

Sustainable Collaborative Efforts in Internet Development in Asia: AI3 Phase II

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Abstract

The AI3 (Asian Internet Interconnection Initiatives) Project started in 1995 as an R&D project for the Internet research community in Asia. The project installed its testbed network in Indonesia, Hong Kong, and Thailand in 1996. On this network, several research activities and experiments, such as the WWW cache mechanism using a new management scheme, the distant learning system called "Virtual University" over the Internet, and video multicasting over this infrastructure using IP multicasting, were undertaken with AI3 research partners.

In 1997, we are going to expand this effort to four or five more countries using a new datalink technology: TDM multichannel access with C band satellite links. In this system, we assign a single transponder (30 megabytes per second [Mbps] total) for traffic between a hub station in Japan and AI3 regional stations in partner's countries. We are developing a new interface hardware to manage this "fat pipe" in a TDM manner. Using this mechanism, we can handle unbalanced traffic over international Internet links more effectively.

In this paper, we report several results from the ongoing research project on the AI3 testbed and introduce a new approach, called "AI3 phase II," to expand its efforts to more countries.

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Introduction

Internet development has been very active in Asian countries in Asia over the past several years. Many people in the region are using the Internet for various purposes such as personal communication, human resource development, research, education, advertisement, product support and promotions, and other areas not limited to computer communication technologies. The Internet is going to be established as a common communication infrastructure for people all over the world.

However, there are still several issues facing sustainable development of the Internet in this region. One is technology transfer and sharing expertise on Internet development among Asian countries. Currently, the commercial Internet service providers (ISPs) are major players in Asian Internet developments and operations. Because there are several interconnection links among ISPs in Asian countries, technical coordination and sharing has become important for the stable operation of the Internet. For this purpose, several activities such as APRICOT[1] or APNG[2] exist for the Internet community in the Asia and Pacific region.

Technology transfer from the research community to commercial entities is also vital for the future of the Internet. Internet researchers and engineers are developing several technologies such as IPv6, IP multicasting, high-speed datalinks, and resource reservation mechanisms for the Internet in order to add more powerful communication functions. These technologies are going to be applied to the Internet environment, so we need a good path for technology transfers. One way is by installing testbed networks and undertaking collaborative research and experiments on these new technologies among both research and commercial communities. For this purpose, several projects such as G7/GIBN, ATM testbeds in several countries, APAN[3], and APII testbeds have been developed so far.

The Asian Internet Interconnection Initiatives (AI3) Project [4], jointly started by the WIDE Project [5] and JSAT Inc. [6] in 1995, aims to provide a testbed network environment for the academic and research community in Asia. A major purpose is to accelerate cooperative work for research and development of Internet technologies. Research topics of the AI3 project include network design for the future Asia-Pacific Information Infrastructure (APII), new technologies to enable IP multicasting over satellite communication channels, advanced routing methods to use the channels efficiently, and promotion of Internet technologies in Asian countries. In 1996, we started testbed operations with AI3 partners in Indonesia, Hong Kong, and Thailand. Several research activities are now going on.

In this paper, we report the current status of the AI3 project and introduce its new direction for adding more research partners in Asia using C band satellite communication channels.

AI3 Phase I

Since October 1995, we have been developing our testbed using Ku band satellite channels. In 1996, we invited several research partners to join the AI3 project: the Institute of Technology in Bandung (Indonesia), Asian Institute of Technology (Thailand), and the Hong Kong University of Science and Technology (Hong Kong). With these partners, we designed and implemented our testbed network. We installed 1.5 megabits per second (Mbps) links for all partners and put them online in October 1996. On this network, called the "AI3 Phase I network," several research activities and technical challenges are going on. In this section, we briefly introduce several outputs from our challenges on the Phase I network.

Testbed network configuration

Our Phase I testbed network is built on top of the Ku band VSAT service provided by the JCSAT-3 communication satellite. As the satellite provides several beams, we are using the Asian Zone beam for our network. Figure 1 shows the coverage of the beam. This picture also depicts the antenna size required to receive 2 Mbps satellite links. At major cities in East and South Asia, a 3.6 m diameter antenna is enough to provide a 2 Mbps point-to-point link.

