a multimedia transport protocol for realtime communication and some reliable multicast protocols for reliable communication. In this way, the MBone has grown into worldwide test-bed and has been connected with hosts of various performance and nature. However, there is an important problem. The MBone consists of many tunnels layed out on an Internet based on "best effort". Because of the overhead needed to maintain these tunnels the Mbone is not suited for functions as a high band width multimedia communication test-bed. Therefore, the JB/M will build a live test-bed for multicasting to make use of "JB" test-bed, and experiment on multicast communication with the next generation Internet environment in mind.

Furthermore, another important study concerning IP multicasting technology is the development and deployment of a scalable multicast routing protocol and to find out and solve the problems discovered during this process.

In other words, it is for these reasons that IP multicasting has not seen worldwide deployment despite its superior technological value.

4.2 JB/M Roadmap

On the "JB", IPv6 is ready to operate from the beginning as stated at section 3. JB/M assumes that it is the core protocol for development and operation.

When considering scalability, we hypothesize several different size scales for the Internet and develop and deploy several appropriate multicast routing protocols for each accordingly.

Practical reliable multicast protocols are also going to be designed and implemented by making use of QoS guarantee technology And as application of these, technology for multi-point delivering will be developed.

Finally, JB/M is going to focus on the establishment of high speed datalinks, IP technology, Multicast routing and applications taken as a whole on the next generation Internet Infrastructure. In other words, the technologies that have been developed by JB/M will be adoptable on the next generation Internet immediately.

4.2.1 Schedule

1999/4	begin implementation simple PIM/DM multicast routing protocol daemon
1999/6	begin deployment of PIM/DM at all JB sites
1999/7	begin implementation of multi-point video conference system using DV
1999/9	implemented of simple PIM/SM multicast routing protocol daemon
2000/3	review and deployment more advanced technology

Table 2: Table of JB/6 schedule

4.2.2 Work items

At the beginning, we are going to focus on establishing a multicast capable test-bed of a scale of about 20 sites on "JB", using PIM/SM as the multicast routing protocol.

Also, we are going to focus on a establishment of technologies for high band width multimedia transport such as Digital Video(DV) streaming.

Starting from April 1999, we will focus on a simple implementation of PIM/DM multicast routing protocol daemon. It will be available by July 1999, and then we will deploy it to all "JB" sites. From September 1999, we will begin to develop PIM/SM daemons and continue to experiment through the test-bed. We will review and re-schedule our plan by March 2000, and then continue to tackle any remaining or new issues.

5 JB/Q: the Quality of Service plane

The goal of JB/Q plane is building a quality control capable network for next generation Internet infrastructure.

5.1 Background

There is a growing demand to multiplex voice, video and data into a single infrastructure, without sacrificing scalability of the Internet. The IETF's differentiated services (diffserv) working group has been trying to solve the problem and standardize protocols for the differentiated services mechanism. In the diffserv framework, interpretation of the IP Type-of-Service field has been redefined so that various queueing mechanisms and packet-drop mechanisms can be deployed at routers.

However, the standardization of an IP-based QoS framework does not tell us how best to classify packets and prioritize them within the given traffic mix of voice, video and data. While a lot of work has been done in the area of QoS, very little work focuses on flow aggregation and their probabilistic QoS-guarantees. Little is known about the probabilistic QoS-guarantee on aggregation of flows; there is a large possibility that network engineers must fill the gaps between application requirements and the underlying mechanisms, such as traffic class, drop preference, queueing mechanism and so on.

The opaque nature of the diffserv framework leaves a good number of design alternatives for network engineers. While the standard can be directly adaptable to enterprising networks demanding assured forwarding of voice traffic or expedited forwarding of business transactions, the scale and multiplexing nature of the Internet makes it difficult to apply the standard to the backbones of the Internet. For example, an ISP must be able to handle such questions as if we prioritize a specific customer, what kind of quality will the other customers receive?

If diffserv is going to be widely available across the Internet, we must have at least one working service model for the differentiated services.

5.2 JB/Q Roadmap

JB/Q is going to bridge the gaps between application practitioners and protocol designers by providing a live QoS infrastructure. Our focus is on both software implementation and network deployment, since it enables fast feedback to software/protocol development process.

Our goal is as follows: 1) provide open-source implementations for a QoS infrastructure, 2) accumulate working knowledge of QoS-enabled network design, 3) develop algorithms as well as implementations for intra-domain QoS-routing, admission control, bandwidth allocation across multiple administrative domains, and flow aggregation at domain boundary, and 4) provide live QoS-enabled infrastructures to researchers in various science fields.

5.2.1 Schedule

1999/3	implemented simple DSCP-marking at DS boundary nodes implemented CBQ at DS-capable nodes
1999/4	begin implementation of intra-domain QoS-routing begin deployment of DS nodes at several JB sites
1999/5	minimal COPS implementation (PDP, PEP) begin deployment of PDP and PEP at several JB sites
1999/6	early deployment of DS-capable commercial routers (Toshiba CSR, Hitachi GR)
1999/9	second COPS implementation (PDP, PEP) study interactions between PDPs begin deployment of PDP and PEP at all JB/Q sites
1999/10	second implementation of intra-domain QoS-routing
2000/4	begin implementation of inter-domain QoS-routing expand QoS infrastructure to all JB sites

Table 3: Table of JB/Q schedule

5.2.2 Work items

Starting from April 1999, we will focus on intra-domain QoS frameworks. Our work spans across routing, forwarding, QoS signalling, and admission control. Whenever possible, we will try to build multiple implementations and conduct interoperability experiments between them. After a one-year focus on intra-domain QoS frameworks, we will be able to move on to implementation and deployment of inter-domain QoS frameworks, starting from April 2000.

We are going to develop a service model incrementally through actual deployment. Our initial applications are Internet telephony and digital video transmission, as well as live IPv6 data traffic.

Several people are studying the effects of flow aggregation at DS boundary routers.

COPS (Common Open Policy Service) implementations are in progress. They will be tested starting from May 1999. Interactions between different types of clients and servers, as well as service location mechanism, will be tested here.

DSCP marking at DS boundary routers is another issue. While it has been easy to identify packets based on TCP ports, it becomes impossible with IPsec encapsulated packets. Interaction between COPS, IPv6 flow-label and DSCP will be studied here.

6 Conclusion

The "JB" project is an advanced network research project in Japan. It focuses on "high speed", "high band width", "well-designed" and "reliable" technologies for the next generation Internet infrastructure. It especially focuses on "IPv6", "Multicast" and "QoS" as a "plane" for this project. It is therefore called "Japan Backbone" which is one of the things which "JB" stands for.

Although, we described the background, schedule and work items at each section of "plane", the "JB" project's work is still in progress. However it will provide robust, high-quality reliable and high-speed service for everyone in near future. It is exactly as the name JB suggests, "-just beginning -".

7 Acknowledgement

Our deep gratitude goes to members of the CKP(Cyber Kansai Project), ITRC(Internet Technology Research Committee) and WIDE Project, for their support and collaboration.

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