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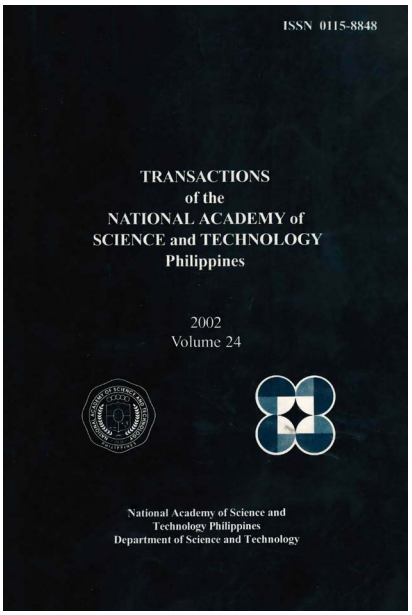

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ABSTRACT

The Philippine Research, Education, and Government Information Network (PREGINET) project is intended to create an environment that encourages collaborative research, development, and education activities in emerging technologies and to provide a platform for experimentation of innovative next generation Internet applications and services.

This paper discusses the implementation and status of the PREGINET project. Designed as a broadband network for the next generation network testbed in the Philippines, technologies include Asynchronous Transfer Mode (ATM), TDMA-DAMA over satellite, IPv6, IP Multicasting and Network Measurement.

Key Words: Philippines, next generation Internet (NGI), PREGINET

I. INTRODUCTION

Internet and the Next Generation

In the early development of the Internet, the research and education community deployed network technologies, services and applications that expanded their capabilities and accelerated the pace of research. The Internet today is an outgrowth of several investments in research networks. They have developed and

evolved through multi-agency programs that build on the successes of the previous programs. These investments by the academia and industry stimulated the rapid growth of Internet market.

The Internet is now on the threshold of evolving into the next generation Internet (NGI), the creation of new type of interconnected community. This NGI community will be able to exchange information in far richer ways and with far less delay and risk than using today's Internet. As with Internet development, the success of the NGI initiative will depend on effective partnerships among universities, the private sector, and the research community.

In the Philippines, NGI is the next step in achieving an interconnected country necessary to support research and development in the academe and industry. The next generation Internet (NGI) in the Philippines will create a foundation for a powerful and versatile network for the country. This will cultivate collaboration among academia, industry, and the government that will keep the country at par with the current information and communications technologies.

The Advanced Science and Technology Institute's (ASTI), a research and development agency under the Department of Science and Technology, initial effort on the NGI initiative for the Philippines is the Philippine Research, Education and Government Information Network (PREGINET).

Research and Education Networks Initiatives

In advanced countries, the research and academic communities with support from the government and private sector are building their next generation Internet. These new networks are built with technology that enables next generation network services and applications to be developed, tested, demonstrated and deployed. Some Asian countries have followed the same trend. It should be noted that it is the government that spearheaded all these research and education networks initiatives. Here in the Philippines, there is no existing identifiable research and education network.

In order to enable ICT development and sustainability, the country needs a network that is contiguous and wide in coverage, with available bandwidth on which next-generation network technology and services testing and deployment, and applications development, experimentation, and demonstration can be conducted.

The Philippines Research, Education, and Government Information Network (PREGINET) is an environment that allows collaborative research, development, and education activities in next generation Internet technologies, services, and applications. The network is also designed to serve as the primary network to integrate existing and proposed Philippine government information networks. A common network exchange for all these institutions is more efficient, secure, and reliable compared to the current practice of interconnecting through separate commercial ISPs where quality of connectivity is not assured.

PREGINET is a national research, development, education, and government effort in broadband technologies. The project is realized as a persistent and scaleable network infrastructure supporting network research and collaboration. PREGINET will link the government, universities and research institutes through the high-speed transmission systems of optical fiber transmission technology. It is planned to also have access points for the government agencies, the universities, colleges, IT Centers and the high schools throughout the country.

