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Current Development: SOIASIA Project: A New and Effective Distance Learning Environment for Internet Developing Area Utilizing the Satellite Link

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SOIASIA PROJECT
A NEW AND EFFECTIVE DISTANCE LEARNING ENVIRONMENT FOR INTERNET DEVELOPING AREA UTILIZING THE SATELLITE LINK

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This paper describes a distance learning environment using the Internet via satellite in Asian regions where Internet infrastructure is insufficient. The merit of distance learning is that students can receive cutting edge lectures from professors all over the world. For those areas with sufficient Internet infrastructure, there would be no problem receiving these kinds of lectures. However, it is difficult for countries with insufficient Internet infrastructure to receive them. The SOI (School of Internet) ASIA project proposes and demonstrates a distance learning environment utilizing satellite links as an Internet infrastructure that can be quickly installed with low cost for those areas.

1. Introduction

With the expansion of the Internet infrastructure, distance learning using the Internet is becoming popular. Massachusetts Institute of Technology has decided to archive their lectures on the Internet [1], and Stanford University has been delivering its lectures to distant students for some time [2]. These distance learning programs mainly use video and audio streaming through the Internet. Therefore, students at home or in offices need sufficient Internet connectivity to receive these lectures.

However, in locations without sufficient Internet infrastructures (We call these locations “Internet developing areas”), it is difficult for students to participate in these distance learning programs due to a lack of sufficient network bandwidth to receive high enough quality video and audio from those universities.

The SOIASIA Project has proposed a distance learning environment using a satellite link as an Internet infrastructure for these Internet developing areas. We designed the distance learning environment with lecturer, student and gateway sites, and formed partnerships with 11 educational organizations in Asia. We established a distance learning environment including 5 lecturer sites in Japan and the United States, 11 student sites in Asia and 1 gateway site in Japan, and evaluated the environment through actual university level lectures as proof experiments.

2. SOI and AI^3

2.1. SOI Project

In 1997, the WIDE Project [3] established the SOI [4] research working group. Since then, the SOI project has been working to deliver higher-education programs to anyone who has a will to study “anytime and anywhere” utilizing Internet technology. The SOI project digitizes the educational resources used in real universities, and provides those facilities to students all over the world. Figure 1 shows the top page of SOI project virtual university.

Figure1. SOI top page

Today, more than 14,000 students are registered at the WIDE University, and half of these students are adults who are interested in continuing their education through the Internet. The SOI project has more than 1,000 hours of video archives of lectures, allowing the students to study independently. The project is also providing real-time lectures once a week through the Internet. Additionally, joint lectures between Keio University and Nara Institute of Science and Technology are held continuously every year using DVTS (Digital Video Transport System) applications [5] through the Internet.

2.2. AI^3 Project

The AI^3 (Asia Internet Interconnection Initiative) project [6] is an international research project in Asia established in 1995 in collaboration with the WIDE Project and the JSAT corporation, the largest satellite operator in Asia. Since then, 11 research institutions and universities in Asia have joined this project. This project aims to form a group of researchers to develop cutting edge technologies using the satellite link-based Internet infrastructure among these 11 partner organizations. The research field includes satellite Internet, IPv6, WWW caching and replication mechanisms, multimedia communication mechanism and applications for the advanced usage of the Internet. The AI^3 project is providing Internet connectivity via satellite to its partners, and these partners are allowed to use the network under academic use in an AUP (Acceptable Use Policy), similar to that of NSFnet (National Science Foundation network) in 1990s.

2.3. SOIASIA

In 2001, the SOI project and the AI^3 project started a joint research program called the SOIASIA project [7][8], which aims to develop a distance learning environment in Asia utilizing the Internet infrastructure over satellite links.

At first, partnerships among 11 research institutions and universities within Asia (including 3 AI^3 partners) were established. We then installed receive-only earth stations at each partner site utilizing UDLR (UniDirectional Link Routing) [9] technology, enabling those partners to quickly install a 6 Mbps Internet infrastructure. UDLR technology enables combining one way satellite link and a terrestrial link (e.g. a 56k modem line) as a single IP link. We

designed standard lecture, gateway and student sites. The overview of our environment is shown in figure 2.

