第15部

Asian Internet Interconnection Initiatives

第1章 Introduction

Large number of technologies utilized for Internet has been developed and improved continuously from their beginning. These process of technology development and improvement always require the network environment where engineers and researchers can make implementations of the technologies and test and evaluate them. This network environment is so called a testbed network. It is quite popular for the Internet community to provide testbed networks for specific technology development. Mbone, for example, has been set up and operated since early 1990's and this network is for IP multicast technology development and deployment. Other example is 6bone which has been composed based on the same idea for IPv6 and operated since mid 1990's. The testbed network can accelerate process of technology development and its engineering, therefore, it is fairly important for research groups of Internet technologies to construct and operate its testbed network.

The project discussed here is an international research consortium among research institutes in Asian region and is aiming to form a group of researchers to develop leading edge technologies for the Internet, such as IPv6, WWW caching and replication mechanisms, multimedia communication mechanism, and applications for the advanced usage of the Internet. The name of the project is Asian Internet Interconnection Initiatives[1] [172, 173, 174] or "AI^3" (ei-tripl-ai) in short.

1.1 Its History

This project was formed in 1996 by WIDE Project and started its activities with its initial partners that are Institute of Technology in Bandung (ITB) in Indonesia, Asian Institute of Technology (AIT) in Thailand, and Hong Kong University of Science and Technology (HKUST) in Hong Kong. As its testbed network, Ku-band satellite communication channels have been used, therefore, each AI^3 partner is operating its Ku-band VSAT earth station and gateway systems to attach its local testbed environment to AI^3 backbone. For the first three years of the project, all the members of this project worked hard to develop several technologies for the Internet, and series of experiments utilizing this testbed backbone were conducted. The operation of our testbed network is a large-scale satellite Internet infrastructure, and at the moment when we started this project, there was not satellite Internet infrastructure but only ours, hence, we have a good opportunity to develop several technologies that are vital for smooth operation of the satellite Internet infrastructure.

In 1999, AI^3 project decided to expand its activities to more countries and add several C-band satellite channels to span these new partners as its new backbone network. As of March 2000, the project invited 5 more research institutes as its new partners: Temasek Polytechnic (TP) in Singapore, Universiti Sains Malaysia (USM) in Malaysia, and Advanced Science and Technology Institute (ASTI) in Philippine, Institute of Information Technology (IOIT) in Vietnam and University of Colombo (CMB) in Sri Lanka (see Fig.12). On this new C-band backbone, several challenges are planned.

In this report, we explain details of the AI^3 testbed network and report current research activities conducted in this AI^3 project. The future plans and works of the project are also shown in the following chapters.

第2章 AI^3 Testbed Network

The AI^3 testbed network is a part of global/international Internet infrastructure based on satellite communication system in Asian re-

[1] This research project is supported by Communication Research Laboratory and also supported by JSAT Corporation.

図 12　AI^3 Site Map

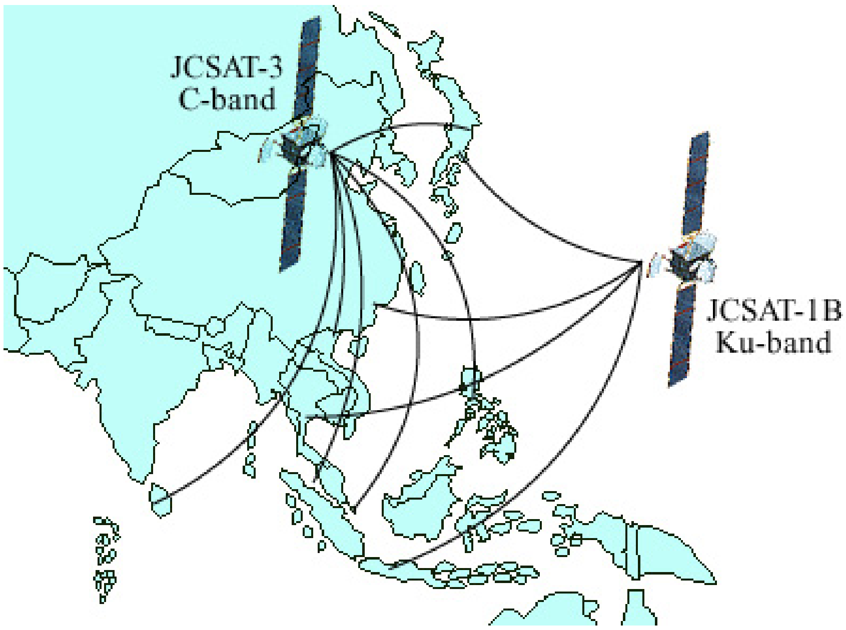

図 2.1　AI^3 Testbed Network

図 2.2 AI^3 Hub Stations located in Japan: The left hub station is for Ku-band located in NAIST and the right one is C-band hub station located in SFC, Keio Univ.

gion. This network provides Internet direct connectivity among AI^3 partners.

Its backbone part consists of point-to-point links based on satellite communication channels and high-speed ATM connection between 2 satellite hub earth station located in Japan (see Fig. 2.1 and Fig. 2.2). All the links between a hub earth station and partners are in asymmetric configuration: 1.5Mbps from Japan and 512kbps to Japan. Between 2 hub earth stations, we installed 10Mbps ATM link.

We have been using JCSAT-1B Ku-band channels for Internet connections from Nara Institute of Science and Technology (NAIST) in Japan to 3 initial partners (ITB, AIT, and HKUST), since 1996. Our motivation to use Ku-band is to verify it in the tropical Asian region as an Internet link, even though Ku-band satellite channel is not recommended in that area due to its weakness against rainfall attenuation. Based on our 3 years operation of this system, we can conclude that Ku-band is strong enough for Internet link even in the tropical area.

In 1999, we added JCSAT-3 C-band channels for this project. Its hub earth station is located in Keio University in Japan (see Fig. 2.2) and connects new partners. This new part based on C-band is still under construction, and connections for TP, USM and ASTI are in operation as of March 2000.

From the view of the Internet layer, these satellite communication links and a terrestrial ATM link form a single routing domain (autonomous system) in the Internet. This testbed network is connected to WIDE Internet and APAN[175, 176] directly. Through these networks, we can provide global connectivity for AI^3 partners. In some cases, the AI^3 links are positively used and shared as an international backbone not only for the partners but also for their domestic academic and research community.

第 3 章 AI^3 Operation and Research

In this chapter we show several results on operation and research in our project.

3.1 AI^3 Link Status

The latest information on AI^3 link status are shown in Table 3.1. Almost all of the link bandwidth are in asymmetric configuration as shown. 1.5Mbps from Japan and 512kbps to Japan are basically assigned, however bandwidth allocation may be dynamically changed on research basis. The bandwidth for JP-ID has been increased up to 2.0Mbps / 768kbps for the purpose of a study relating a fully congested satellite link based on usage for international academic backbone link between Japan and Indonesia. On the other hand, JP-TH has been also upgraded due to a joint re-

図 3.1　New AI^3 C-band Earth Stations: These stations are located in Temasek Polytechnic, USM and ASTI in order from the left side.