The high-speed and high-capacity features of PREGINET permit users to quickly and efficiently conduct, transmit, and receive extremely large and critical data nationwide. It also allows videoconferencing and use for education, employment, and healthcare services. This translates to improved delivery of public services and information to citizens and businesses.

II. PROJECT STRATEGIES AND OBJECTIVES

With the strategic objective of establishing a nationwide broadband network for research and academic institutions involved in new technologies and applications development, testing, and deployment, PREGINET directly addresses the government's priority in the area of information and communications technology (ICT). These priorities include developing the country's physical ICT infrastructure as well as upgrading the country's human resource base through improved science and technology education.

PREGINET seeks to develop a nationwide broadband network that shall:

- Serve as the primary network for integrating existing and proposed Philippine government information networks;
- Serve as a next generation network testbed; and
- Serve as a national research and education network to connect to research and education networks worldwide.

PREGINET likewise seeks to contribute to the development of the human resource base by:

- Improving access to information, material, and people conducive to continuous education and advancement of the skill level of the public sector;
- Providing an environment for research on next generation network technologies and services to support next generation applications; and
- Encouraging the development of network-based applications and content.

PREGINET application priority areas are (1) network technologies, (2) distance education, (3) bio/medical informatics, (4) agriculture, and (5) disaster mitigation.

PREGINET will enhance the country's ability to generate, source, distribute, and utilize information and knowledge nationally and internationally. With the concerted effort of researchers, students, teachers, and government, the project is expected to accelerate the Philippines' development, especially in terms of research and development activities and development of the technological capability of the nation's human resource in the cutting-edge of ICT and other advanced science and technology fields.

The activities and the applications over the broadband network are also the major benefits of the project. With PREGINET as the basic network platform and focal point for ICT-enabled activities within the research and education community as well as for government inter-departmental connectivity, research and training grants for the development of ICT and its use (including for development of applications and content) can be given emphasis and focus.

PREGINET also provides an equal opportunity and competitive research ground for all research and learning institutions that have access to the network. The institutions can share the fruits of their research activities and learn from each other. The present infrastructure is inadequate to provide our researchers and academe with the facility to see and learn from what others are doing. With the project, the formation of local and international research consortia in all areas of science and technology is encouraged and facilitated.

III. NETWORK IMPLEMENTATION

Network Infrastructure

PREGINET is designed to use various networking technologies. Technologies include asynchronous transfer mode (ATM), multi-protocol label switching (MPLS), Frame Relay and demand assigned multiple access (TDMA-DAMA) very small aperture satellite (VSAT) system for the backbone network. With in the National Capital Region (NCR), broadband wireless technology such as Local Multipoint Distribution System (LMDS) will be deployed as well as fiber optic technology. Technologies such as Digital subscriber line (DSL), leased lines, and IEEE 802.11 WLAN will be utilized for connecting partner institutions and organizations

The network consists of three levels of connections namely, the backbone network, the access points, and the "Last mile" connections. The backbone network consists of three eXchange Points (XP) with ATM switches. These three XPs will be linked together via microwave transmission links and satellite using a TDMA-DAMA VSAT system. At the access points located in each of the country's regional center, routers with ATM uplinks will connect to the nearest exchange points. All routes between access points will be routed through the exchange points.

The three exchange points will share a Ku-band, 2 MHz bandwidth link from Agila II satellite of the Mabuhay Philippine Satellite Corporation and links

between the Visayas and Mindanao exchange points will utilize existing microwave transmission facilities of the Department of Transportation and Communication-Telecommunication Office (DOTC-TEFLOF).

In last-mile connections, users can access the network using leased line, dial-up or wireless broadband going to an access point. The type of technologies that will be used in different locations will be determined by the available telecommunications infrastructure in the area.

Pilot Network Phase

Initial funding for the PREGINET project was given by the Department of Science and Technology (DOST), under its Comprehensive Program to Enhance Technology Enterprises (COMPETE) program. Development of a High-Performance Broadband Infrastructure (with PREGINET as the network) is the R&D component of the Virtual Center for Technological Innovation in Information Technology (VCTI-IT). The project takes advantage of the existing telecommunications infrastructure of the Telecommunications Office of the DOTC in the Visayas and Mindanao regions (NTP 1-2 and 1-3) and makes use of E1 transmission links.

