第 15 部

Asian Internet Interconnection Initiatives

第 1 章

Introduction

The Internet development has been very active in countries in Asia since the last several years. As the result, many people in this region are now using the Internet for various kinds of purposes such as personal communication, human resource development, research, education, advertisement, product support and promotions, or other areas not limited to the computer communication technologies. The Internet is going to be established as a common communication infrastructure for people in the world.

However, there are still several issues for sustainable development of the Internet in this region. One of the major issues is technology transfers and sharing expertise on the Internet development among Asian countries. Currently, the commercial Internet service providers (ISPs) are major players of the actual Internet developments and operations also in the Asian countries. Since we have several interconnection link between the Internet in Asian countries, technical coordination and sharing expertise on the Internet operation among commercial ISPs has become very important for the stable operation of the Internet. For this purpose, several activities such as APRICOT[?] or APNG[?] are existing for the Internet community in Asia and Pacific region.

On the other hand, the technology transfer from the research community to the commercial entities is also vital for the future Internet. Through the Internet development, the Internet researchers and engineers are developing several kinds of technologies such as IPv6, IP multicasting, high speed datalinks for the Internet, or resource reservation mechanism for the Internet in order to add more power communication functions to the Internet. These technologies are going to be applied to the actual Internet environment, therefore, we need a path for technology transfers from research community to commercial entities. Installing testbed networks and to undertake collaborative researches and experiments on these new technologies among both research and commercial community is considered as a practical way for this technology transfer. For this purpose, several Internet testbed such as G7/GIBN, ATM testbeds in several countries, APAN[?], or APII testbed were formed so far.

The AI3 Project[?] jointly started by the WIDE Project[?] and the JSAT Inc. [?] in

1995 is aiming to provide a testbed network environment for the academic and research community in Asia. A major purpose of this project is to accelerate cooperative works for research and development of the Internet technologies. Research topics of the AI3 project includes network design for the future Asia-Pacific Information Infrastructure (APII), new technologies which enables IP multicasting over satellite communication channels, advanced routing method to use the channels efficiently, and promotions of the Internet technologies for countries in Asia. In 1996, we started our testbed operations with AI3 partners in Indonesia, Hong Kong and Thailand. On this testbed, several research activities are going on.

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

第 2 章

AI3 Phase I

Since October 1995, we have been working for construction of our initial testbed using Ku band satellite channels. In 1996, we invited several research partners to 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 1.5Mbps links each for partners and started their operation in October 1996. On this testbed network called "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.

2.1 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 JCSAT-3 communication satellite provides several beams, we are using the Asian Zone beam for our testbed network. Figure 2.1 shows the coverage of the beam. This picture also depicts requirements of the size of the antenna at ground stations which can get 2 Mbps satellite links. At major cities in East and South Asia, 3.6m diameter antenna is enough to provide a 2Mbps point-to-point link.

The initial topology of our testbed network is a star-shaped network. In WNOC-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 1.5Mbps satellite link. Figure 2.2 shows the current topology of our Phase I testbed network.

In this testbed network, gateways for the satellite link are IBM PC compatible systems running under BSDI's BSD/OS with RISCOM's high speed serial interfaces. The reason why we are using BSD/OS system is very simple: the BSD/OS is provided with its source code. Since the BSD/OS is provided with its kernel and utility source codes, it is convenient for us to modify the networking protocol stack for several experiments on our testbed

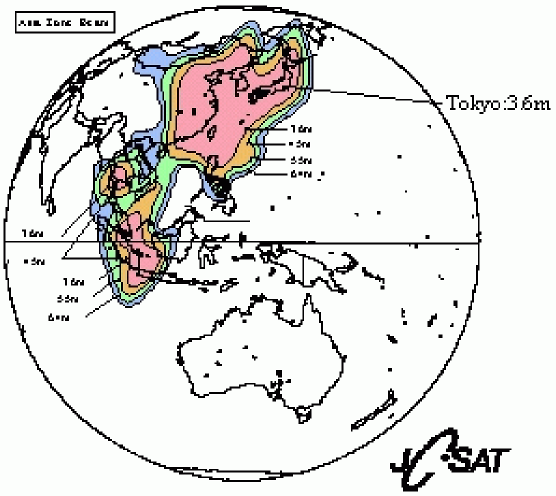

図 2.1: The coverage map of the Asian Zone beam of the JCSAT-3 Communication Satellite

