第XVII部

Asian Internet Interconnection Initiatives

第17部
Asian Internet Interconnection Initiatives

第1章 Introduction

Satellite links have wide area coverage and are used for international backbone links. Asian Internet Interconnection Initiatives (AI^3) project is one of the most operational satellite based R&D network in Southeast Asia. AI^3 project has started since 1995, and goes on with the deployment of the testbed network called AI^3 network since 1996[12]. AI^3 project has provided our efforts to make international collaboration since its beginning. As a part of APII testbed and also as a part of APAN[28, 87], our testbed network has been continuously working as a network infrastructure interconnecting among the Asian countries for academic and research purposes. APII project is leaded by CRL. CRL and WIDE project is cooperatively accelerating research and development activity for the next generation Internet technology in the Asian region.

Figure 1.1 shows the current AI^3 network topology. The dotted lines means that those links are not connected as of April 2002; i.e. The earth station in Sri Lanka is under financing, while the earth station in Hong Kong is in failure. As shown in this figure, AI^3 Network consists of the two satellite circuit. One is Ku band network, and the other is C band network. In Ku band network, NAIST in Japan takes role of the hub connecting with Institut Teknologi Bandung (ITB) in Indonesia, Hong Kong University of Science and Technology (HKUST) in Hong Kong and Asian Institute of Technology (AIT) in Thailand. In C band network, SFC, Keio University (Keio) in Japan also plays the role of the hub which is connected with Temasek Polytechnic (TP) in Singapore, Universiti Sains Malaysia (USM) in Malaysia, Advanced Science and Technology Institute (ASTI) in the Philippines, Institute of Information Technology (IOIT) in Vietnam and Institute of Computer Technology (ICT) under University of Colombo in Sri Lanka.

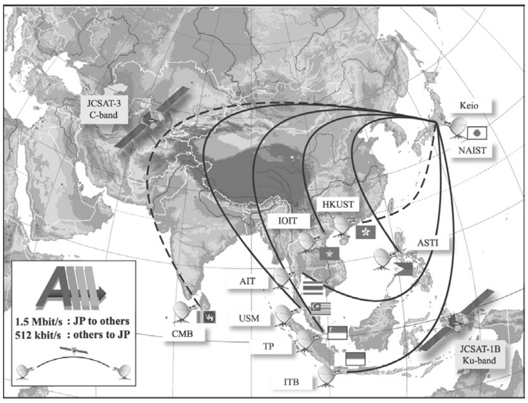

Fig. 1.1. AI^3 Network Topology as of April 2002

In this report, we describe our approach about IP multicast over satellite. IP multicast is the important technology for the future Internet. Broadcast capability of the satellite link is suitable for the IP multicast application. However, the satellite broadcast link is Uni Directional Link (UDL). They are not widely used for IP multicast, which routing protocol design is based on the bidirectional link. Uni Directional Link Routing (UDLR) technology is one of the solutions to provide multicast routing for Uni Directional satellite link. The UDLR technology can use satellite links as the Internet infrastructure. We discuss the way to provide wide area IP multicast using UDLR technology, and describes its evaluation on AI^3 project, and also describe the actual application on AI^3 multicast network, such as web cache distribution and distance learning.

In addition to the topics on IP multicast over satellite, this report includes the progress report about the software development for the purpose of AI^3 network monitoring, some site updates in the

Asian countries such as Singapore and the Philippines. Furthermore, this report also includes AI^3 related APII testbed project report presented at APEC-TEL 25th meeting for reference.

第 2 章　Multicast over Satellite

2.1 Problems related to the UDL

Satellite link is basically Uni directional link (UDL). Through UDL, the datagram sent by the Feed (sender for UDL) is received by the Receiver (receiver of UDL). However, the Receiver cannot send any datagram to the Feed via the UDL. At the Receiver node, datagram sent to the receive-only interface's link layer would be discarded. At the Feed, the send-only interface's link layer does not receive any datagram, even if another Feed on the UDL sends the datagram to the UDL.

For the multicast packet forwarding, RPF (Reverse Path Forwarding) algorithm and IGMP (Internet Group Management Protocol) is used. IGMP is used to reduce the unnecessary packet forwarding to leaf networks. The multicast routers know the presence of multicast member nodes. If there is no multicast member on the leaf network, multicast router does not forward any multicast packet to the leaf network. In Figure 2.1, the receive node (R) is on the leaf network. The multicast router (MR) controls the multicast membership and if R is not the member of multicast group, MR does not forward the multicast packet to R. RPF is used to avoid duplicate packet forwarding. In Figure 2.1, from the multicast router (MR) to source node of the multicast (S), Router A on the shortest path while Router A′ is not on the shortest path. Based on the RPF algorithm, MR does not forward any multicast packet from Router A′ to receive node of the multicast (R).

IGMP and RPF do not work on the UDL correctly.