The three Exchange Points equipped with ATM switches are located in Manila for Luzon, Cebu for the Visayas and Cagayan de Oro for the Mindanao region (Figure 1). All XPs will be connected via satellite using shared bandwidth of 2Mbps. There is a redundant link between Cebu XP and Cagayan de Oro XP using TELOF transmission at speeds of E1 (2Mbps).

Access points within Visayas and Mindanao regions are connected to their respective exchange points. Utilizing existing government transmission facilities particularly TELOF, each of the access points has a bandwidth of 2Mbps up to the exchange points.

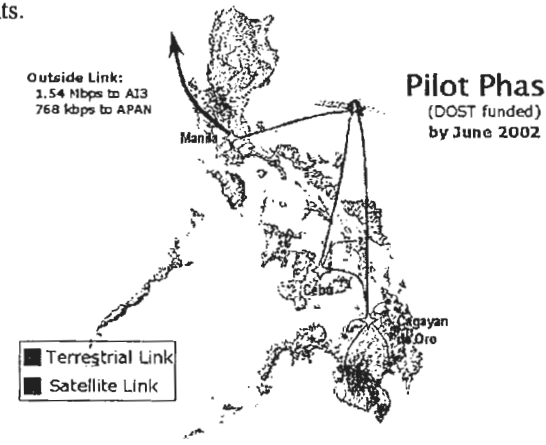

Figure 1: PREGINET Pilot Phase Network

Within the Metro Manila area, the project is planning to deploy a wireless broadband network to connect key universities and institutions (Figure 2). Albeit the initial high investment, such an infrastructure provides more flexibility in the future expansion of the network. The PREGINET is positioning in the use of wireless technologies using frequencies in the Industrial Scientific Medical (ISM) band, which is defined to be licensed free for low power spread spectrum use in most countries.

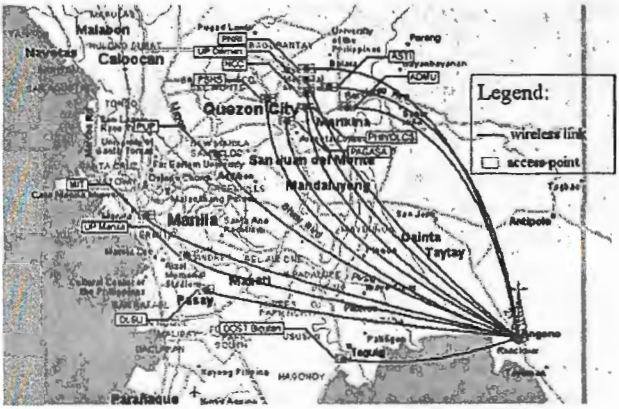

Figure 2: NCR Wireless Broadband

Outside Connectivity

In early 2000, the Advanced Science and Technology Institute (ASTI) officially became a partner of the Asian Internet Interconnection Initiatives (AI3) project (Figure 3). The AI3 is a Japanese research initiative whose aim is to build a network testbed for networking research and experimentation in Asia. The network provided country partners interconnection and connectivity to the Asia Pacific Advanced Network (APAN) and other research and education networks globally. Through this partnership with the AI3 project, several Philippine research and academic institutions were given the opportunity to participate in networking research and experimentation being conducted within the region.

Aside from the AI3 connection, PREGINET has connections to the Asia Pacific Advanced Network (APAN) through the Philippine Network Foundation Inc. (PhNet) which is a domestic wide area network that provides the Philippines the first full IP (Internet Protocol) connection to the Internet.