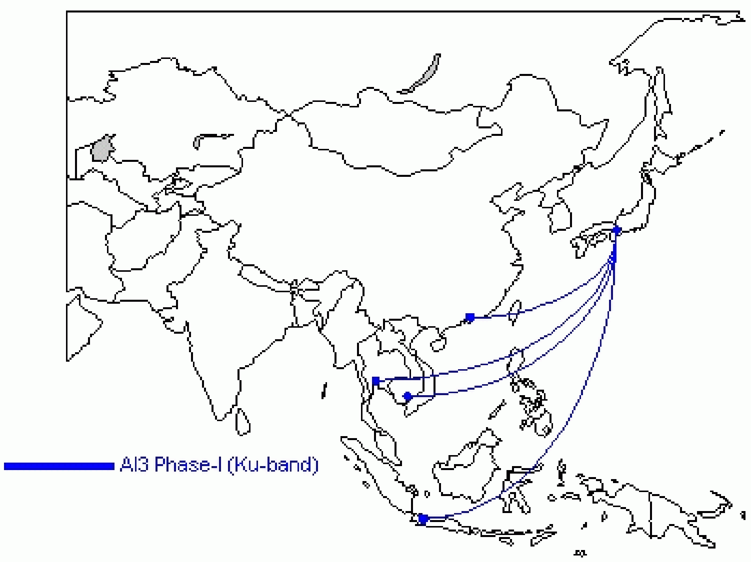

図 2.2: The network topology of the AI3 Phase I network

network and to integrate new technologies to this testbed 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.

2.2 Ku Band Service

While the C band service is very popular for satellite communications in Asia and Pacific region, there are few cases so far to use the Ku band service because the Ku band service is considered as weak against heavy rain. Since the tropical regions such as East and South Asia have heavy showers in rainy seasons, many people believes that it is hard to guarantee link quality for commercial operations with the Ku band service which has the rain attenuation characteristics.

In the AI3 Phase I network, we use the Ku band service for developing a way to apply it to commercial Internet operations. In order to guarantee link quality for commercial operations, we designed the AI3 link with (1) adding more rainfall signal margin in its datalink layer configurations and (2) applying the dynamic routing scheme using either BGP-4 or OSPF to switch a satellite link to a terrestrial link as its backup in the case of the satellite link down. As the result so far, we got only a single time (5 seconds) link down on Indonesia link during 4 months operation. This result shows that our link design can fulfill requirements on commercial operations of ordinary satellite links. In other words, the Ku band service for the satellite communication can be used for commercial Internet operation in tropical regions. This result is also meaningful in the sense of effectiveness of frequency use.

2.3 Multimedia on our link

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

1. FDM. Two carriers are assigned for a single point-to-point link. Nodes at each ends uses 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 TDM manner.

3. combination of 2 methods shown above.