表 3.1　Current AI^3 Link Status (Date: 31 May 2000)

Countries	*Frequency Band*	*Uplink Bandwidth*	*Downlink Bandwidth*	*Availability*
JP-ID	Ku-band	2.0 Mbps	768 kbps	Up
JP-HK	Ku-band	1.5 Mbps	512 kbps	Down
JP-TH	Ku-band	1.5 Mbps	1.5 Mbps	Up
JP-SG	C-band	1.5 Mbps	512 kbps	Up
JP-MY	C-band	1.5 Mbps	512 kbps	Up
JP-PH	C-band	1.5 Mbps	512 kbps	Up
JP-VN	C-band	1.5 Mbps	512 kbps	-
JP-LK	C-band	1.5 Mbps	512 kbps	-

search project between AIT and GIOS which is leaded by SOI of WIDE project and their program on distance education needs 1.5Mbps link bandwidth in bidirectional way.

JP-HK is unfortunately down at present due to failture of their earth station and it is still unclear when JP-HK link will revive with repairs of their fault parts.

New link connections with C-band partners have rushed on since the end of 1999. SFC C-band hub station has started operation since November 1999. JP-SG link has been up as soon as SFC earth station started and then follows JP-PH and JP-MY in turn. The Figure 3.1 shows the new stations respectively.

The links between Japan and Vietnam/Sri Lanka are in preparation. In Vietnam, IOIT is waiting for arrival of some satellite equipments to complete construction of their station. AI^3 project has entered into an agreement to exchange MoU (Memorandom of Understanding) document with CMB in Sri Lanka. CMB has completed obtaining technical information regarding their earth station from JSAT Corporation. As they have a funding problem, they have applied for a few donors for possible funding and they are waiting for a reply. They are expected to receive a reply by end of May.

As for JP-CN link, the link has been eliminated from our list, because an opposite site in China which institute had kept interesting in joining AI^3 project finally decided to give up the partner candidate in December 1999 due to license problem in China. Hence AI^3 project has started considering to invite a new partner from other Asian country and a research institute in Nepal is marked with the highest priority at present. Nepal is under coverage of JCSAT-3 satellite and they stand by to join our project.

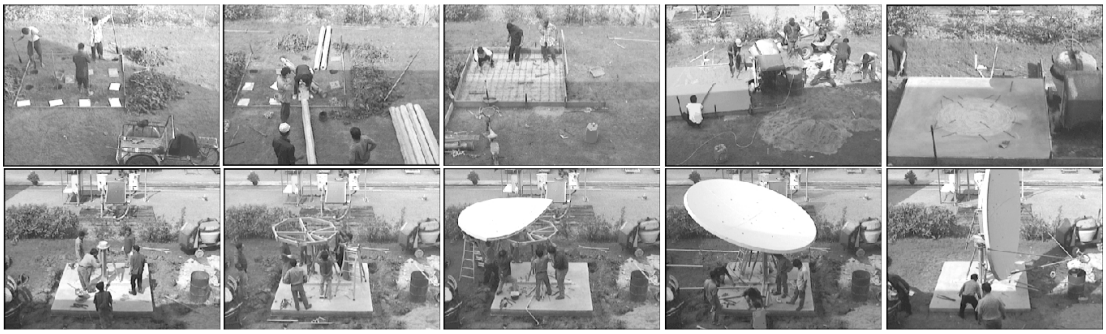

図 3.2 Moving AI^3 antenna in AIT from Jan. 4 to Mar. 6, 2000

3.2 Ku-band Satellite Transferring

We have experienced Ku-band satellite transferring from JCSAT-3 to JCSAT-1B among AI^3 Ku-band group on the basis of request by JSAT Corporation. In conclusion, the work for transferring successfully finished with about 1 month technically supported by JSAT Corporation and local vendors in each country from December 1999 to February 2000. During this transferring period, the part of the Ku-band links in our testbed network was suspended in operation, because the earth stations located in NAIST and AIT had to be moved to get a clear field of view for JCSAT-1B satellite.

Through this transferring, we faced some problems with the level of transmission in AIT, even when the power of transmission signal is at the maximum. Although it has been controlled that both IDU and ODU are working fine, the output power was not enough strong to reach the nominal JCSAT-1B satellite input level (about 1.5 dB lower).

In conclusion, these problems have originated in cooling level of the ODU, fineness of adjustment for azimuth/elevation/polarization angle of the antenna and a miss alignment between each pannel of the antenna dish.

1. it was not easy for AIT staff to adjust azimuth, elevation or polarization angle to an exact number because there was no motor on the antenna and nothing provided to read the value of the angle. For elevation and azimuth, AIT could use the screw to change little by little. Through several fine positioning of the antenna, Eb/No ratio had been gradually increased.
2. AIT staff had investigated on some temperature problems. They found out that the fan were not working in the RF unit, so they installed a big external fan on the heat skin. ODU did not work well under high temperature and it had to be cooled down by the external fan.
3. The last problem to be solved in order was a miss alignment between each pannel of the dish. They guessed that it was wrong as much as 1/4 of the wave length. At last the antenna installer had to come again in order to make some correction on the dish planarity.

As a result, AIT succeeded to restore the operation, but they are formed with computer stuff "only." Ideally all of VSAT earth stations should be able to handle that matter much more easily, especially in case of usage for Internet connections. The easier way to maintain earth stations basically contributes to sustain satellite Internet infrastructure and to expand it in Asia with ease even under circumstances like shortage of technical supports for maintenance.

Automated mechanism to manipulate the antenna direction and sensors to capture a satellite are better to be attached to VSAT earth stations. However it cannot be expected in all cases.

In some cases technical collaborations are needed among satellite providers, local venders and station maintainors. This transferring indeed needed such tight works among them. Our experience is useful to solve problems under similar situations in future, because satellite transferring is unavoidable if we run satellite based information infrastructure in a long term.

3.3 SFC C-band Earth Station and Its Operation

SFC earth station is a C-band earth station type with a 7.6 meter satellite dish which is pointed to JCSAT-3 satellite (see the right side in Fig. 2.2). The callsign of this station is JC222 and this station has been licensed on October 28, 1999. SFC earth station has two sets of DownConverter, UpConverter, and HPA (high power amplifier) in redundant way. Currently this earth station transmits 4.5Mbps data for three partners with transmission power of - 15dBm (57dBw E/S EIRP) for 1.5Mbps on each modem output.

SFC sent two sets of SDM-300A IDU to our partner, USM in Penang, Malaysia; one is used for UAT and the other is for spare. USM has already bought two sets of IDU without RS (Reed Solomon) FEC (Forward Error Correction) function before the operation of its C-band earth station. USM cannot use the modems because of the lack of RS FEC function on them. The lesson learned from this case is we have to tell detailed enough information to the new partners regarding the earth station requirements and also don't have to open technical information describing specification of the earth station in public through the Web, because such information change in response to advance of communication technology even in a short period.