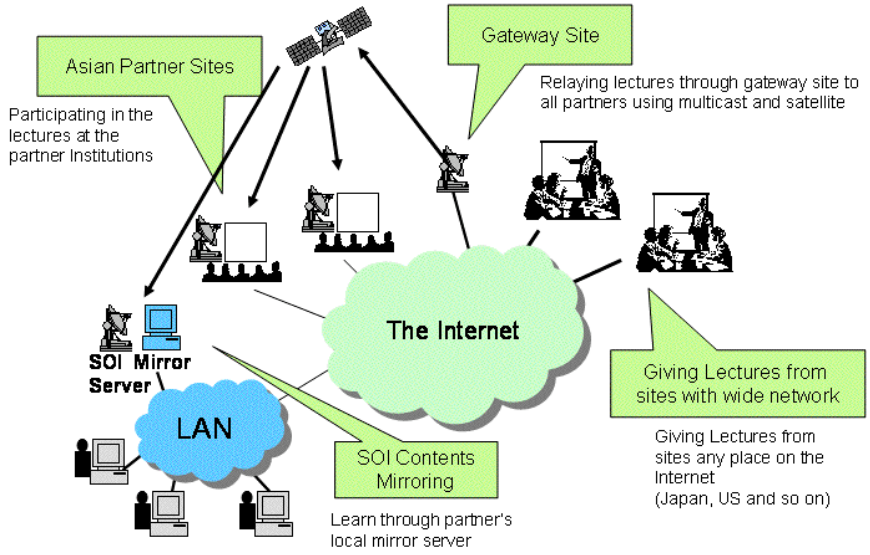

Figure2. Overview of SOIASIA environment

3. Network architecture and application configuration

3.1 Why satellite?

The SOIASIA project aimed to implement its environment in as many Internet developing areas in Asia as possible. It is often true in Internet developing areas that they do not have sufficient budgets to afford costly programs, so we aimed to install our program in a cost-effective manner. Moreover, we think that these areas will be equipped with broadband Internet in the future, and so we wanted our infrastructure to fill the gap until those infrastructures are someday installed. Therefore, we aimed to install our environment as quickly as possible.

Using a satellite link as a communication infrastructure has the following merits, making it optimal for the rapid rollout of our Internet infrastructure:

- A satellite earth station can be set up within the satellite footprint in a short time
- Theoretically, only three satellites are needed to cover the world; hence the satellite links can be applied to wide area
- Satellite is a broadcast medium and is suitable to deliver lectures to many places at the same time
- Equipment required for satellite infrastructure is identical at each site

Usually, uplink capable satellite earth stations are costly compared to receive-only earth stations, and sometimes it can be difficult to obtain radio station licenses in certain countries. Such earth stations need to have technical staff for maintenance, and it might also be difficult to find such staff in Internet developing areas. On the other hand, receive-only earth stations can be installed at lower cost, and licenses are easier to get or not needed in some countries. The maintenance is also simpler (similar to a satellite TV

antenna). Therefore, we have decided to use a satellite link as a one-way circuit. However, since the Internet assumes that communication links are bidirectional, a one-way satellite link cannot be used as it is for the Internet. Hence, we have employed UDLR technology to overcome this problem, and we have arranged that the lectures are delivered to each partner's site in high quality video and audio through the satellite link and the feedback from the partner's site during the lecture will be communicated through each partner's existing terrestrial Internet infrastructure. Each partner is free to choose the most optimal application they prefer for the feedback based on their network bandwidth.

3.2 Lecturer site configuration

3.2.1 Network configuration

The network requirement for the lecturer's site is provide sufficient bandwidth to deliver sufficient quality for the video and audio streams. From SOI experiments, we set the minimum bandwidth to be 128kbps. The lecturer site can be built anywhere that meets these requirements.

3.2.2 Application configuration

There are 2 requirements for the lecturer site application: 1) lectures can be delivered to multiple sites simultaneously through video and audio; 2) student feedback to the lecturer can be made based on each site's terrestrial link bandwidth.