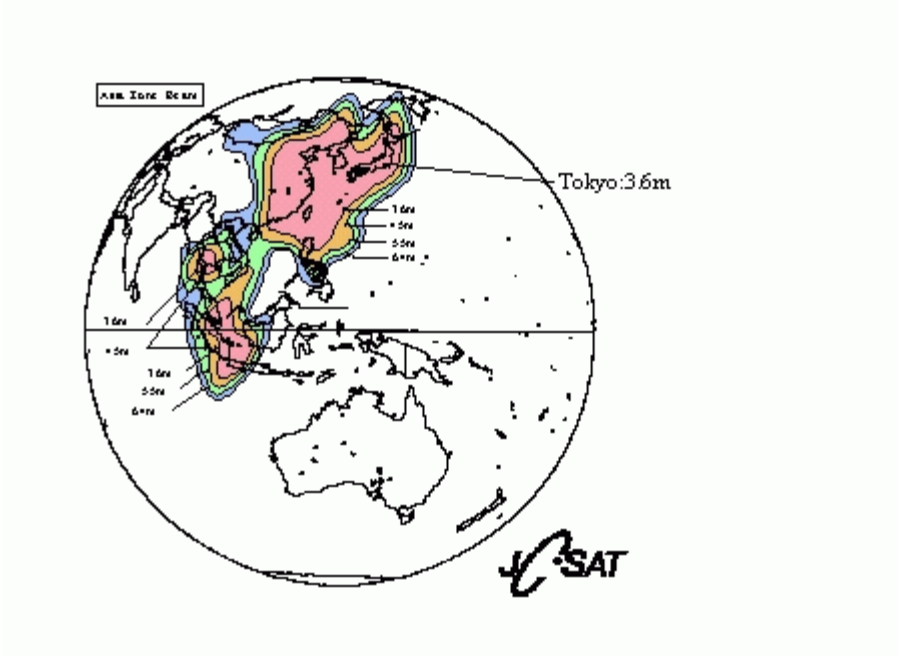


Figure 1: The coverage map of the Asian Zone beam of the JCSAT-3 communication satellite

The initial topology of our testbed network is a star-shaped network. In WNOG-Nara in Japan, we set up our hub station, which can handle up to 8 VSAT links simultaneously. Through this hub station, our testbed network is connected to the Internet backbone (the WIDE Internet) in Japan. Each partner's VSAT ground station is connected via a 1.5 Mbps satellite link. Figure 2 shows the current topology of our Phase I testbed network.