From the beginning of operation until present, SFC only had two incidents: power failure on April 7, 2000 and disconnection of PH link during WIDE Camp Spring 2000 (March 14-17, 2000). The power failure was unscheduled so there was nothing SFC team couldn't do except reported

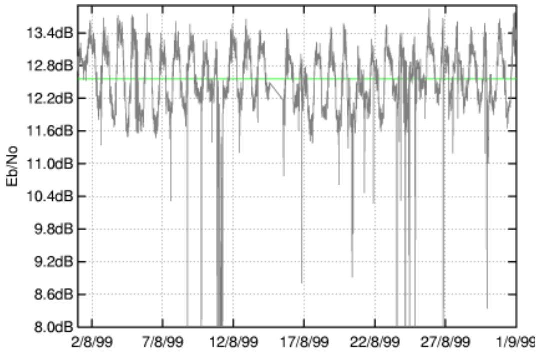

図 3.3 IDU monitoring at AIT in August 1999

the incident to YSCC (Yokohama Satellite Control Center). The PH-link problem happened because AI3-PH team forgot to turn on their ODU power. PH team did not report the disconnection to YSCC because they did not know about the reporting procedure. The lesson from this problem is SFC has to write a reporting procedure to YSCC and inform AI^3 partners about it.

3.4 Satellite Internet Monitoring

It is quite important for network operation to keep its environment healthy. In order to this purpose, we are using an SNMP based network management system. With the system, we keep tracking all the status of routers, switches and other network devices and share this information among network operators and researchers in our project, in order to know fault point in the case links or gateway systems are down.

However, unlike the ordinary Internet system, we are using satellite system for our backbone connections, we also have to monitor satellite links. The characteristics of satellite links is not same as the terrestrial digital leased line provided by telephone companies. Especially in case of Ku-band in the tropical region such as our link for Indonesia, rainfall attenuation affects link stability due to heavy rain even though the link margin is well estimated. In our experiences, the satellite link between Japan and Indonesia is down mostly at the beginning of normal rain and the IP reacha-

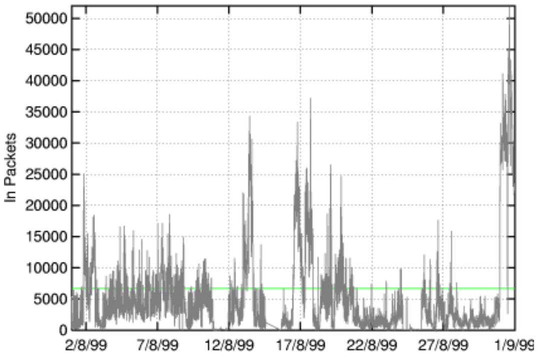

図 3.4 the number of packets over JP-TH link monitored in August 1999

bility is established in about 5 minutes. If the rain is very heavy, the link was up again after the link is down between 5-10 minutes.

In order to find out fault points promptly and to share information among remote sites in the testbed, we developed some tools to monitor communication (wireless) devices for satellite channels. Information periodically gathered from the devices are compiled and depicted as a Web page. As well as this information, we started to try to get live data from weather stations where heavy rain frequently falls like Indonesia in order to locate the reason of link disconnection. With our tools, for example, we can check statistical information about our satellite links through the Web as a result of our monitoring system; Figure 3.3 shows a data plotting Eb/No of IDU located at AIT from August 1 to 31 in 1999. Figure 3.4 shows the number of packets transmitted over the link between Japan and Thailand during the period.

3.5 Multimedia Communication

Since the beginning AI^3 testbed has been used for various experiments on transmitting video, audio and data streams. There were two major categories from the transmission point of view: broadcasting and conferencing. Each time priority was given to public domain software, at least for the receiving part so that the viewer had not to invest into some proprietary software. As our typical broadcasting experiment, during the event of UNFCCC/COP3 in 1997 and UNFCCC/COP4 in 1998[177, 178, 179], AI^3 network testbed performed a part to relay audio and video broadcasting from the conference hall to a large Internet audience in Asia. In conferencing, the testbed was frequently used for the path to transmit audio and video streams between remote conference sites. For instance, AI^3 testbed was used as a part of APAN in March 1999, to transmit video and audio streams of GOIN'99 conference[176, 180] between AIT, NASDA in Japan and GOIN'99 conference site at Hawaii and those streams were also exchanged with some sites in APAN, NREN, NISN, DREN, Abilene and etc. shown in Figure 3.5.

Through these experiments, we have played a part as distributor or relay sites while training ourselves for modern network conferencing and content distribution tools.

3.6 AI^3 Cache Bone

The hierarchical WWW cache formation for providing both higher hit rates and saving the overall bandwidth consumption through fetching WWW objects and redistributing them among the partners' caches has been proposed as AI^3 Cache Bone. It is designed for an application on satellite Internet infrastructure. The cache structure is based on the star-shaped topology of AI^3 satellite network.

As shown in Figure 3.6, the hub cache is a core unit which is located at the satellite hub station and gathers WWW objects from the Internet, while the rim cache fetches requested WWW objects through the hub cache as well as receives WWW objects being pushed from the hub cache. The rim cache analyzes the users' access pattern to generate the list of the frequently accessed URLs that should be prefetched. The prefetching strategy of the rim cache is based on the statistical pattern analysis of users' accesses. The traffic monitoring is used to control both prefetching and