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

2.4 WWW cache

The major traffic in our testbed networks is also for WWW services. In order to reduce the WWW traffic in our testbed network, we are operating the hierarchical WWW cache system. What we are going to implement on this environment is an adaptive WWW cache mechanism also for keeping high hit rate of the cache for WWW users in our AI3 testbed network. Our cache mechanism has 3 components: a cache manager, a prefetching engine called "Wcol", and a traffic controller called "Agent." As a cache manager, we are using "Squid" cache system. In order to improve its hit rate, we introduce a pager prefetching mechanism called "Wcol" developed by the WDE Project[?]. This prefetching engine may sacrifice bandwidth consumption but can improve cache hit rate dramatically. In our preliminary evaluation of this prefetch system, Squid+Wcol cache system with simple prefetch strategy (one anchor look-ahead) can provide over 60% hit rate, while the Squid cache system provides around 40% with the WWW request pattern observed in the campus network of Nara Institute of Science and Technology, Nara, Japan. However, the prefetch add more traffic. In this case, the mechanism adds 200% increase of the WWW traffic. To reduce this traffic increase, we add the Agent for each cache system located in the AI3 testbed network. The purpose of this Agent is to provide effective prefetch strategy for each cache system. The Agent develops the strategy based on observations of cache hit rate, access pattern, and bandwidth consumption caused by both Squid and Wcol. As users' behavior around WWW system may change occasionally, the Agent provides the strategy adaptively for the Wcol. The details of this cache system is reported also in the INET'97 conference[?].

第 3 章

AI3 Phase II

In 1997, we are going to add 4 or 5 more partners to our testbed network. In this section, we introduce our expansion plan of the AI3 testbed in 1997.

3.1 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 3 partners so far, and will add one more partner (Cambodia) in 1997. However, it is very hard to add more partners to this Phase I network because there is no available bandwidth in the Asian Zone beam (Ku band) of the JCSAT-3. The major reason why there is no available bandwidth in the beam was that the satellite digital TV broadcasting service was started in 1996. In order to carry over 100 TV channels, the satellite digital TV broadcasting companies purchased the bandwidth on the JCSAT-3 as much as possible. Therefore, there had been no additional transponder to be assigned for the Asian Zone beam (Ku band) on the JCSAT-3. This means we cannot expand our AI3 testbed network with using the Asian Zone beam provided by the JCSAT-3.

In order to expand our AI3 activities to other countries, we decided to use the C band service also provided by the JCSAT-3 communication satellite. There are several advantages in use of the C band service.

1. The C band service covers wider area than its Asian Zone beam (Ku band) on the JCSAT-3.

2. The cost for using the C band service is much cheaper than the Ku band service. The cost for the C band service is around 40% for the same bandwidth in the Ku band service. This cost saving can make our project run our testbed network for more months with the same budget.

3. The C band has less rain attenuation characteristics than the Ku band. This link characteristics is more adequate for use in the tropical regions such as South East

Asia.

In 1996, we undertook the design of our new testbed network called "AI3 Phase II network" which uses the C band service. Currently, we are planning 2 configurations for the Phase II network.

3.1.1 Inter-band Cross Strap Operation

One of the configurations we design is to use the inter-band cross strap operation of the JCSAT-3 communication satellite. JCSAT-3 has the inter-band cross strap function which relays any traffic in a single transponder to the other 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 for the terrestrial microwave communication channels in Japan, using the C band for the satellite communication is still very limited in Japan, even its use is very popular in the other countries. Unfortunately, it is very hard to obtain the operation license for C band ground stations. However, there is no need to obtain any licenses in the case we install the "receive only" C band ground stations. Fortunately, on the JCSAT-3, there is one more transponder available for the Ex-Ku band and obtaining the Ex-Ku band ground station is much easier than one for the C band ground station.

This situation makes the fundamental idea of the AI3 Phase II network using the inter-band cross strap function provided by the JCSAT-3. In this idea, the ground station located in Japan uses the Ex-Ku band for sending data to the satellite, and also use the C band for receiving data from the satellite. With this configuration, we need only a license for the Ex-Ku band ground station. By means of the inter-band cross strap function provided by the JCSAT-3, data sent via the Ex-Ku band can be relayed to the C band channel for other AI3 ground stations. For other AI3 ground stations, both sending and receiving data via satellite are done in the C band channels. The figure 3.1.1 depicts this communication configuration.