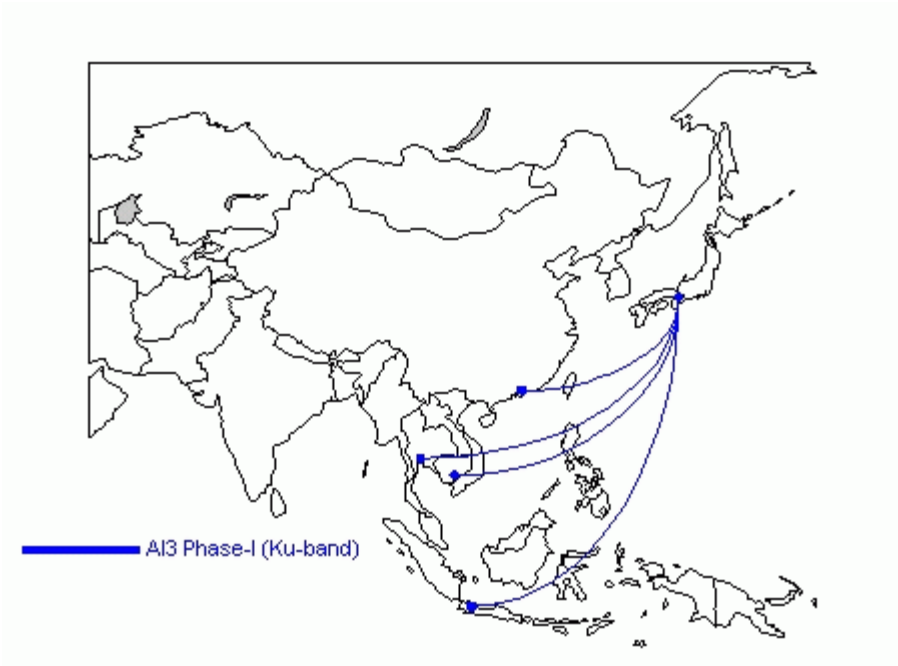


Figure 2: The network topology of the AI3 Phase I network

In this network, gateways for the satellite link are IBM PC compatible systems running under BSDI's BSD/os with RISCOS's high-speed serial interfaces. The reason we are using the BSD/os system is simple: the BSD/os is provided with its own kernel and utility source codes, making it convenient for us to modify the networking protocol stack for our testbed network and to integrate new technologies into this environment. For example, we are using the WISH driver, which enables IP multicasting over satellite links developed by the WIDE Project.

Our testbed network forms a single autonomous system from the view of IP routing. We are using BGP-4 routing

protocol for exchanging the routing information with other neighboring autonomous systems, while OSPF is used for internal routing control. Moreover, our testbed network is a transit network to a global Internet for autonomous system which includes our partners' networks.

Ku band service

While the C band service is very popular for satellite communications in Asia and the Pacific region, there are few calls so far for Ku band service because reception is considered weak in heavy rain. This is obviously a problem for the many tropical regions in East and South Asia that have heavy showers in rainy seasons. Many people believe it is hard to guarantee link quality for commercial operations.

In the AI3 Phase I network, we are developing a way to apply the Ku band service to commercial Internet operations. In order to guarantee link quality, we designed an AI3 link that (1) adds rainfall signal margin in its datalink layer configurations and (2) applies a dynamic routing scheme using either BGP-4 or OSPF to switch a satellite link to a terrestrial link as a backup in case the satellite downlink fails. In a four-month trial in Indonesia, this link experienced only one failure for 5 seconds. This shows that our design can meet commercial requirements for ordinary satellite links. In other words, the Ku band service can now be used for commercial Internet operation in tropical regions. This result also means more effective frequency use.

Multimedia on our link

Basically a satellite link can be modeled as a one-way broadcasting channel. There are several ways to configure a bidirectional (point to point) link with this datalink service:

1. FDM: Two carriers are assigned for a single point-to-point link. Nodes at each end use one of two carriers to transmit their packets to the other end.
2. TDM: A single carrier is assigned for a single point-to-point link and two ground stations at each end of the link use it in a TDM manner.
3. A combination of the two methods.

In the AI3 Phase I network, we use the first method for each point-to-point link. In order to carry the IP multicast traffic over our satellite links, we use a special datalink driver called "WISH driver" developed by the WIDE project.

For the preliminary study of the multimedia traffic handling on our testbed network, we carried a live video/audio stream and verified the implementation of our IP multicast driver for the satellite links. The source of the stream was a concert by Ryuichi Sakamoto in Mito Music Hall (Japan) in December 1996. For this live feed, we used the StreamWorks technologies developed by Xing Technology Inc. and NV/VAT over IP, multicasting simultaneously. Through this live feed, we also gathered statistical data on the traffic, delay, and packet losses. The details of these experiments are reported on our WWW site [7].

WWW cache

The major traffic on our testbed networks is WWW services. In order to reduce WWW traffic, we are operating a hierarchical WWW cache system. We are also implementing an adaptive WWW cache mechanism for the high hit rate on our testbed network. Our cache mechanism has three components: a cache manager, a prefetching engine called Wcol, and a traffic controller called Agent. We are using the Squid cache system as a cache manager. In order to improve its hit rate, we introduced the Wcol pager prefetching mechanism developed by the WDE Project [8]. This engine may sacrifice bandwidth consumption but can improve cache hit rate dramatically. In our preliminary evaluation, the Squid+Wcol cache system with simple prefetch strategy (one anchor look-ahead) provides a more than 60% hit rate with the WWW request pattern observed on the campus network of Nara Institute of Science and Technology, Nara, Japan; the Squid cache system alone provided around 40%. However, the prefetch adds more traffic, in this case 200% more. To counteract this increase, we add an agent for each cache system located in the AI3 testbed network. This agent provides effective prefetch strategies for each cache system, using observations of cache hit rate, access pattern, and

bandwidth consumption caused by both Squid and Wcol. As users' behavior around the WWW system may change occasionally, the agent provides strategy adaptively for Wcol. The details of this cache system are reported in the INET'97 conference [9].