Currently, the project is seeking for a direct connection to the Science, Technology, And Research Transit Access Point, or STARTAP. This is a persistent infrastructure funded by the US National Science Foundation (NSF) to facilitate the long-term interconnection and interoperability of advanced international

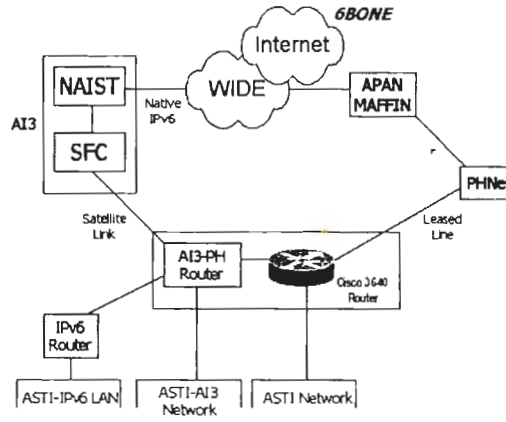

Figure 3: AI3-ASTI Network

networking. STARTAP enables network traffic to flow to international collaborators from over 150 U.S. leading-edge research universities and institutions, including supercomputing centers.

IV. RESEARCH ACTIVITIES

Important new technologies are in today's next generation Internet. The PREGINET project will leverage on these technologies for the efficient use of the network. With PREGINET, the country can be an active participant in the development, testing and deployment of these new technologies so that improvement in the country's commercial networks as well as the delivery of benefits to the citizens is accelerated.

A. Internet Protocol Version 6 (IPv6)

Internet Protocol Version 6 (IPv6) was designed as an evolutionary step from the current Internet Protocol (IPv4). It was designed to maintain all usable functionality of the current IP while removing unused ones. One of the most important components in the design of IPv6 is its transition and interoperation capability. This provides transparent transition upgrades to IPv6 and coexistence of the new and old protocol for years.

The new protocol has an increase in the address space to support more levels of addressing hierarchy and a much greater number of addressable nodes. To reduce the processing cost of packet handling by router nodes and efficient use of bandwidth, header improvements are applied on IPv6. IPv6 provides a solution

to the problem of explosion of routing tables. It uses inter-domain routing technology to take advantage of this hierarchy. This will simplify routing tables and provide aggregation of hierarchical address structure for the Internet. IPv6 also reduces the burden on system administrators by allowing networks to be configured automatically. This automatic generation of global address to network hosts is done thru auto-configuration.

Transparent transition and interoperability are the key features of IPv6. These features take advantage in providing ease of migration for networks. Network hosts can be installed with dual protocol stacks. These provide nodes capability of both IPv4 and IPv6 communications. Packet transmissions between IPv6 networks can also be encapsulated over existing IPv4 networks through tunneling.

IPv6 Network Implementation

The IPv6 working group of the PREGINET project has implemented an IPv6 network testbed. Its objective is to assess and evaluate implementation of IPv6 technology on existing networks and provide a venue to promote the use of the technology within the Philippine Internet. With the gain competency on the IPv6, the PREGINET project will deploy a nationwide scale implementation of IPv6 on the network.

With the deployment of the ASTI IPv6 Network testbed, common network services were deployed to duplicate IPv4 functionality. These include web, email, proxy and DNS for the new protocol IPv6. Implementation of the IPv6 was accomplished using the KAME dual protocol stack (www.kame.net) on a Unix machine. This protocol stack enables the network node to communicate both for IPv4 and IPv6.

To provide a connection to the 6BONE network (www.6bone.net), a tunnel link is made into operation through the courtesy of the Information Science Institute (bah.isi.edu). Using a pTLA (pseudo Top Level Aggregate) 3ffe:080C::/48 from ISI, this tunnel setup provided IPv6 transit to the 6BONE network. Using the AI3 network connection, native IPv6 connection has been established to the 6BONE. Native IPv6 implies communications between network nodes that use IPv6 as a means of transporting packets without intervening IPv4 networks. Using the sTLA (Site Top Level Aggregate) 2001:0200:0800::/40 delegated from the AI3-6BONE network, it has allocated network prefixes to all of its partners with the intention of building a native IPv6 network on top of its existing topology. The routing information between the ASTI-IPv6 network to 6BONE is carried out using RIPng (Routing Information Protocol for IPv6) (Figure 4).