In our system, we first chose to use WMT (Windows Media Technology) for delivering the lectures since it has multicast capability, but we discovered that WMT generates large encoding and decoding delays on the order of 30 seconds. Since large delays are not suitable for real-time question and answer sessions, we decided to use VIC (Video Conference Tool) / RAT (Robust Audio Tool) for the lectures, because it also has a multicast capability but a very short delay. Even though WMT had a better video and audio quality, shorter delay was deemed more important when conducting a real-time session.

For the question and answer sessions, we use VIC/RA T, Polycom (Video conferencing system), Microsoft Netmeeting, Bulletin Boards, Yahoo Messenger, MSN Messenger and IRC (Internet Relay Chat), so that the partners can choose which application they prefer based on their Internet infrastructure. For the synchronization of lecture materials (MS Power Point), we used the RPT [10] application, which is one of the SOI project implementations. When a professor changes the Power Point slide, RPT sends a signal using IRC; the remote site RPT receives the signal and then changes the Power Point slide. This enables the synchronization of Power Point slide.

Figure 3 shows the application configuration of our system.

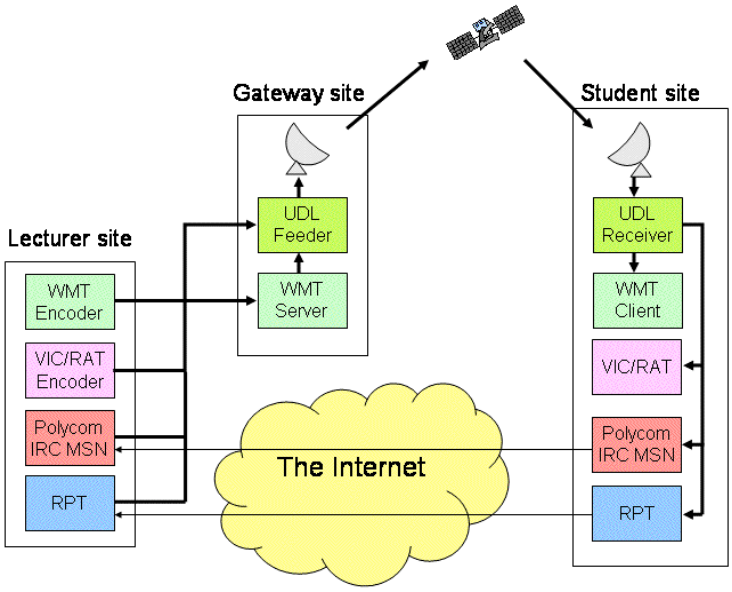

Figure 3. Application configuration

As discussed before, lecturer sites can be separated from the gateway site as long as they have enough bandwidth to send video and audio to the gateway site. Therefore, we designed 4 types of lecturer site application configurations according to the network bandwidth: 1) sites with over 100 Mbps connection to the gateway site, 2) sites with over 1 Mbps connection to the gateway site 3) sites with over 128 kbps connection to the gateway site and 4) gateway site is the lecturer site.

3.3 Student's site configuration

3.3.1 Network configuration

The student sites can be in any Internet developing areas. The minimum equipments for the student site are 1) satellite antenna 2) UDLR receiver 3) IP router.

The only special equipment in the student site is the UDLR receiver, which converts the satellite signal back to its original form (Ethernet frames), and sends the frames to the LAN. The UDLR receiver converts the satellite signal back into Ethernet frames, and also enables the bidirectional emulations by using LLTM [9]. With this mechanism, traffic from student sites to lecturer sites is actually routed through the student site terrestrial link while the hosts view their outgoing traffic sent through the satellite link.