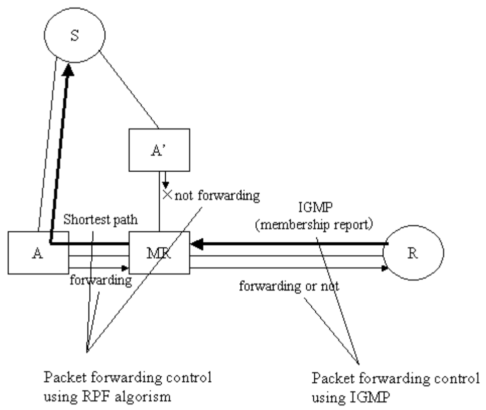

Fig. 2.1. RPF and IGMP for Multicast

1. Problem on IGMP
   In Figure 2.1, if the MR and R are connected to UDL and MR is the feed of UDL, IGMP membership report packet from R cannot reach MR via reverse direction of UDL and MR cannot know the presence of R. As a result, MR does not forward any multicast packet to R, because MR has no multicast member on the UDL.
2. Problem on RFP
   In Figure 2.1, if the A and MR are connected to UDL, A is the feed of UDL. A and MR cannot exchange the routing information packet via UDL. A cannot know the presence of MR, MR → A′ → S the shortest path from MR to S. As a result, the multicast packets from S sent from A to MR via UDL are discarded by the RFP rule, because A is not on the shortest path any more.

2.2 UDLR solution

To solve this problem, the LLTM (Link Layer Tunneling Mechanism) is introduced. This mechanism emulates bidirectional connectivity[73]. The new and thin layer is added in the datalink in order to emulate bidirectional links using IP tunnels. LLTM enables Feed and Receivers connected to an UDL to send datagrams as if they were all connected to a bidirectional link. The tunneling mechanism should be implemented in the link

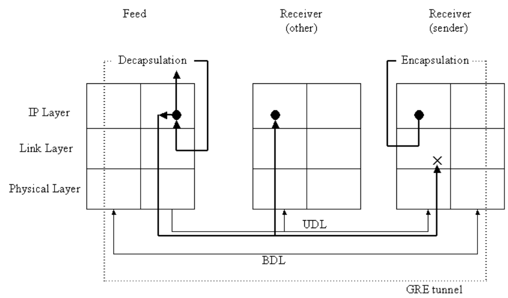

Fig. 2.2. Example of LLTM

layer of each node connected to the UDL. The implementation aims to conceal the unidirectional nature of the link from upper layers, the network layer and above. With this tunneling mechanism, all nodes are required to have another interface to an IP interconnected infrastructure with bidirectional IP connectivity.

For example, Receiver wants to send the packet via UDL. This packet is not sent to the UDL interface, this packet is encapsulated and sent to the Feed via some other bidirectional network such as global Internet. Feed decapsulates the packet, receives for local use on Feed and forwards to UDL for another receiver (Figure 2.2).

2.3 Installation of Multicast Network on AI^3

The transition plan from unicast only network to multicast capable network must be considered carefully, because many users do not want any degradation of the current unicast based services.

If we can share the existing link for both of unicast and multicast traffic and we can use the existing routers, we don't need additional equipments. However, it may cause degradation of the current unicast services. Multicast traffic may occupy large part of communication bandwidth and multicast routing function may have bad influence to unicast routing function. Therefore, in the operational network, this method is not appropriate.

To minimize influence to the existing unicast infrastructure, a new multicast network should be built. In this case, it is necessary to use multicast routers. At the beginning MBONE, the first worldwide area multicast network, DVMRP tunnels were used to interconnect the unicast networks. Multicast routers were operated independently with limited communication bandwidth, and unicast and multicast traffic shared the communication link.

AI^3 project considers the existing unicast communication infrastructure as important because these links are fully used for transit to Internet. So the approach is not to disturb the unicast equipment and bandwidth. Therefore, we decided to add the new UDL satellite links and the new multicast routers are prepared for our multicast service. This scheme does not affect the existing unicast infrastructure of AI^3 network in terms of communication bandwidth and routing. Figure 2.3 shows the overview of AI^3 UDL networks.

In our current installation, the C band UDL link has 6.4 MHz bandwidth, the modulation is QPSK, the FEC is combination of Viterbi (3/4) and Reed-Solomon (188/204) and the information rate is 6.6 Mbps. This means we installed 6.6 Mbps multicast link in Southeast Asia area. A 3.0 m receive only antenna is sufficient in most area. We can expand the UDL capacity by using additional satellite bandwidth. JCSAT-3 has twelve C band transponders. Each transponder has 36 MHz bandwidth. If we use the same modulation and FEC, one transponder has 37.1 Mbps capacity. JCSAT-3 satellite has the capability up to 445.2 Mbps in C band. The Ku band UDL link has 2.0 MHz bandwidth, the modulation is QPSK and the FEC is Viterbi (3/4) and the information rate is 2.048 Mbps. JCSAT-1B has thirty-two Ku band transponder, sixteen 36 MHz transponders and sixteen 27 MHz transponders. The total bandwidth of JCSAT-1B is 1 GHz and this satellite has the capability about 1 Gbps.