AI3 Phase II

In 1997, we are going to add four or five partners to our testbed network. In this section, we introduce our expansion plan for the AI3 testbed in 1997.

Using C band service

The AI3 Phase I network uses the Ku band service provided by the JCSAT-3 communication satellite. The Phase I network connects three partners so far, and will add one more (Cambodia) in 1997. However, it is very hard to add more partners because there is no available bandwidth in the Asian Zone beam (Ku band) of the JCSAT-3, mostly because of the satellite digital TV broadcasting service started in 1996. In order to carry over 70 TV channels, broadcasting companies purchased as much bandwidth on the JCSAT-3 as possible, leaving no additional transponder to be assigned for the Ku band.

In order to expand our AI3 activities, we decided to use the C band service provided by the JCSAT-3 communication satellite. There are several advantages to this service:

1. The C band service covers a wider area than the Asian Zone beam (Ku band).
2. The C band service is much cheaper than the Ku band service, around 40% for the same bandwidth. This can make our project run for more months with the same budget.
3. The C band is less attenuated by rain than is the Ku band, making it better for use in tropical regions such as southeast Asia.

In 1996, we began the design of our new testbed network, called "AI3 Phase II network," which uses the C band service. We are planning two configurations for the Phase II network.

Interband Cross Strap Operation

One of our configurations uses the interband cross strap function of the JCSAT-3, which relays any traffic in a single transponder to another transponder in a different band. For example, with this function, we can assign a single C band transponder to be relayed to a single Ku band transponder on the JCSAT-3.

Because the C band has been used in Japan for terrestrial microwave communication channels, its use for satellite communication is still very limited, even though it is popular in other countries. Unfortunately, it is hard to obtain an operation license for C band ground stations. However, "receive only" ground stations do not need any licenses. Fortunately, on the JCSAT-3 there is one more transponder available for the Ex-Ku band and obtaining an Ex-Ku band ground station is much easier than obtaining a C band ground station.

This situation provided the catalyst for the AI3 Phase II network using the interband cross strap function. In this network, the ground station in Japan uses the Ex-Ku band for sending data to the satellite and the C band for receiving data. This configuration needs only a license for the Ex-Ku band ground station. With the interband cross strap function data sent via the Ex-Ku band can be relayed to the C band channel for other AI3 ground stations. For AI3 ground stations in other countries, both sending and receiving data are done in the C band. Figure 3 depicts this configuration.