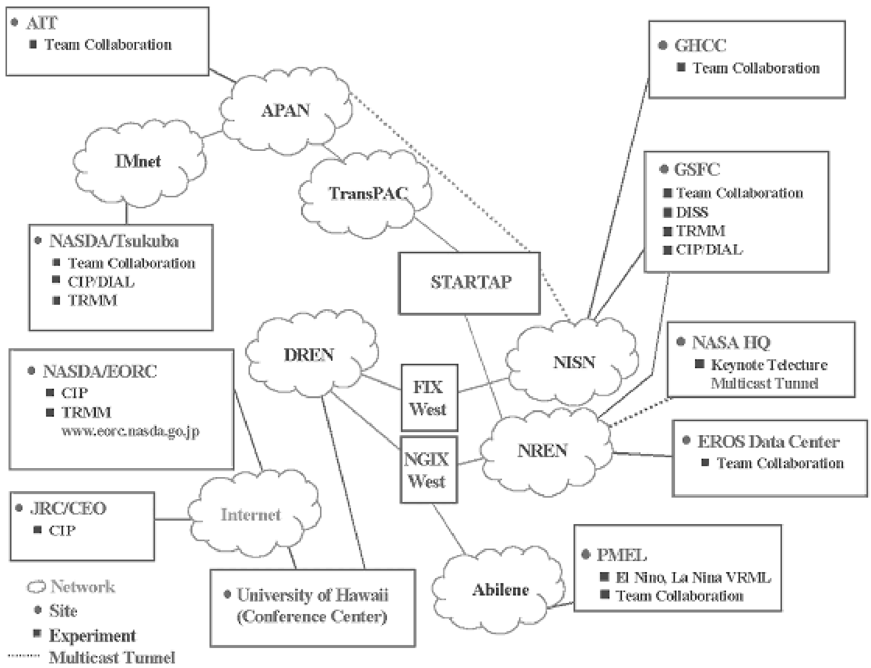

図 3.5　GOIN99 Network

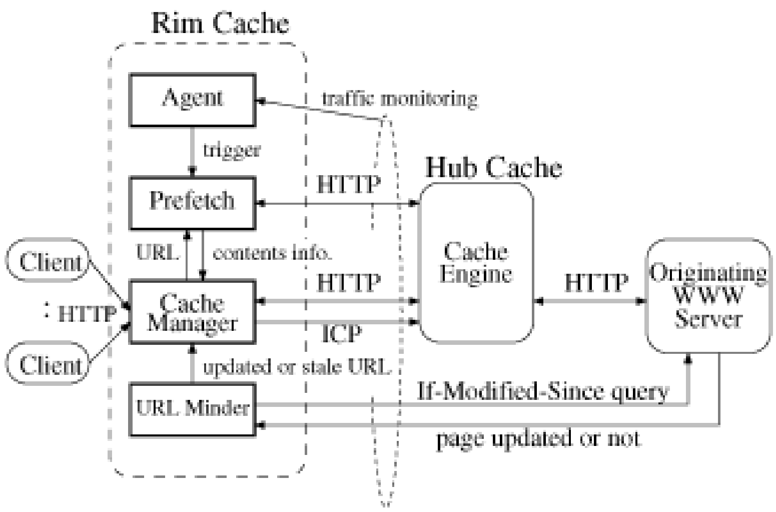

図 3.6　System Architecture of AI[3] Cache Bone

pushing object operations. In order to reduce the consumption of bandwidth on the satellite links, the multicast transmission of WWW objects is introduced to distribute the prefetched Web objects from the hub cache to all connecting rim caches. Furthermore, the cached objects are checked regularly with 'if-update' tag so that their consistency can be kept with a reasonable overhead. The AI[3] Cache Bone is designed and implemented with the above adaptive scheme of hierarchical WWW cache formation[181, 182].

It has been found that failure of either Rim or Hub cache caused infinite waiting time for the users before they realize the fault of the system like a hardware trouble or a hunged up process. Several actions have been planned to improve the

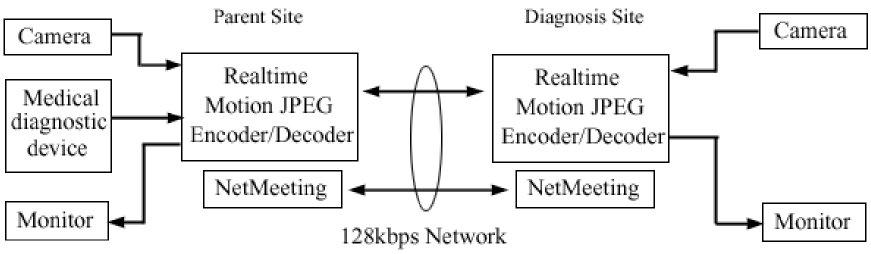

図 3.7 System component of Telemedicine Experiment

situations and we have already connected with APAN cache as ICP parent cache connection in April 2000. We will report other future works relating Cache Bone in the following Chapter 5.

3.7 Telemedicine over Satellite

A new telemedicine system which enables us to perform real-time remote diagnosis using medical image sequence on a public digital network up to 128kbps has been developed and was applied to our testbed in June 1999. The system component is shown in Figure 3.7.

This experiment verified that the proposed system provides real-time telemedicine environment over our testbed between Thailand and Japan[183]. The both test sites were connected by Internet between Rajavithi Hospital in Bangkok, Thailand, and the Hokkaido conference hall in Sapporo, Japan, where "The 72nd Scientific Meeting of the Japan Society of Ultrasonics in Medicine" was held. The Rajavithi Hospital performed as a patient site with some patients and the conference hall performed as a diagnosis site with some Japanese medical specialists. Actually in this experiment, the staff prepared some patients who have cardiological disease or obstetrical disease at the patient site in Thailand, and we also asked cardiologists and obstetricians to be at the diagnosis site in Japan.

Figure 3.8 shows an example for medical image sequence transmitted over the testbed.

Figure 3.9 shows the network topology for this experiment. In the figure, Rajavithi hospital in Bangkok and AIT were connected with 128kbps ISDN link. The link between AIT and NAIST is on our AI^3 network. Also a link NAIST and the Hokkaido conference hall were connected with a 128kbps ISDN. Round trip time between both ends was around 590 ms.

In order to transmit medical image sequences, we developed image sequence handling software running on FreeBSD UNIX system[1].

As a result, the medical specialists in Japan diagnosed the amount of amniotic fluid, the state of a navel string and the mitral insufficiency. However the specialist abandoned diagnosis of the heart rate and coronary thrombosis[184]. In conclusion, even though we use a satellite link as long delay thin bandwidth Internet connection, we confirmed that our testbed is enough valuable for real-time telemedicine by using a low bit rate sequences of medical image.

3.8 Knowledge Management in AI^3 Indonesia

Various activities on knowledge management has been done by Knowledge Management Research Group of ITB, Indonesia. KMRG stands for Knowledge Management Research Group. Its aim is to research knowledge management system to manage the Intellectual Capital (IC) assets of an organization. Managing the ITB's IC is its current focus. KMRG has a close relationship with AI^3 ITB, because the main individual also the staff of AI^3 ITB and CNRG ITB. KMRG is located at

[1] FreeBSD 2.2.7 on Pentium II 233MHz with 128Mbyte memory.

図 **3.8**　An example of medical image transmitted over our testbed

ITB Central Library, where AI^3 ITB has a cyber library project. We show the status reports of KMRG's activities as follows. The first our activity is Libraries Catalogs Network (ISISNetwork). Then follows the report on GNU-Library Automation Project and Ganesha Digital Library. And the last report is Knowledge Networking Project.

Libraries Catalogs Network is an electronic network between libraries across the Internet, that interconnect libraries catalogs databases so that people can search the catalogs from the Internet. The databases are originally in the format of CDS/ISIS. We are using ISIS - freeWAIS software to enable the searching over the databases. We call this network as ISISNetwork.

Objectives of the ISISNetwork are as follows.

1. To enable the information sharing among libraries
2. To enable the information and resources finding by users from the Internet
3. To enable the online transaction (inter libraries loan, photocopy, referral, etc) between users and librarians using the Internet

We report the current status of the ISISNetwork. The number of servers using ISIS-freeWAIS and connected to the network is 5 servers (ITB, PDII LIPI, PT Rekayasa Industri, University of Muhammadiyah Malang, and National Family Planning Board). The number of libraries that hosting their database at ITB Central Library Wais server are 12 libraries. The numbers of databases located at ITB Central Library Wais server are more than 50 databases. The main server's URL is http://isisnetwork.lib.itb.ac.id/ and the members can order copies or loan from the web.

GNU-Library Automation Project is an on going project of KMRG ITB. It was started by 1st April 2000 and are planned to be finished at September 2000. Its main aim is to develop a library automation software that is free for every libraries in Indonesia. KMRG holds this project because Indonesian libraries have no enough fund to buy a library automation software that usually very expensive compared to their condition. The existing software in Indonesia are whether expensive or not good enough.

Objectives of GNU-Library Automation project are as follows.