2.4 Multicast Routing on the AI^3

Actual multicast traffic flows from HUB station in Japan to RIM station in each country (Figure 2.4). Satellite multicast routers are installed in HUB station and RIM stations. AI^3 network

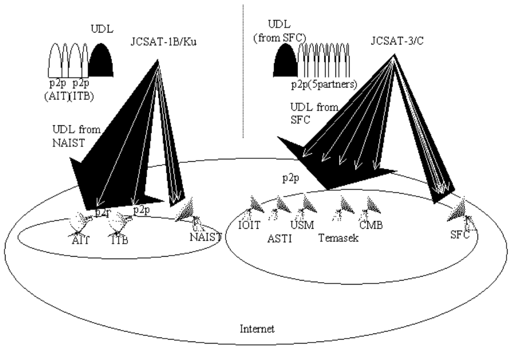

Fig. 2.3. Overview of AI^3 UDL Network

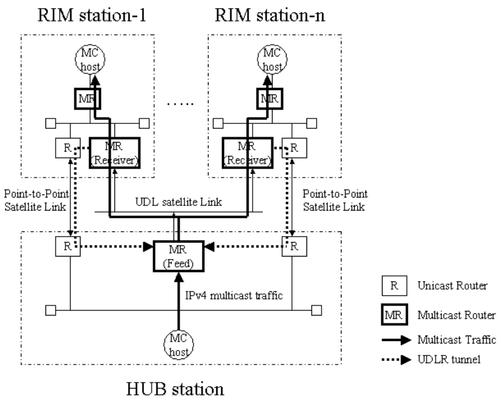

Fig. 2.4. Multicast Routing on the AI^3

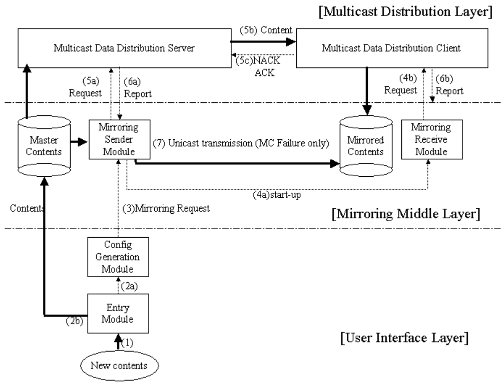

Fig. 2.5. Design of Content Mirroring Software

exchanges the route information with several sites belonging to the other Autonomous Systems (AS), however our UDL multicast network does not care about AS, so we use DVMRP as routing protocol. This multicast network is independent from the other multicast networks in the world. As shown in Figure 2.4, the IP multicast traffic from HUB station to RIM stations goes though UDL, and from RIM station to HUB station goes through UDLR tunnel on the point-to-point satellite link.

2.5 Web cache and Web mirroring

International telecommunication cost for Asian countries is very expensive and Web is the most popular application of the Internet. Therefore, if the frequently accessed Web contents are cached or mirrored to server in domestic, usage of international link will be reduced. The cost of server and mass storage is relatively cheaper than the cost of international telecommunication, so the demand to such information cache and/or mirroring is high. Moreover, since this information is made to be accessed in many cases in other countries, the information distribution to cache server or mirror server in each country by using multicast is effective. This is a strong candidate of content and application using multicast in intra Asia. Figure 2.5 shows the design of our content mirroring software which has 3 logical layers. The multicast distribution layer handles contents distribution using multicast including NACK (Negative Acknowledgment) based retransmission. The mirroring middle layer is responsible for the reliable contents distribution. This layer uses multicast distribution layer and traditional unicast transmission properly. The user interface layer provides a good user interface to upload the contents and designation of mirroring servers.

2.6 Distance Learing

The digital divide is one of international big themes. We have to perform not only the maintenance of the infrastructure or computers, but also the education to operators and users. When performing an educational program, face to face conventional classroom in the intra Asia is difficult because of geographical restriction. Distance learning using Internet is one of the solutions. We can deploy two forms of remote education. One is a real time lecture, where all members participate simultaneously and have an interactive communications. The other is an on demand lecture, which takes a lecture on the lesson accumulated individually for every participant. In real time lecture, the image and voice of the teacher are captured, encoded and delivered to all participants, also the teaching materials are digitized and sent to participants. This is a classroom type, the one to many communication in which a teacher is present before the participants, and multicast technology can be adapted to effectively use the telecommunication bandwidth. In on demand lecture, a participant accesses the archived lectures. In this case, it is not desirable to have only one archive server because of the scalability issue. If all users of each country connect to this server, the traffic would congest the international link and also server's performance would be degraded. An archive server is installed in each country to avoid that problem. These servers are synchronized so every server has the complete, up to date archived contents. Users of each country can take lectures by accessing a local server. Using multicast for the lesson data distribution will use the bandwidth effectively. As mentioned above, in intra Asia, there is the demand for information sharing called distance learning, Web cache and/or mirroring. Since it is a one to many information distribution, multicast is useful from the viewpoint of efficiency use of a bandwidth. The communication cost of intra Asia is much higher than such cost in HDD or CPU processing capability. It leads to a conclusion that building a multicasting infrastructure in this area is very meaningful.