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

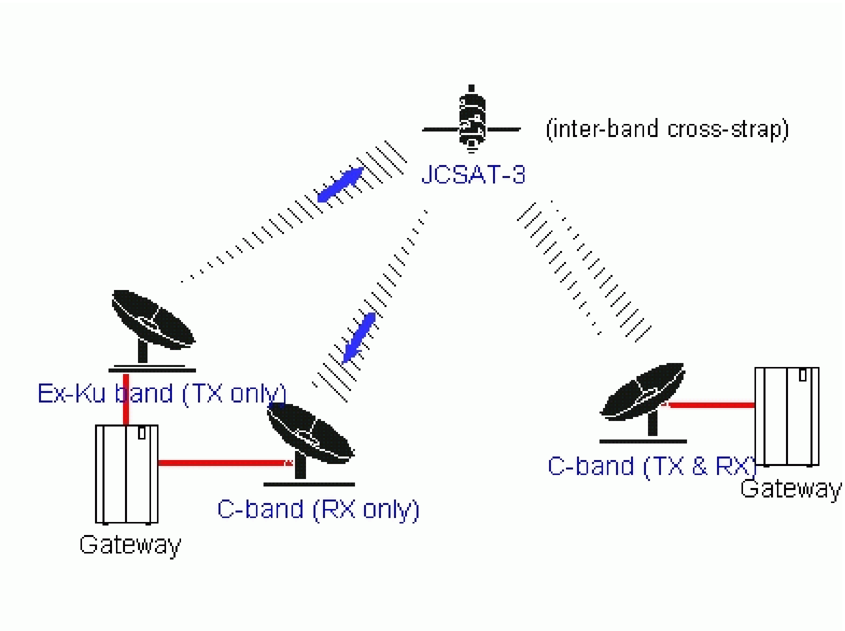

図 3.1: The AI3 Phase II network using the inter-band cross strap function provided by the JCSAT-3 communication satellite.

3.1.2 TDM Operation

As growing the WWW traffic in the Internet, we can observe the unbalanced traffic pattern over several international Internet links, especially links between the United States and Asian countries. This unbalanced traffic is caused by the nature of the WWW service: The size of a single WWW request sent by a WWW client is normally much shorter than WWW replies corresponding to the request. Since the Internet in the United States has huge number of the WWW server, the Internet links to the United States tend to have an unbalanced traffic pattern: the inbound traffic from the States is larger than the outbound traffic from the country.

In order to handle this unbalanced traffic effectively in the AI3 Phase II network, we are also developing a new datalink technology, i.e., TDM multi-channel access with C band satellite links. In this system, a whole transponder (30Mbps) can be assigned for traffic between its hub station located 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 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 1.5Mbps or 2Mbps (Figure 3.2, 3.3, 3.4). Since the inbound traffic for each regional station is carried by a whole transponder in this configuration, we expect that each regional station can get

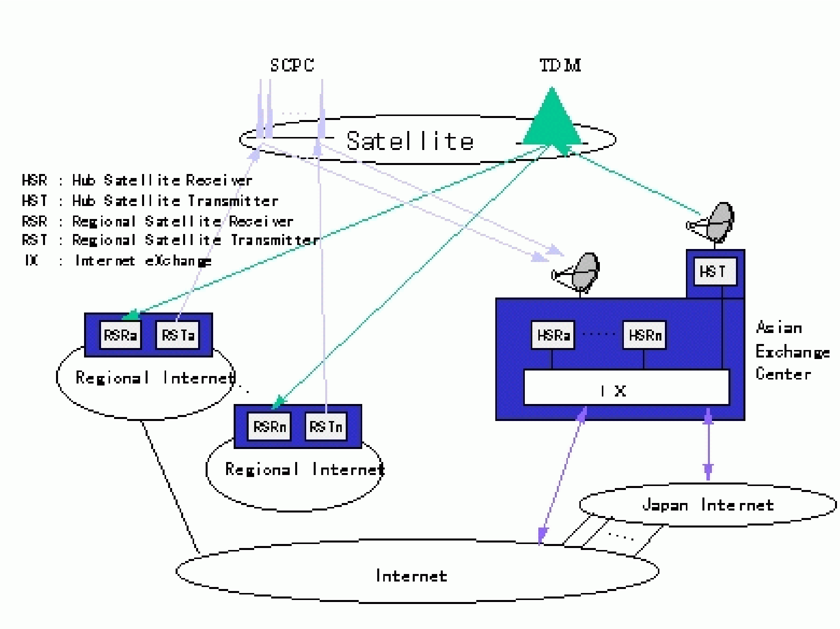

図 3.2: System Configuration of AI3 Phase II network in TDM operations: (a). Overall System Configuration

good throughput.