3.3.2 Application configuration

The student's site configuration has four classifications according to their terrestrial network bandwidth.

a) Fully interactive sites: a site with 128 kbps or more connection to the Internet
- Receiving lectures: WMT, VIC/RAT
- Sending questions: VIC/RAT, Polycom, Netmeeting
- Synchronization of PowerPoint: RPT
- Question and answer session: Video and Audio, BBS, IRC

b) Semi interactive sites: a site with an unstable Internet connection

- Receiving lectures: WMT
- Sending questions: VIC/RAT, Polycom, Netmeeting
- Synchronization of PowerPoint: RAT
- Question and answer session: Video and Audi o, IRC, BBS (changes according to the network status)

c) Semi unidirectional sites: a site that has an Internet connection, but is not connected to our UDL network for various reasons.
- Receiving lectures: WMT
- Sending questions: No applications
- Synchronization of PowerPoint: RPT
- Question and answer session: IRC and BBS

d) Fully unidirectional sites
- Receiving lectures: WMT
- Sending questions: No applications
- Synchronization of PowerPoint: Cannot be done
- Question and answer session: FAX and telephone

3.4 Gateway site configuration

3.4.1 Network configuration

The gateway site has to have broadband connectivity to the lecturer site to receive high quality video and audio, so this site must be developed in a location where the Internet infrastructure is already built, and is near to the network backbone.

3.4.2 Application configuration

The gateway site should fulfill the 4 lecturer site configurations, which are mentioned in 2.3.3. The detailed configuration is described in [11].

4. Evaluation

With these designs, we set up a distance learning environment in Asia. A gateway site is located at Keio University, Shonan Fujisawa Campus in Japan, since its network on Japan's Internet backbone. Lecturer sites are located in 5 places in Japan as well as one in the United States.

We formed partnerships with 11 research institutes and educational organizations in seven countries including 3 AI^3 partners, and student's sites are established in each of them. Table 1 shows the partner organizations of our project.

The student site is designed to be located in multiple countries quickly and with low cost. In our approach, we utilize a combination of satellite links and existing terrestrial lines as the Internet infrastructure. We confirmed our design is feasible by building our distance learning environment to 11 educational organizations in 7 countries in Asian from January to February 2002.

Table 1. SOI ASIA partner organizations

Organization	Country
Brawijaya University Sam Ratulangi University	Republic of Indonesia

Hasanuddin University Institute of Technology Bandung	
Laos National University	Lao People's Democratic Republic
University of Computer Studies, Yangon	Union of Myanmar
Chulalongkorn University Asian Institute of Technology	Kingdom of Thailand
Asian Youth Fellowship	Malaysia
Advanced Science and Technology Institute	Republic of the Philippines

The existing terrestrial lines in the University of Computer Science, Yangon and the Laos National University were dial up networks, but those dial up networks were not connected to our UDL network. So their environment virtually did not have any terrestrial lines in the view of UDL network. For these sites, the satellite link is unidirectional since there was no return path to emulate a bidirectional link.

Table 2. SOIASIA lectures

Date	Name of the lecture	Conducted organization
February – March, 2002	Information Technology Special Lectures	Japan Advanced Institute of Science and Technology
June – July, 2002	Information Technology and Social Studies	Keio University, Shonan Fujisawa Campus
September 2002	Advanced Topics for Fisheries and Marine Science	Tokyo University of Fisheries
September 27, 2002	Special Seminar on E-learning of IT Economics	Asian Institute of Technology
October 10, 2002	E-Government Seminar in Indonesia	Brawijaya University
November 20, 2002	The Graduate School of Science and Technology International Graduate Programs on Advanced Science and Technology	Faculty of Engineering, Keio University
November 2002 to January 2003	Advanced Internet Technology	WIDE Project
February 20, 2003	SOIASIA Project, Real-time ASEAN Interaction	SOIASIA Project Embassy of Japan in Myanmar
April 29, 2003	Introduction to reactive fluid dynamics	Faculty of Engineering, Keio University

However, we built our environment in these sites, and we confirmed that delivering WMT multicast packets does not need a return path, and that these sites without any terrestrial link can receive lectures using WMT via the one-way satellite link.

With our distance learning environment, we have conducted 39

lectures for 86.5 hours including 4 lecture courses as shown in table 2.

Through these lectures, we confirmed that high quality video and audio could be delivered to the student sites through the Internet over a satellite link and that student sites could send feedback according to their existing terrestrial network bandwidth.