Figure 2.6 shows the overview of distance learning network on AI^3. Master contents servers are located in HUB station and mirrored contents servers are located in RIM station. They are synchronized using mirroring software described in the previous section. The contents on the contents server are shared with the distance education servers. One of distance education server works as the web server which provides document or slide base materials to users and the other works as the streaming server for video and audio based materials.

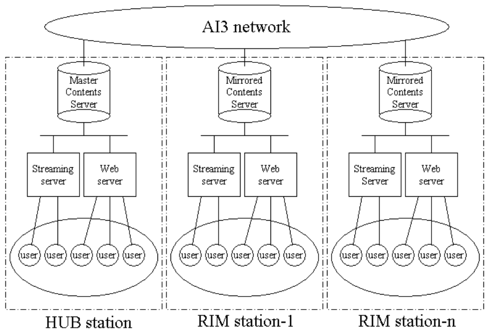

Fig. 2.6. Distance Learning on AI^3

第3章 Monitoring Software Development

The software for monitoring Comstream modem has been updated to include graphics generated by RRDtools (http://people.ee.ethz.ch/~oetiker/webtools/rrdtool/).

The general architecture of the software remains the same, that is derived into three subsystems: acquisition, archiving and viewing. The main idea is to provide long time storage of the data collected, through a database, where archives can be kept indefinitely for later usage.

The acquisition subsystem is independent from the archiving, it is generaly run on the machine where the data are generated, or close to the system that is monitored, this avoids problem of network unavailability. Data are then stored locally and dumped to the database whenever the access to the database is granted.

Last module will collect the data from the database to populate an RRDtool database which is used to produce graphics.

In this new version, signal/noise ratio data and AGC data have been enhanced to include IP error as detected by the satellite router, whenever on IP packet is received with an error, a red impulse is marking the time of the error.

This version also display a graph of received IP

Fig. 3.1. AI3 C band Receiving-Only and bidirectional antenna at AIT, Thailand

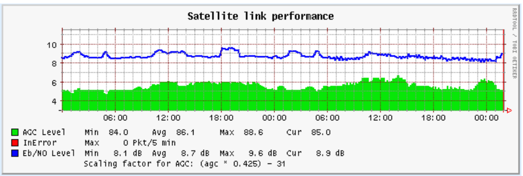

Fig. 3.2. AI3 C band UDL Monitoring "Satellite Link Performance" on April 25, 2002

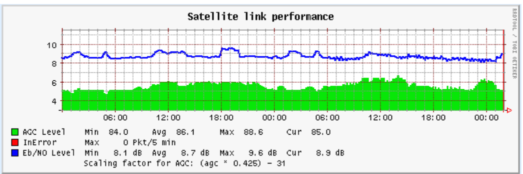

Fig. 3.3. AI3 C band UDL Monitoring "Data Received" on April 25, 2002

bytes and received IP packets. Only the received data are included, as the monitoring cannot be done on the sent data, that are hopefully error free.

Graph of the data for the Ku band station can be found at the following URL.
http://www.cs.ait.ac.th/ai3/reports/netmon/

This software has been ported to monitor the quality of the C band receiving only station shown in the Figure 3.3. The front side antenna in this picture is the C band receiving only station at AIT, Thailand, and the back side with the sticky logo painting on the face of the antenna is used for the Ku band bidirectional link.

The sample of the monitoring results are also shown in Figure 3.3. Data are collected from the Sony receiver though a telnet connection, and can be viewed at the following URL.
http://www.cs.ait.ac.th/ai3/reports/netmon_udlr/

Since the C band monitoring software has been installed, it helped detecting a fault on the antenna assembly at AIT, where the LNB receiver got out of focus for purely mechanical reasons (http://www.cs.ait.ac.th/ai3/reports/Apr-2002/).

C band monitoring software need to be rewritten to include a better data collection. Signal/noise ratio is collected only once every five minutes, that could lead to incorrect measurement, for example if the link becomes unavailable between two measures, this would go unnoticed. Rewriting the data collection will make measurement at a more frequent rate (about a second) and average of the data will be populated to the database.