Because this kind of TDM operation of the satellite link has never been done before, it is required to develop a new interface hardware for handling the TDM channel. Currently, we are going to design and implement this interface hardware for the AI3 Phase II network.

3.2 Topology of the AI3 Phase II network

The network topology of the AI3 Phase II network is shown in Figure 3.2. In the current design of the Phase II network, 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 (45Mbps or 150Mbps) between hub stations in WNOC-Nara and TTC. In the Phase II network, we are going to invite 5 more partners: China, Philippine, Vietnam, Malaysia, and Singapore.

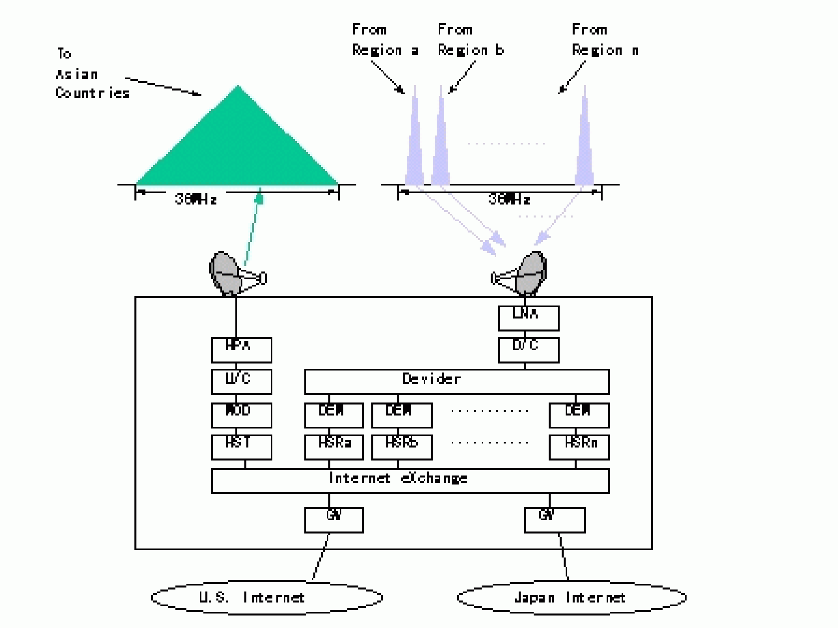

図 3.3: System Configuration of AI3 Phase II network in TDM operations: (b). Configuration of Hub Station