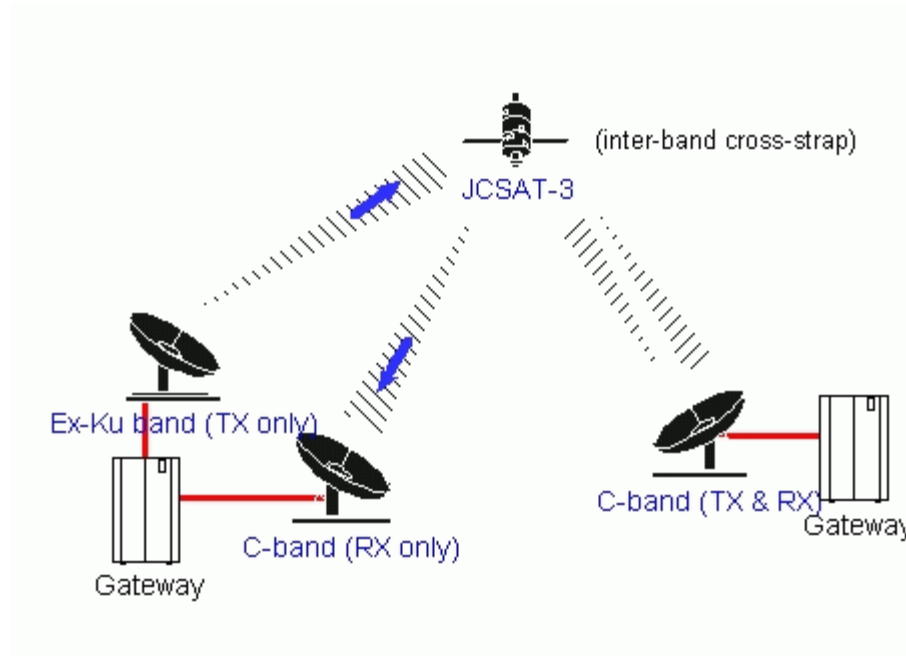


Figure 3: The AI3 Phase II network using the interband cross strap function provided by the JCSAT-3 communication satellite.

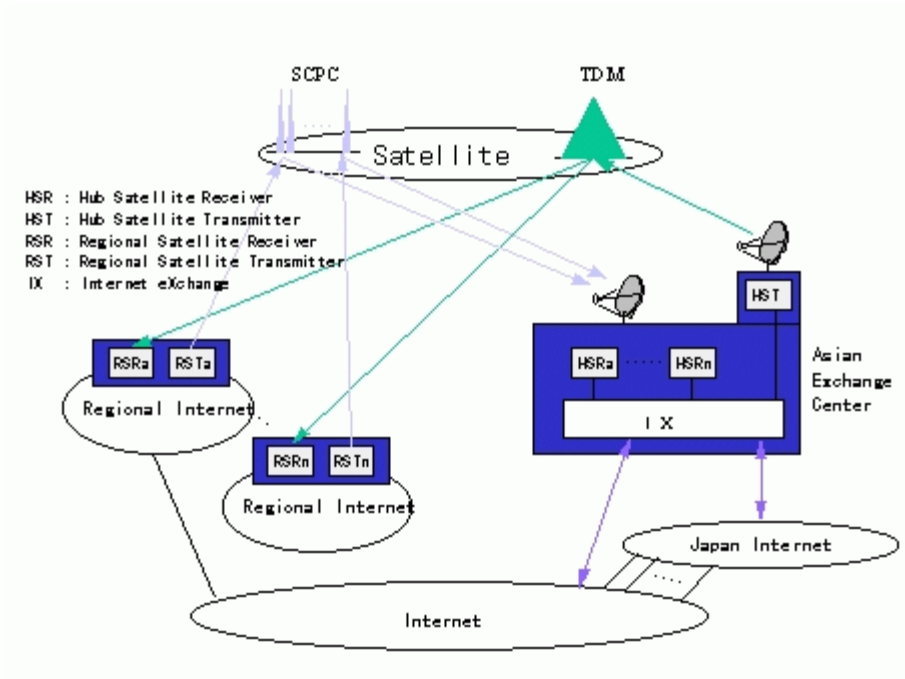
One advantage of this configuration is that we can get around the licensing problem for C band ground stations in Japan. However, the major drawback is that we need two ground stations at the hub site. For the hub station in Tokyo, the minimum required size of the antenna is 3.6 m diameter for the "receive only" C band ground station and 4.5 m for the "send only" Ex-Ku band ground station. Even though installing two ground stations is more costly, we are going to use this configuration as an initial configuration of the AI3 Phase II network.