第 4 章　Site reports

4.1 Singapore Site Report

4.1.1 AI3 project research at Temasek Polytechnic

The Satellite-Internet Competency Unit (SICU) was established on 1 Oct 97 and it is a joint collaborative effort between Temasek Polytechnic, National University of Singapore (Centre for Internet Research) and Nanyang Technological University (Network Technology Research Centre). The SICU is funded by National Science and Technology Board (NSTB) and manages a Satellite-Internet network that is linked to the Asian Internet Interconnection Initiatives, as well as Asia Pacific Advanced Network (APAN) as shown in Figure 4.1.1 and 4.1.1. The SICU is based in the Temasek Engineering School, Temasek Polytechnic. Through developing a Satellite Internet Competency Unit and active participation in the AI3

Fig. 4.1. The 6m dish at SG connecting Singapore to the AI^3 Network

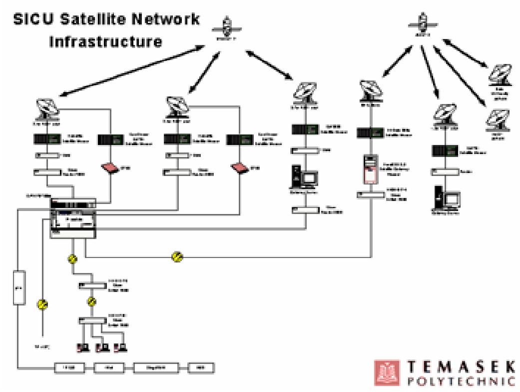

Fig. 4.2. The Current SICU Infrastructure (AI^3 based)

project, Singapore will be able to tap the pulse of development in this expanding technology area to become a regional satellite-networking hub, in preparation for the new emerging technologies in the next century. The Satellite Internet Competency Unit (SICU) uses the AI^3 satellite Infrastructure to work on the various projects related to AI^3 and APAN. The vision of SICU is: To be a center of excellence in satellite-Internet technologies and applications. Research conducted at SICU-TP on AI^3 testbed had resulted in publications in local and regional conferences, symposiums as well as on journals.

4.1.2 IPv6 on JP-SG AI^3 link

SG is active in the IPV6 satellite implementation on the AI^3 link. Currently, we have 2 FreeBSD 4.3 machines running apache web service running dual stack. Next step: setup 6DNS server and Tunneling in IPv4 networks.

4.1.3 Network monitoring on JP-SG AI^3 link

The AI^3-SG Network traffic grapher server using MRTG server was live since since August 2001. It is running on NT4 webserver 202.249.x.x segment. The statistics are posted on www.ai3.net under operations → MRTG maps. SG is now implementing Modem Watchdog developed by SFC.

4.1.4 WebCache on JP-SG AI^3 link

The TP AI^3 Web cache server was setup in early 2001 with help from Mr krit from Asian Institute of Technology (Thailand). Currently it sits on the AI^3 satellite segment 202.249.x.x satellite segment. Recent discussions with various AI^3 partners at the April 2002 Spring meeting, Vietnam, Philippines and NAIST will be working on a joint configuration project to connect the caches together. Testing will start as soon as the Global balancer at SFC is ready.

4.1.5 Education related activities on AI^3-JCSAT3 link

A Video Conferencing Lecture with USM was held on 9 February 2002 (See Figure 4.1.5). Mr John Leong (Head of Satellite Internet Competency Unit, Temasek Polytechnic) gave a video conferencing lecture on Satellite Communications to 100 students and academics from the University of Science, Malaysia in Penang. This lecture is the beginning of a series of lecture between the AI^3 partners to promote the use of the AI^3-JCSAT3 satellite link.

4.1.6 AI^3 Spring 2002 Meeting in Singapore

Temasek Polytechnic hosted the recent AI^3

Fig. 4.3. A Video Conferencing Lecture with USM using AI^3 Network

spring meeting in Singapore. 40 over delegates from partner countries participated in this meeting. They update each other on the various projects and also proposes new collaborations among each other.

4.1.7 Research, operational issues

SG staff will be working closely with SFC/NAIST/KEIO University on the different aspects on the AI^3 projects. Namely, CacheBone, IPv6, Routing, Security. Other activities of interest to SG is SOI involvement.

4.2 Philippines Site Report

4.2.1 Introduction

The AI^3 Project is a Japanese research initiative whose aim is to build a testbed for networking research and experimentation in Asia by providing country partners with free access to a JCSAT-3 satellite transponder, a key part in the AI^3 networking testbed (http://www.ai3.net/).

Research experiments have been and are still being conducted by the AI^3 partners in the areas of IP Version 6 (IPv6) implementation and experimentation, multicast transmission over IP, satellite data traffic analysis, Ku band link testing, video conferencing, satellite video broadcasting and distance learning. Much of the results of these experiments, particularly for satellite video broadcasting, satellite video conferencing and distance learning, are very significant and applicable to the Philippines.