1. To learn the library automation system
2. To design and develop a library automation

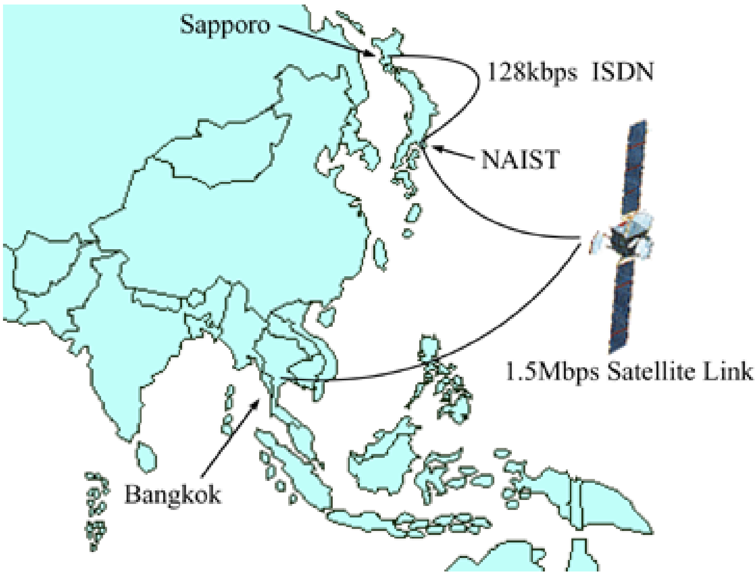

図 3.9 Network topology for Telemedicine experiment

software using free software platform and licensing system

3. To provide documentation system for the application of the software
4. To provide an installation and training service for other libraries

We report the current status of GNU-Library Automation project. KMRG will finish the analysis and design phase by end of May 2000. This project is self-funding. Currently, there is no funding that we receive. We plan to make a fund rising by holding a seminar about "Leveraging IC in Research and Academic Institutions using KM". The URL of this project is http://gnu.lib.itb.ac.id/ and the teamwork members are mostly graduated from ITB and currently still active at CNRG or AI^3 ITB.

Ganesha Digital Library shown in Figure 3.10 is an experimental system to develop a digital library for ITB Central Library. The first version of web site was launched at November 1999. This library consists of the following area.

- Theses and Dissertations
- Proceeding
- Articles
- Web sites
- Electronic clipping
- Resources from Salman Mosque

Current effort is developing third version of Ganesha Digital Library, with the main aim is to leverage the Intellectual Capital of ITB.

Objectives of this project are as follows.

1. To research the digital library system and technology
2. To develop a digital library of ITB that manage the IC produced by ITB community
3. To provide access to the knowledge bases for every individual in ITB and Internet
4. To bring ITB Central Library to be a forefront university in developing digital library in Indonesia

We report the current status of Ganesha Digital Library. We have experiences in digitalizing hard copy material of theses and dissertation into electronic format that ready to be accessed from Internet. Hundreds of metadata and abstracts of final reports, theses, and dissertations have been uploaded into the server. ITB Central Library staffs have been experiencing the maintenance of digi-

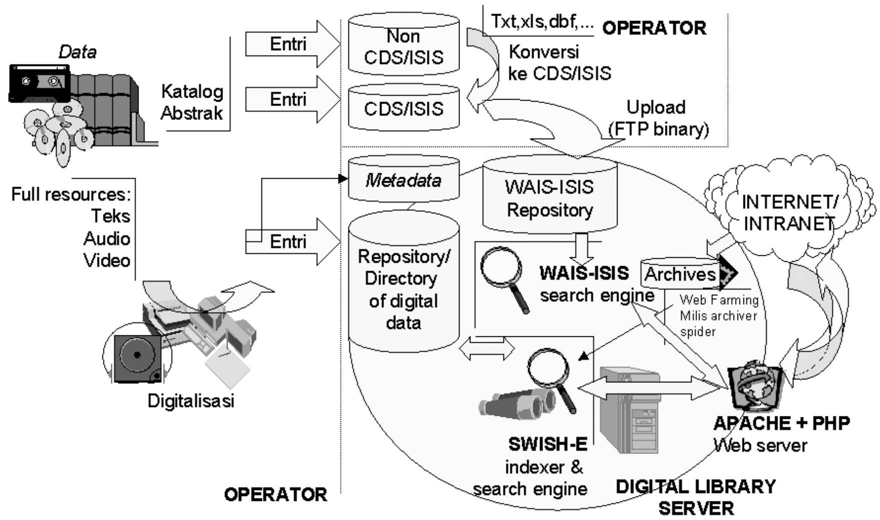

図 **3.10**　Process Element in Digital Libraray

tal library contents. Hundreds of members from Internet have been registered (freely). Our URL is http://digital.lib.itb.ac.id/ and we are preparing the development of the third version of digital library system.

Knowledge Networking Project is a new project of KMRG ITB that its main aim is to develop a knowledge networking system for research and academic institutions in Indonesia. This system will consist of tool (free software), rule, documentation, and agency that will be implemented at every institution joining the network. The tasks of the system are to capture the institutions knowledge and provide access for individual to access the knowledge base.

There are three sub systems that will be developed, namely Sub system for managing the explicit knowledge, Sub system for managing the tacit knowledge and Sub system for managing the network between the knowledge management system's servers.

Objective of Knowledge Networking Project are as follows.

1. To capture the explicit knowledge of institutions in the form of theses, dissertations, research reports, proceeding, articles, journal, etc into digital format and stored in the servers' knowledge base
2. To capture the tacit knowledge of institutions from mailing list and discussion group using a new tools of knowledge construction that will be developed within this project
3. To enable access to the knowledge base for every individual from Internet
4. To develop a knowledge network between the institutions
5. To enable knowledge sharing within institutions and among them

We report the current status of this project. A project proposal has been submitted to PANASIA IDRC at Singapore. The decision of selection will be announced in May, 2000. A collaboration to develop the system has been initiated, with these institutions: YLTI, PDII LIPI, University of Brawijaya Malang, University of Muhammadiyah Malang, Post Graduate Program of ITB, Eastern Indonesia Development Project. The partners are ready to self finance the project with or without grant from other institutions (e.g. PANASIA).

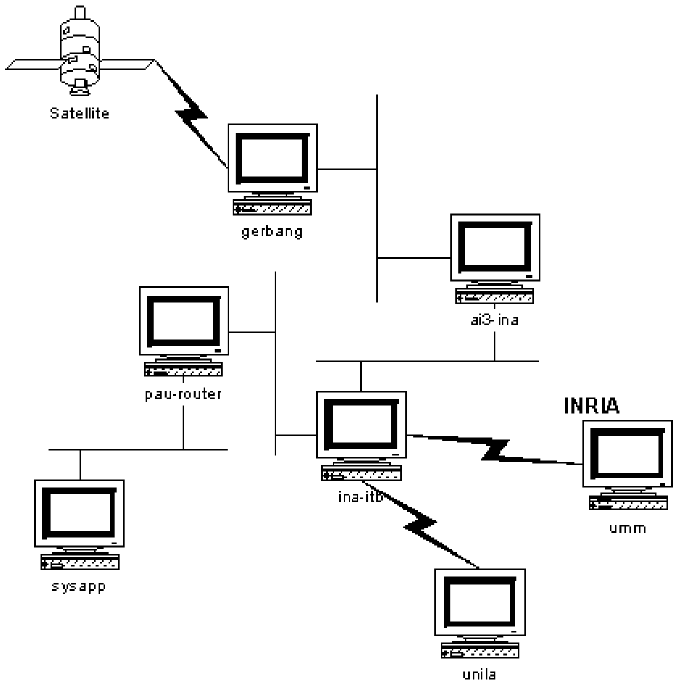

図 **3.11** IPv6 Network around ITB

3.9 IPv6 Network in AI^3 Indonesia

Currently, ITB's IPv6 Network (see Figure 3.11) has connected to couple of universities (Universitas Lampung or UNILA and Universitas Muhammadiyah Malang or UMM) as ITB's partner on the AI^3 network. Those two universities, which is directly connected to ITB IPv6 Network through terrestrial link, also has implemented IPv6 network on their own campus network. Our IPv6 Network is running on top of various platform. Previously, we are running it on top FreeBSD 2.2.8 and FreeBSD 3.2 using KAME IPv6 stack, but now we are gradually upgrading the OS on some main routers to FreeBSD 4.0, which has built in IPv6 stack, imported from KAME.