TDM operation

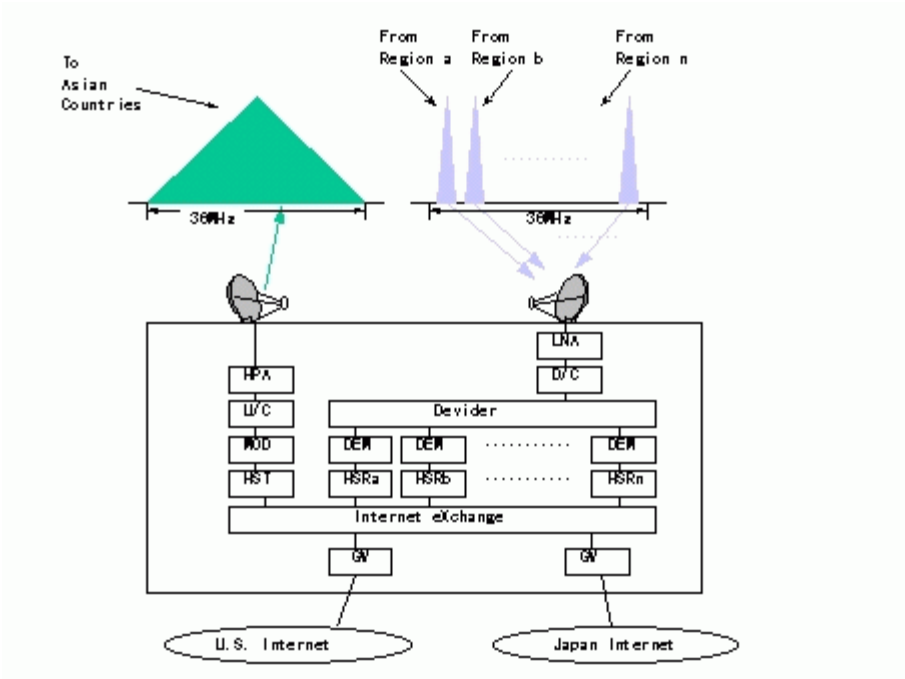
As WWW traffic on the Internet grows, we can observe an unbalanced pattern over several international links, especially between the United States and Asian countries. This imbalance is caused by the nature of the WWW service. The size of a single WWW request sent by a client is normally much smaller than ensuing replies. Because the Internet in the United States has huge numbers of WWW servers, Internet links to the United States tend to have an unbalanced traffic pattern: the inbound traffic to the States is larger than outbound traffic from the country.

In order to handle this unbalanced traffic effectively on the AI3 Phase II network, we are developing a new datalink technology, TDM multichannel access with C band satellite links. In this system, a whole transponder (30 Mbps) can be assigned for traffic between its hub station in Japan and AI3 regional stations in partner countries. The hub station sends data using a whole transponder, which is shared with several regional stations in a TDM manner. On the other hand, a link from each regional station to the hub station is set up using an ordinary SCPC point-to-point link, which is either 1.5 Mbps or 2 Mbps (Figure 5). Because the inbound traffic for each regional station is carried by a whole transponder in this configuration, we expect that each regional station can get good throughput.

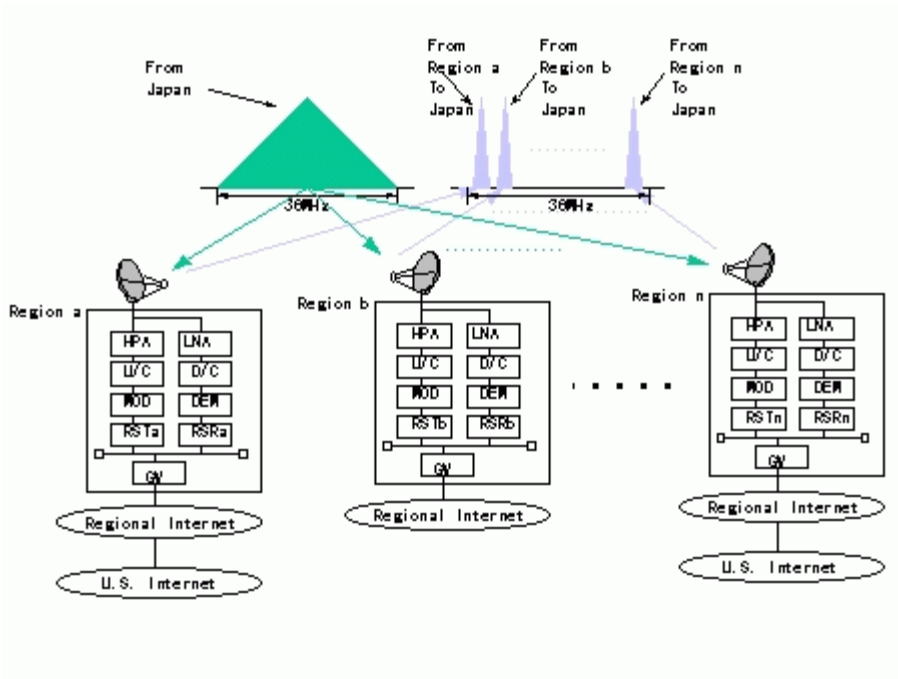
Because this kind of TDM operation of the satellite link has never been done before, a new interface hardware for handling the TDM channel must be developed. We are going to design and implement this interface hardware for the AI3 Phase II network.