In order for the Philippines to participate and benefit from research in the above-mentioned important areas, ASTI, through this project, has established a Philippine AI^{3*} Phase II node (local AI^3 gateway) through the establishment of an earth station and using the available JCSAT-3

* AI^3 Philippines: http://ai3.asti.dost.gov.ph/

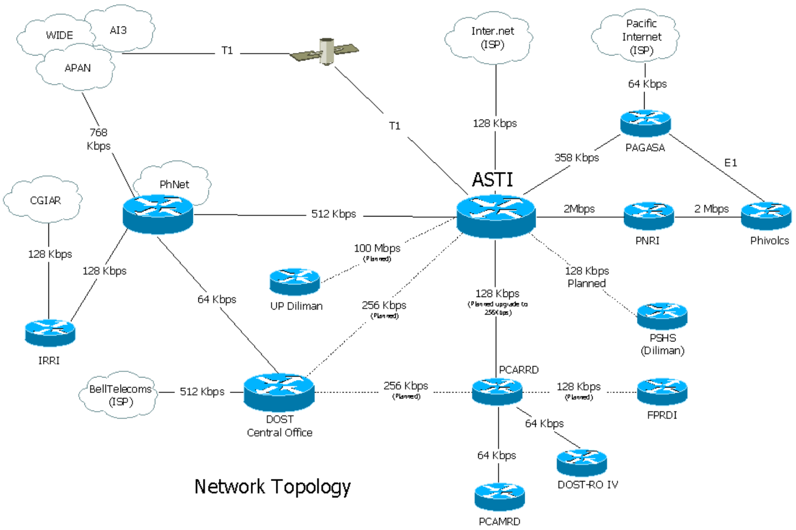

Fig. 4.4. Network Topology in the Philippines around ASTI

transponder to link with the AI^3 network hub in Japan. This earth station is located at the Advanced Science and Technology Institute. All other local participating institutions access this AI^3 gateway using existing as well as planned local links/networks.

4.2.2 Results and Discussion

The Philippines AI^3 earth station was installed in December 1999. The AI^3 satellite link between ASTI in the Philippines and Keio University (Shonan Fujisawa Campus) in Japan was made operational on January 24, 2000. Subsequently, IP (Internet Protocol) connectivity was established on March 3, 2000 with a 1.54 Mbps downlink speed, and 512 kbps uplink speed.

A 512 kbps line connection was similarly established by ASTI to the Asia Pacific Advanced Network (APAN) through the MAFFIN-PHnet link on January 21, 2000.

Figures 1 shows the current topology of the domestic research and education network to which AI^3 is connected.

In terms of experiments over the AI^3 network, the following activities were conducted.

4.2.3 Development and/or Testing of Link Monitoring and Performance Measurement Tools

Tools for network link monitoring as well as for performance measurement are important. A survey of available tools was conducted. Network monitoring tools currently being used by ASTI for monitoring performance of the AI^3 network testbed include MRTG and Weathermap (see http://netmon.asti.dost.gov.ph/).

The project also developed some of its own network monitoring tools. One tool that we developed is used for monitoring the SDM300A satellite modem being used by ASTI in its earth station. Documentation on this tool is at http://ai3.asti.dost.gov.ph/sdm300a/.

4.2.4 Optimization Experiments

Satellite transmission being a high-bandwidth but also high latency medium, experiments were conducted to determine optimum parameters for specific applications. The AI^3 network was used as testbed to verify network simulation test results on some TCP/IP extensions that have been proposed to mitigate effects inherent in a satellite communication channel. Result of this work show improved performance of TCP/IP with these new extensions when used in the hybrid satellite environment.

4.2.5 MBONE Experiments

Connectivity to the MBONE (Multicast BackBONE on the Internet) was established on March 6, 2001 via a multicast connection through a tunnel link with APAN Tokyo Network Operations Center. The link uses PIM-SM (protocol independent multicast sparse mode), MBGP (multicast border gateway protocol), and MSDP (multicast source discovery protocol). Design and implementation of experiments and applications over this multicast connection in cooperation with other AI^3 partners has been ongoing since that date.

Testing, evaluation, and demonstration of multimedia applications are among the activities that have been conducted over this multicast connection.

4.2.6 6BONE Experiments

Connectivity to the 6BONE (IPv6 BackBONE on the Internet) was established on March 20, 2001 via a native IPv6 connection with SFC Keio University through the AI^3 network. Experiments and applications over this network in cooperation with other AI^3 partners have been going on since that date. These activities are reported in the ASTI IPv6 working group website (http://www.ipv6.asti.dost.gov.ph).

4.2.7 Disaster Management System

Activities in this area by local cooperating agencies did not proceed as originally planned. However, activities in this area are still of interest and continue to be pursued. ASTI is actively facilitating the organization of a Disaster Mitigation Working Group involving local government agencies who are interested in applying networking technology and applications for disaster mitigation.

4.2.8 Distance Learning

Since its activation, the AI^3 link has been used to conduct several distance learning sessions/demonstrations. These demonstrations have provided our local network engineers with valuable experience to improve their capability on the use of this technology as well as prove the value of this technology for use in distance learning.