The current IPv6 address prefix assignment at AS4796 network is 5F12:BC00:A7CD:xxxx::/64 (with xxxx are the last 16 bit of the IPv4 Network address). The routing protocol currently deployed is RIPng. The last statistics shows that IPv6 host population on the ITB's (including partners main routers) is about 10 IPv6 routers and 11 IPv6 hosts.

For future direction, as a direct result of New ITB Gigabit Network, we will migrate all of the legacy network (large number of PC routers running FreeBSD or LINUX) that has interconnected many departments across ITB to dual stack router running IPv6 and IPv4. By migrating all the legacy network, we will have two separate network. One is the production network running only IPv4 on top of high performance routers and the other one is a one big research network (which is also deployed as backup networks) running IPv6 and IPv4. This necessary action will have a direct effect on increasing the IPv6 host population across ITB and its neighborhood, encourage students to install IPv6 stack on their computer, and open many future collaboration with WIDE-6Bone network.

3.10 New ITB Gigabit Network in AI^3 Indonesia

To fulfill the increasing bandwidth requirement at ITB. ITB has decided to implement a whole new Gigabit Ethernet Network across ITB. The

図 **3.12** Weather Station in ITB campus

architecture of Gigabit Ethernet network itself is deploying the latest campus networking technology. We are using 1000BaseLX, on top of single mode fiber, for the backbone and Layer 3 switches with built in with feature rich QoS capabilities (including Diffserv).

The network itself is designed with plentiful of physical resource (such as fiber optic cables) and bandwidth which can be used in the future for testbed of a new networking and application technology and open many future collaboration (including research) with partners such as on QoS network, QoS over satellite link, VoIP, and so on.

3.11 Weather Monitoring in AI^3 Indonesia

The objectives of this research are to understand the correlation and impact of rain to the Ku-band link, especially in a tropical country like Indonesia, to monitor the effect on IP network reachability, and gather necessary data for taking action to overcome the problem.

To accomplish those objectives, we get real time data provided by weather stations in ITB campus shown in Figure 3.12. We also monitor data from satellite indoor unit and network interface status of router. The data from weather station are temperature, relative humidity (%), pressure (mm/Hg), wind speed (km/h) and direction (0-360 degrees), and rain data (mm/hr) from satellite indoor unit are signal quality and modem handshake data; and data from router are interface status (up/down) and error rate. These data are then compared to get the result. Parallel to that data collection and analysis, we also modify Riscom/N2 card interface in order to allow the satellite link disruption without setting the interface to down status.

The research is currently underway and we expect to have substantial data by early 2000 since El Nino, which causes lengthy dry season, has influenced Indonesia. For example, in September 1999, there are only two rainy days in Bandung. Attenuation due to rain, which starts to be important at ITB's Ku-band station, because the satellite connection is the primary link to the Internet. In October 1999 almost everyday in Bandung rain drops and almost on every heavy rain, the satellite connection was down for several minutes.

For example, on 19th October 1999, there was

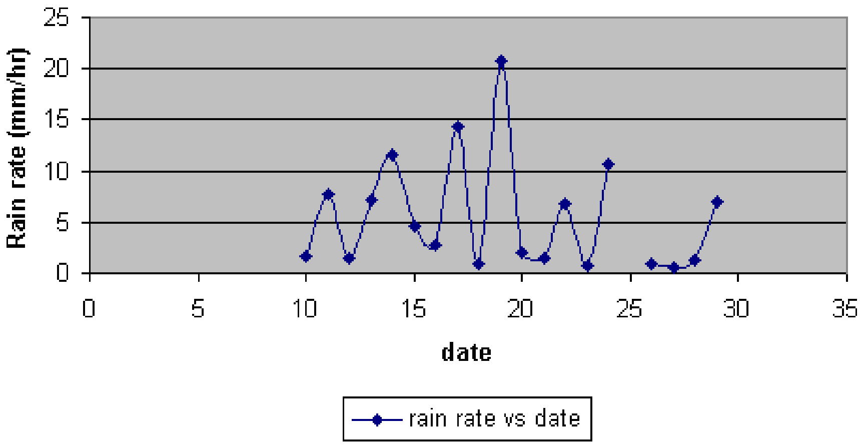

図 **3.13** Data vs Rain Rate on October 1999

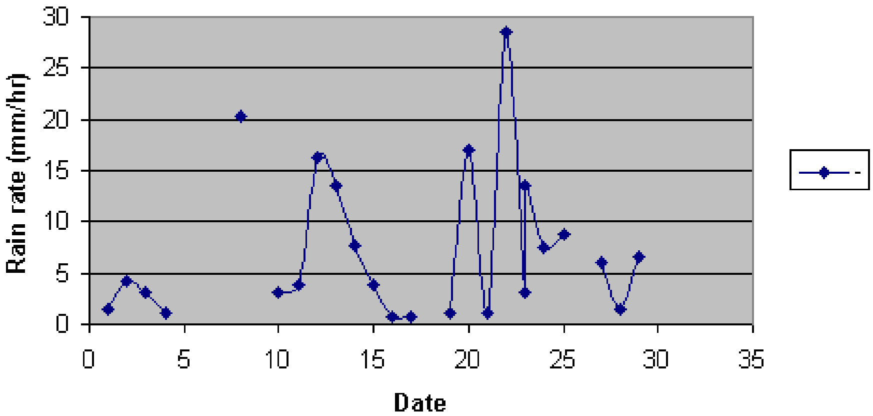

図 **3.14** Data vs Rain Rate on November 1999

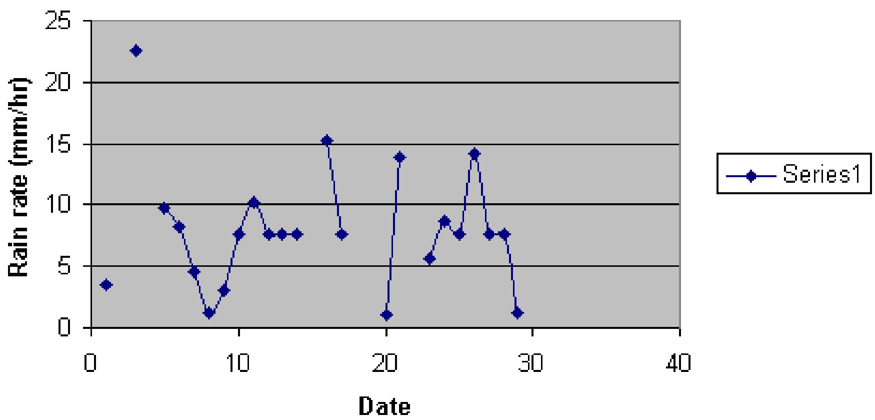

図 **3.15** Data vs Rain Rate on December 1999

表 3.2 Rain Rate and Rain Attenuation

	Rain Rate [mm/hr]	Rain Attenuation [db/km]
19th October 1999	20.828	0.8246
23rd November 1999	28.448	1.1794
3rd December 1999	22.58	0.9047