a. Overall System Configuration



b. Configuration of Hub Station



c. Configuration of Regional Station

Figure 4: System Configuration of AI3 Phase II network in TDM operations

Topology of the AI3 Phase II network

The network topology of the AI3 Phase II network is shown in Figure 5. In the current design, the hub station is located in TTC, Tokyo, Japan. In order to provide a good connectivity between Phase I and Phase II sites, we will install a high-speed interconnection link (45 Mbps or 150 Mbps) between hub stations in WNOC-Nara and TTC. In the Phase II network, we are going to invite five more partners: China, the Philippines, Vietnam, Malaysia, and Singapore.

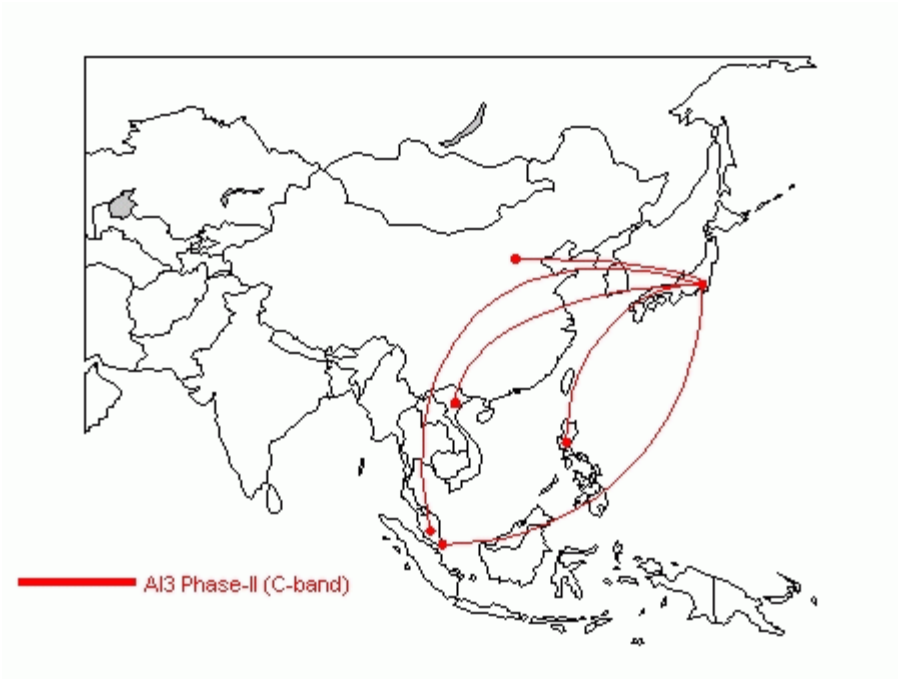


Figure 5: The network topology of AI3 Phase II network

Summary

The AI3 project, started in 1995, is aiming at testbed construction and research activities to accelerate cooperative works in and around the Internet in the Asian countries. In this article, we introduce the current status of and several results from the AI3 Phase I network.

In 1997, we are going to start construction of our new testbed network called AI3 Phase II, which uses C band service provided by the JCSAT-3 communication satellite. We are expecting the network to begin operation around September 1997.

References

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3. APAN WWW site. <http://www.apan.net/>
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5. The WIDE Project is an R&D project established in 1987. The project has several research activities dealing with Internet technologies. You can get information about this project through the WIDE Project WWW site. <http://www.wide.ad.jp/>
6. You can get technical information about the JCSAT-3 communication satellite through the JSAT Inc. WWW site. <http://www.jcsat.co.jp/>
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