4.2.9 Virtual Library Network

Activities on this have not moved as anticipated. There is need to generate renewed interest in this undertaking from the local user community. However, within the AI^3 project itself, activities on this are ongoing with the Indonesian AI^3 partner Institute of Technology Bandung (ITB) taking the leading role with their open source library applications development work.

4.2.10 Routing Experiments

BGP and MBGP are being used on the AI^3 network. BGP4 routing experiments over the AI^3 network testbed have been conducted and have provided ASTI network operations staff with valuable operational experience on the running of a dynamic routing protocol over such a transmission medium.

In addition to the above activities and experiments, the project team also organized and conducted the Symposium on Developing the Next Generation Internet in the Philippines last April 25, 2001. Speakers during the symposium included experts from the AI^3 project partners.

4.2.11 Conclusion

The support provided by the Department of Science and Technology as well as the Philippine Council for Advanced Science and Technology Research and Development to ASTI has been key to the successful partnership by the Philippines (through ASTI) with the AI^3 Project since September 1999. Through this support, the Philippines is now part of the AI^3 network and this connection allows Philippine research and academic institutions to conduct and participate in research, experimentation, and applications development using this advanced networking testbed.

This partnership with the AI^3 is very active so that while the financial support provided by PCASTRD has concluded, activities and projects using the AI^3 network continues. ASTI is currently implementing the PREGINET† Project which involves the establishment of a national broadband research and education network. PREGINET and AI^3 are interconnected so that PREGINET partners automatically have access to AI^3. With this, the value of the Philippines' partnership with AI^3 continues to increase since more local research and education institutions are able to benefit from it.

第5章 Cooperative works with APII testbed project

In order to refer the cooperative works between AI^3 and APII testbed project, the whole of this chapter is almost quoted from the document, "Evolution and Results of APII Testbed for interconnectivity and interoperability project (1996–2002, Japan) and Proposal of APII IPv6 R&D Testbed Project" approved at APEC-TEL 25th meeting in March 2002 at Hanoi, Vietnam.

5.1 Introduction

Since the APII Testbed project was endorsed in 1997, APII Cooperation Center and APII Technology Center have worked on the official project of the APEC-TEL working groups. Korea, Japan and Singapore have acted their own roles and promoted the Internet technology and research. These projects have been carried out on their own budgets on a self-funded basis. Regarding the operation and the extension of APII Testbed, Korea and Japan are making continuing efforts to develop the network into a world-class Testbed. Its nodes are located in Korea, Japan and Singapore to be connected with other networks. As for APII ' s future connection via these nodes above mentioned with European networks, which was proposed by Korea and well discussed in the ASEM in March 2001, APII-CC (APII Cooperation Center in Korea) and APII-TC (APII Technology Center in Japan) are working toward its realization. As a result, APII Testbed is expected to be equivalent to the United States' (Internet2) or European's (GEANT) as a Next Generation Internet Testbed Network as listed in the Figure 5.1.

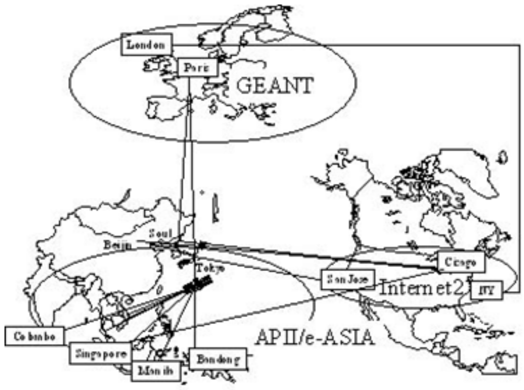

Fig. 5.1. Overview of NGI testbeds in the world at 2001

5.2 Evolution of APII Testbed

5.2.1 Initial Story of APII Testbed project

At the APEC ministerial meeting on telecommunications and information industry, Seoul, in May 1995, Japan proposed six practical experiments including the construction of a research network in the Asia-Pacific region. It was agreed to interconnect the testbed to construct a seamless network in the Asia-Pacific region at the 13th APEC telecommunications working group, Santiago, in March 1996. Korea, Singapore and Japan established relevant working teams at the 14th APEC telecommunications working group, Taipei, in July 1996. In February 1997, the APII Tech-

† PREGINET: http://preginet.asti.dost.gov.ph/

nology Center was established on a premise of the Kansai Advanced Research Center of Communications Research Laboratory, Kobe, Japan. The goal of the APII Test-bed Project was to promote the construction of an efficient information infrastructure which would improve social-economic conditions in the Asia-Pacific region. The APII Test-bed Project had the following five objectives. (a) Facilitating the construction and expansion of an interconnected and interoperable information infrastructure in the region; (b) Encouraging technical cooperation among member economics in the development of the infrastructure; (c) Promoting free and efficient flow of information; (d) Furthering the exchange and development of human resources; (e) Encouraging the creation of policy and regulatory environment favorable to the development of the Asia-Pacific Information Infrastructure.