Figure 4, 5 and 6 show one of our most recent events, “Realtime ASEAN Interaction” held among Keio University, Shonan Fujisawa Campus in Japan (SFC), University of Computer Studies, Yangon in Union of Myanmar (UCSY) and Asian Institute of Technology in Kingdom of Thailand(AIT).

Figure 4
SFC, Japan

Figure 5
UCSY, Myanmar

Figure 6
AIT, Thailand

Moreover, as we wanted our environment to be sustainable, we held 2 operator workshops for each partner’s technical staff, so that they could operate the student site environment on their own. The topic of the first operator workshop was on the entry-level, and it was to develop the knowledge of basic TCP/IP, basic UNIX commands and basic UNIX server management. The topic of the second operator workshop was at the advanced level, which was to develop the knowledge of UNIX operating and networking especially for the SOIASIA project, real-time lecture application operation and archived lecture contents creation. Through these workshops, partner sites’ technical staff have learned how to operate the student site environment, and we confirmed that these kinds of operator workshops are useful [12].

5. Conclusion

As an achievement in 2002 to mid-2003, the SOIASIA project has established a distance learning environment in 11 educational organizations in Asia, through which graduate university level lectures can be delivered. We have conducted 39 lectures from January 2002 through April 2003 using this environment; and a total of 46 professors have given lectures through our environment. We have also sent certificates to students after 3 lecture series, and 87 students have received lectures in the “IT and Social Science” lecture series, while 53 students have received lectures in the “Advanced Fisheries and Marine Science” lecture series and 41 students have received lectures in the “Advanced Internet Technology” lecture series.

As shown in our paper, the SOIASIA project have provided cutting edge education to students who want to study in a simple way that had not been realized before. We have also provided lectures through our environment as a proof experiment, and confirmed that our environment is feasible.

The SOIASIA project is running as well this year, and we are working to make our environment more sustainable as an educational program, while also working to establish a student exchange program using our environment.

This program is now in the student and university selection stage. We also aim to provide the student sites with an up stream network to the lecturer site with low cost video and audio question and answer sessions.

References

[1] MIT http://caes.mit.edu/programs/distance.html
[2] Stanford online http://scpd.stanford.edu/scpd/default.htm
[3] WIDE Project http://www.soi.wide.ad.jp/
[4] KAWAI, Keiichi, OKAWA, Keiko, MURAI, Jun "Practical Experiences of Higher Education on the Internet -Cases from the School of Internet-" Proc. of ICCC'99, Tokyo, Sep. 1999
[5] Akimichi Ogawa, Katsushi Kobayashi*, Kazunori Sugiura, Osamu Nakamura, Jun Murai “Design and Implementation of DV based video over RTP”, Packet Video Workshop 2000,2000.5
[6] Tomomitsu BABA, Hidetaka IZUMIYAMA, Suguru YAMAGUCHI, “AI^3 Satellite Internet Infrastructure and the Deployment in Asia”, Vol.E84-B, No.8, pp.2048-2057, August 2001, IEICE Transactions on Communications
[7] SOIASIA Project http://www.soi.wide.ad.jp/soi-asia/
[8] Shoko Mikawa, Keiko Okawa, Jun Murai “Establishment of a lecture environment using Internet Technology over satellite communication in Asian Countries”, SAINT 2003 Workshop, January 2003
[9] E. Duros, W. Dabbous, H. Izumiyama, N. Fujii and Y. Zhang, “A Link-Layer Tunneling Mechanism for Unidirectional Links”, RFC3077, Internet Engineering Task Force, March 2001
[10] RPT http://www.soi.wide.ad.jp/doc/rpt-e/
[11] Shoko Mikawa, “Approach and substantiation to tertiary education distance learning in Internet developing area”, Graduate school of Keio University, School of Media and Governance Masters Thesis 2003 (Written in Japanese)
http://www.soi.wide.ad.jp/library/doc/funya_thesis-final.pdf
[12] Yasuo Tsuchimoto, Shoko Mikawa and Keiko Okawa, “The deployment of UDL network on satellite circuit with training workshop”, SAINT 2003 Workshop, January 2003