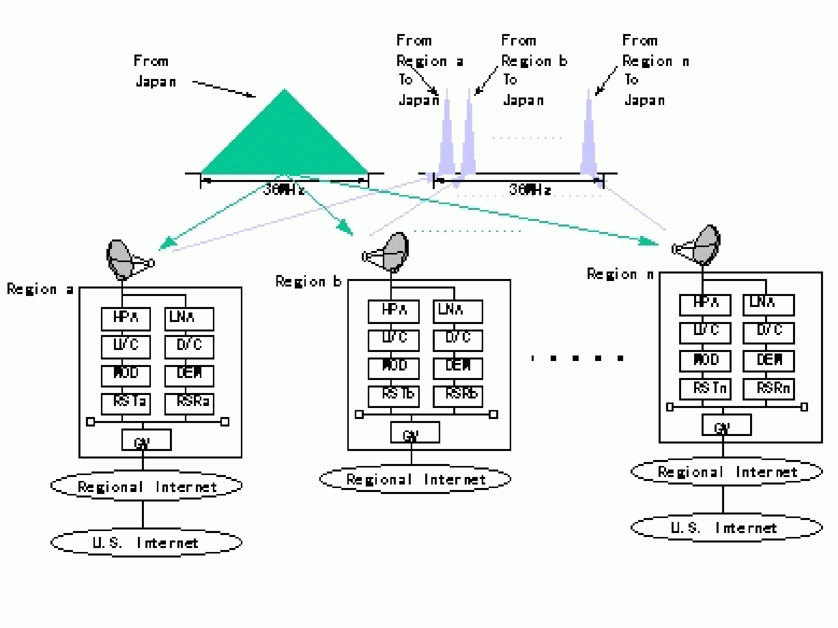

図 3.4: System Configuration of AI3 Phase II network in TDM operations: (c). Configuration of Regional Station

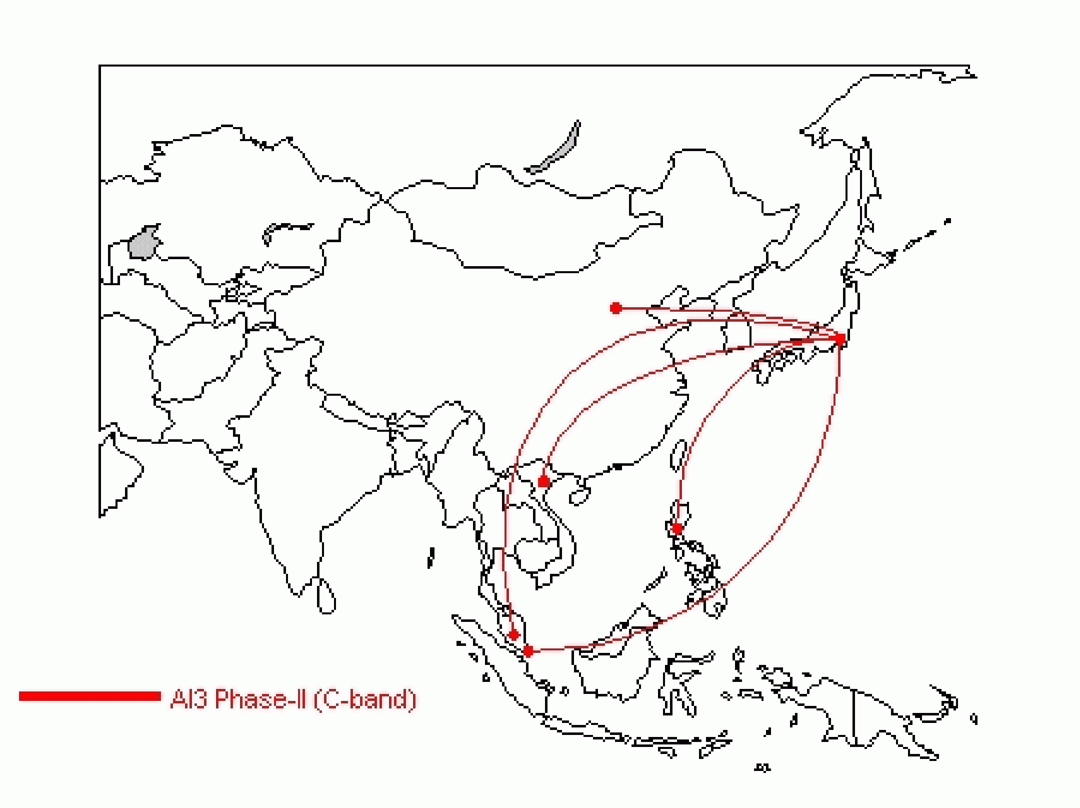

図 3.5: The network topology of AI3 Phase II network

第 4 章

Summary

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

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

第 5 章

外部研究予算実績等

- 平成 8 年度 国際共同研究助成金 通信・放送機構より、1,000 万円
- 平成 9 年度 郵政省電気通信局事業政策課より、約 500 万円を予定