5.2.2 Progression of APII Testbed

The APII Technology Center, CRL-NGI, MPHPT and some responsible international colleagues have been forming an advanced infrastructure in Asian region, mainly for the network research and experiments as a basic infrastructure of researchers in this region. In 1996, Korea, Singapore and Japan formed bilateral agreement and connected each other by submarine cables building up so-called Layer 2 networks. Since 1999, Japan has expanded this Testbed network to the whole Asia, working cooperatively with WIDE project and AI^3 project. The AI^3 and APII Testbed have established the native IPv6 Testbed environments. Korea is now establishing an Asia-Europe link to form TEIN (Trans Eurasian Information Network) as a gateway of APII Testbed to Europe. As the result, this Testbed is now playing the role of the basic infrastructure not only for Next Generation Internet research.

5.2.3 Current Status of APII Testbed

In order to promote the APII Testbed Project, the international networks have been configured by international submarine cable systems using optical fibers between Japan and Korea and between Japan and Singapore. The transmission capacity of these international links is 8 Mbit/s between Japan and Korea and 2 Mbit/s between Japan and Singapore. Between Japan and Korea, they determined to extend the duration of the project until March 31, 2003. International networks using Ku band satellite links have been configured among Japan, Hong Kong, Thailand and Indonesia. Furthermore, C band satellite links have been added or under planning of construction in 2000 among Japan, Singapore, Malaysia, Philippines, Vietnam and Sri Lanka. The transmission capacity of each satellite link is 1.5 Mbit/s from Japan to the other countries and 512 Kbit/s from the others to Japan. A lot of experiments such as the Next Generation Internet technology have been performed on the links. These satellite-based networks are also called AI^3 Testbed Network. Originally it was initiated in 1996 and kept running for academic and research purposes on a nonprofit and nongovernmental basis in conjunction with many research institutions in Asian countries. Since APII Testbed Project inherited AI^3 Testbed Network in April 1999, the APII Testbed Project has been collaborating with AI^3 members. The part of satellite networks in the APII Testbed network is connected with each domestic testbed network through each satellite gateway. The satellite part of APII Testbed also has helped sustainable development of human resources especially in Indonesia. Many fields of research such as high-speed network technologies have made progress thanks to Internet backbone connectivity through APII Testbed.

5.3 Issues of the Testbed projects: Current Status of Next Generation Internet Testbed

TEIN actually connects bilaterally between France (RENATER) and Korea (KOREN). In this course of negotiation and formation, not only the collaboration between Government and Government (G2G) but also that between APII-CC and APII-TC were crucial and they should act the role of an arbitrator for both the European and Asian side. Because there were no integrated systems or frameworks in Asia such as Europe's DANTE or GEANT or TEN-155 that can act as the steering and adjusting institutions among the member economies. APII-CC and APII-TC had to act as a kind of "APII" frames as the reliable institutions in Asian area for establishing Area-to-Area connections.

In the meantime, APII-CC and APII-TC faced a critical issue that had to be solved. Since the purpose of TEIN project was to form the Area to Area network promoting the science and technology, network research and applications, APII-CC and APII-TC had to form a model for this. European community required the same number of institutions in Asian area as their over 3,000 research institutes to be connected with the network as the Layer 3 connection under transparent AUP-Free policy. The APII Testbed purpose was basically the project-based type. At the same time, the European side expected us to finish negotiations even among the domestic networks such as IMnet, SINET and other Japanese networks and to make a promise for transparent transit to them. From this point of view, the true purpose of European groups was based on connecting Japanese scientists and so on. The Japanese governmental side, however, there were no fundamental budgets for such a domestic End-point free model. In course of the efforts, the APII-CC and APII-TC extended some items' definitions for the AUP. Finally, they hammered out the limited agreement of AUP free policy for the TEIN project as one of the objectives of Internet research. Overriding the basic purpose and fundamental explanation of this kind seem to be adjustable, however in practice, there were many barriers because the cables fee always consumes a large amount of budgets. Comparing the US model with EU model, the small governmental commitment would be recommended for promotion and deployment of Internet technology and forming Internet issues.

5.4 Conclusion

It is about time for the APII Testbed and APII project to be re-organized or to establish new collaboration frame. The Example of the TEIN project shows the Area-to-Area network communities are required. IPv4 to IPv6 migration and transition could be the timing for making a new organization just as APII project. The incomplete list of Asian area resources for international Testbed indicates Internet institutes and research activities. Such trial and producing information sharing of this type is important mainly for monitoring the actual activities in Asian area. Thus, systematic trial is required. Cooperation and joint work among a lot of Asia-oriented projects (such as APII, APAN, AIC, APT, AP-bionet, APEC and so on) would be important to make the effective activities not only for researching but also for G2G, B2B and P2P frames.