a heavy rain with rain rate 20,828 mm/hr for 75 minutes shown in Figure 3.13. The calculation for rain attenuation is $\gamma_r = KR^a$, γ_r = rain attenuation (db/km), R = Rain rate (mm/hr), and α = 1.41 x $f^{0.0779}$. If the frequency is 14,07750 GHz, then K = (4.21 x 10^{-5}) x $14,07750^{2.42}$ = 2.53 x 10^{-2}. We calculated α, α = 1.41 x $14,07750^{0.0779}$ = 1,1475. The rain attenuation (γ_r) is = KR^a = 2.53 x 10^{-2} x $(20.828)^{1,1475}$ = 0.82465 db/km. In addition to this result, We show three data in Table 3 based on our observational results in November and December, 1999 as shown in Figure 3.14 and 3.15.

The duration between start rain and finish the rain average more than 60 minutes. We don't have any exact data how many kilometers raindrop to the earth.

When rain drops, In our Ku-band station there was a phenomena, the connection to satellite was down (lost sync) for several minutes (about 5 to 10 minutes) and up again (sync) although the rain still comes. Eb/No for our IDU ground station is > 10 dB after synch between satellite and Ku-band ground station happened. Theoretically, there will be no connection between ground station and satellite because rain still drop around ground station but there was a connection between ground station and Ku-band station (when rain dropped, the connection was lost and synch again after several minutes later.

When synchronization to satellite was lost (no sync cause rain) , the Internet connection was also lost. In our routers (gerbang.itb.ac.id) we used pc as a router and from IDU modems to routers connect via serial port card Riscom N/2 card (RS-449). The Console will show messages in terminal while the connection to satellite was down (rain or etc) and interface to serial down too. If the connection to satellite down then the all traffic to Internet from and to ITB's network were down too. In our gateway (router), we used BGP-4 protocol. If the connection to satellite was lost, and then routing to Internet changes automatically to our back-up link (128kbps) to Indonesian Telecommunication company (PT Telkom). If the connection to Internet was up again in several minutes later, then routing changes again to main link to Internet.

In conclusion, the propagation on Ku-band have a critical point to Internet from ITB's network. Our experiences show that Ku-band can be used in tropical country like Indonesia where we have rainy season and heavy raindrop. When heavy rain comes, the connection from Ku-band ground station to Internet was down and after several minutes later (5 to 10 minutes), the connection between Ku-band and satellite was up again although the heavy rain is still comes. We continue to make further study on characteristics of propagation on Ku-band with actual data captured from IDU. We also plan to make clear behavior of BGP route propagation over Ku-band under rain degradation in order to evaluate the usage of Ku-band as Internet backbone.

第 4 章 Conclusion

We have been running AI^3 project for these three years. During this period, many international collaborations have been produced and our testbed has been used for the purposes of experiments in the process of technology development and deployment.

Many AI^3 C-band parnters have joined us in this joint research project involving their domestic research partners. Each C-band earth station in Singapore, Malaysia and Philippine has been constructed and the station in Vietnam is now under construction. These new partners have presented various research proposals to be achieved in our testbed network and they will accomplish their research goals in cooperation with AI^3 Ku-band parnters, while taking the lead in Internet research areas with each domestic research community.

Although our satellite links have much less bandwidth than modern terrestrial Internet links, we confirmed worth of our testbed network based on satellite links through our experiments. For application technology development, our project enables researchers to develop advanced Web caching mechanism and to achieve the international telemedicine experiment. For Internet development, AI^3 project verified feasibility of the use of Ku-band satellite links in tropical region in Asia. This result accelerated satellite operators to provide Ku-band transponders which covers Asian countries.

AI^3 project also has helped sustainable development of human resources. We can find a notable case study from our experiences in Indonesia. Because AI^3 network testbed has survived even in economics crisis in Indonesia, ITB has been taking a leading part in this human resource development in Indonesia. What ITB is using for this purpose is many mailing lists. Now the number of mail delivery on their server has grown to send more than 70,000 mails every day to Internet community in the country. As reported in the former chapters, many research results are being produced in Indonesia conducted by ITB with our testbed network.

AI^3 project is expected in the other Asian countries such as Vietnam to accelerate their research and development activities focused on Internet technologies. When the first AI^3 meeting in Vietnam was held in October 1999 inviting many research institutions in Vietnam, the Voice Of Vietnam (VOV), the official radio of the government of Vietnam immediately broadcasted a report on our project. 80% of Vietnamese polulation usually listens the VOV. Several major newspapers similarly covered the news about the project. In particular the news has been covered with a large space by a VN news publisher which is very popular with young VN people.

As stated above, our project is putting together researchers from many different Asian countries to work together and to achieve common objectives. Through this process, the Internet research culture has propagated with sharing and openness through out testbed network. AI^3's impact has certainly increased both in term of circles and depth over these times in Asia, involving more Internet researchers and developers.

AI^3 project has provided our efforts to make international collaboration since its beginning in conjunction with WIDE project. As a part of APII testbed and also as a part of APAN, our testbed is continuously expected to work as a network infrastructure interconnecting among the Asian countries for academic and research purposes.

第 5 章　Future Works

At the end of this report, we summarize our future works in AI^3 project.

5.1 AI^3 Operation

SFC will soon establish satellite links with Vietnam and Sri Lanka, so there would be five partners connected to SFC. Besides the new satellite links, AI^3 SFC will have a connection to WIDE at Fujisawa NOC using ethernet link and also to APAN using ATM link. On these links, AI^3 will establish EBGP sessions so AI^3 will have better connectivity to these organizations. As the AI^3 SFC network is getting more links, SFC will install a server to monitor the AI^3 SFC NOC net-

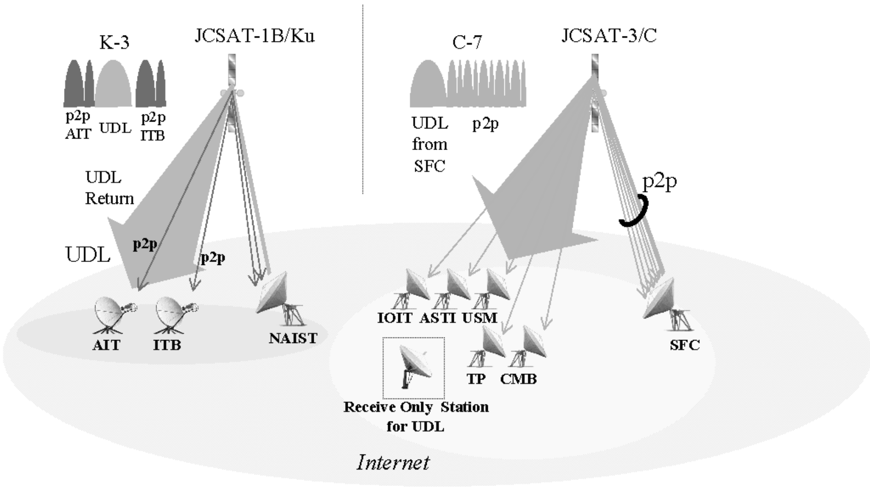

図 5.1 Future AI^3 Testbed Network with UDL Experiment

work operation.

As many research institutes have been enrolled as AI^3 partners, it is important for our testbed network to provide communication channels to make it easy to work together. Although our regular meetings are held two times every year, they are not enough number of times. At the last meeting, we have come to an agreement to use MCS for AI^3 suggested by USM team. MCS is a software for a full-fledged versatile multipoint video conferencing system and it can transmit and receive audio and video in real-time and in full motion. We have successfully tested MCS between AIT and USM in full motion. We are also interested in IP telephony over satellite like Aplio Phone. We succeeded to test it between SFC and AIT. These products are expected to facilitate upcoming tighter collaborations among us as well as with WIDE project.

5.2 Unidirectional Link

Although all the satellite links in our testbed network are currently configured as bi-directional, we are planning to add some unidirectional links in our testbed. Figure 5.1 shows the testbed network with unidirectional link experiment.

With those links we start to work research on integration between point-to-point and point-to-multi point satellite links to function well as satellite based network infrastructure. For instance, we are going to develop a new routing mechanism working with unidirectional link routing[185]. This link integration technique is useful to control satellite link bandwidth in response to temporal increases of one way traffic. Also it can be shared among multiple sites to receive Internet application traffic such as Web cache injection and replications, content mirroring and etc. Developments of core technologies to enable us to configure this kind of unidirectional link is undertaken. With bandwidth available in our C-band channels, we are going to conduct experiments of this unidirectional link technologies with our partners in 2000.

The other research goal related to this unidirectional link is to develop applications for receive only site. In some areas in Asia, there is still no communication infrastructure including stable telephone lines, but there is heavy demand to feed up-to-date information for people living in such area, especially for education purposes. Making “receive-only” satellite earth station is inexpensive and normally not required to obtain appropriate license from authorities. With this kind of “receive-only” terminals, we are going to make on-demand data feed mechanism on the unidirectional links.

For example, we are planning to build a good infratsructure to deliver contents using unidirectional link to remote areas. This challenge is to provide courseware for distant education and also to reach out more countries and regions in Asia with content dissemination by our advanced technology. The contents are web-based video on demand stuff. Those courseware will be delivered to the widest possible audience including those in remote areas where terrestrial connection may not even be available. At remote sites, sizeable Web and VDO servers will be equipped for local course dissemination as well as receiving only station. During the process of content replication, courseware will be scheduled to be pushed and also will be cached in remote places using enhanced IP multicast. For instance, FEC (Forwarded Error Correction) mechanism is considered as enhancement we can implement to multicast. In addition to FEC technique of satellite communications at the link layer, multicasting with FEC is an efficient and yet more reliable contents replication with one way traffic.

5.3 AI^3 Cache Bone

The following research topics have been planned.

1. Reliability
   A model to improve reliability of Hub-Rim Cache system is planned to be considered. In order to increase redundancies at the Rim end, with two cache servers Rim Cache will run in pararell.
2. Hierarchical and Distributed Cache Bone Architecture
   An integrated model for the Cache Bone to enhance efficiency and reliability is under consideration.
3. Contents
   Co-operations among proxies based on contents is considered as extension of the ideas designed for HINT server system[182].
4. Multicast+UDL+PUSH
   Continuation of existing research is scheduled to implement more efficient cache delivery mechanism on unidirectional satellite links by means of functions based on IP multicasting and intelligent pushing.

5.4 AI^3 Multicast Backbone

Satellite based information infrastructure has the advantage of capability of simultaneous information delivery to widespread areas with ease. It enables us to use IP multicast in simple way differently from terrestrial networks where Mbone path is complex in geneal. AI^3 Multicast backbone is planned to be implemented over unidirectional links in the testbed network with capability of reliable transport. The topology planned for this backbone are shown in Figure 5.2. In this figure, NAIST and SFC perform a part of feeder, because the capability to transmit signals is enough powerful. The other partner sites function as receivers. MR means a multicast router and each arrow shows the flow of IP multicast packets.

AI^3 Multicast backbone over unidirectional links is helpful to reduce the consumption of bandwidth on one way over the satellite links. In this case a policy routing mechanism should be introduced at the satellite gateways to switch the route between bidirectional and unidirectional links. World Wide Web Consortium (W3C) has contacted AI^3 project to mirror their content through our testbed network and Multicast backbone is useful for such replication purposes. As well as IPv6 multicasting, we study on new technologies to construct Multicast backbone in efficient way convering Asia region.

5.5 6bone-AI^3

IPv6 is a key technologies for the Internet next generation. In the AI^3 network testbed, 6bone-AI^3 is in operation and it is connected with 6bone.

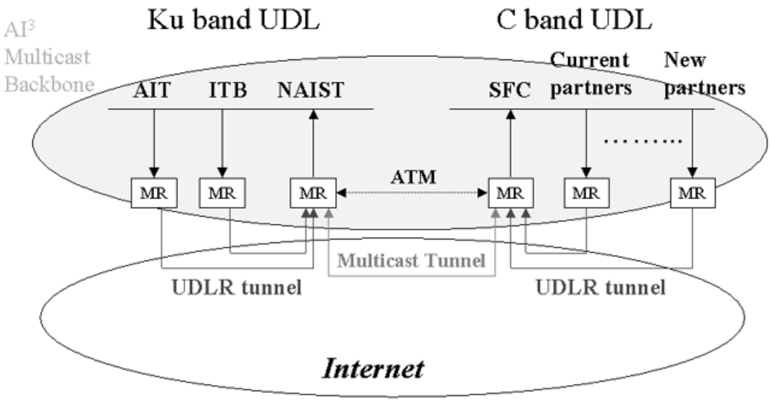

図 5.2 Future AI^3 Multicast Backbone

We focus on IPv6 research issues on wireless networks such as study on IPsec function that is standardized in IPv6 specification for an encryption method in IP layer. Furthermore we gradually expand IPv6 experimental networks to the Asian countries through our testbed.

Details are described at the other part of IPv6 in this WIDE annual research report.

5.6 Distant Education and Learning in Asia

Research and development on distant learning have become active in Asia[186, 187].

As one of our applications, AI^3 started to make its own courseware in which people can learn technologies implemented in AI^3 testbed network. This application is aiming to provide technology transfer path for other researchers and engineers in Asia, hence, we are expecting to help sustainable human resource development in this region. Our members in Keio University and AIT are working hard to provide first edition of our courseware in 2000 and several lectures have been recorded in NAIST and AIT along with its course design.

As well as above, AI^3 partners have developed their own courseware and applications, namely JavaDCourse implemented in AI^3 Indonesia, Java based tele-manufacturing system produced by Temasek Polytechnic in Singapore, Digital Course developed by Institute of Rice Research Institute in Philippine and etc. We exchange each experiences and feedback to each system, encouraging and promoting their products in Asia.

Details for AI^3 School of Internet are described at the other part of School of Internet in this WIDE annual research report.