Upgrade and installation of the AI3-PH router for dual stack capability has been made operational. Using the IPv6-enabled packages, additional services were made into operation to evaluate services needed for a smooth transition and interoperability of the existing network.

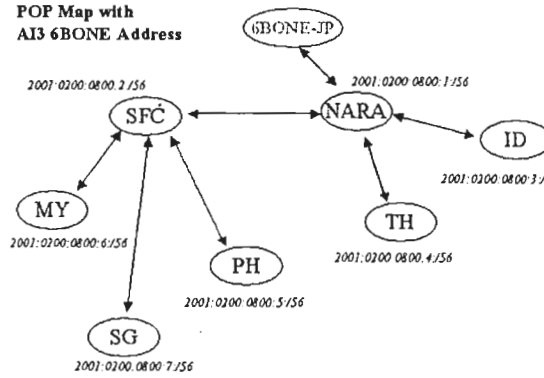

Figure 4: AI3 6BONE Address Allocation Network

B. Network Measurements

Network management is a critical component in the deployment of network infrastructure. With this in mind, we intend to set up monitoring applications over PREGINET in order to analyze network traffic. The collected information is used in the analysis of the health of the network to ensure reliability, quality of service, fault discovery (network breakdown), and performance optimization over the network.

Simple Network Management Protocol

The underlying protocol that makes it possible for the monitoring server to collect data from the devices is the Simple Network Management Protocol (SNMP). SNMP defines a client-server relationship. The client program or Network Manager connects to each of the devices being monitored. A server program (which resides in the devices) is responsible for responding to the client program and provides it with the data being asked for. The server program (or SNMP agent) maintains a database called MIB (Management Information Base) and it is here where statistical and standard values regarding the particular device are stored.

Network Monitoring Implementation

Figure 5 shows an example of how monitoring servers will be set up. There is no limitation to the number of monitoring servers that can be set up in the network. However, as the number of monitoring servers increases, it is quite possible that polls from the servers could cause congestion (thus defeating the purpose). Moreover, a lot of servers may put undue burden on the routers that are

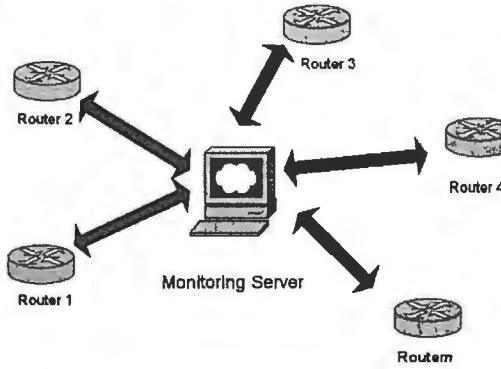

Figure 5. Example setup for monitoring the network

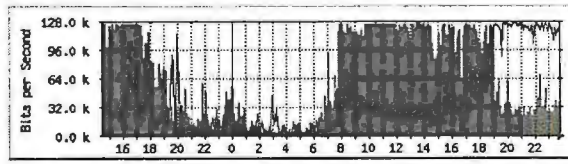

Figure 6. MRTG Graph

being monitored, since the routers will have to reply to each and every server that asks them.

The function of the monitoring server is to basically send PDUs (protocol data units) to each of the routers, and wait for the routers to respond with the requested data. The routers respond with PDUs of their own and these may contain the number of packets (incoming and outgoing through an interface), number of errors (dropped packets incoming and outgoing through an interface), and the time when the router(s) was switched on. These data (i.e., no. of packets) will then be graphed against time to see the percent utilization and percent errors over the link. The Multi-Router Traffic Grapher makes it possible to do this. MRTG displays the graphs in a web page for easy access over the Internet.

It helps to see the big picture if we could visualize the whole network in one easy-to-understand graphical user interface. Hence, a web page containing the whole network map will be constructed showing the links between the routers. The links themselves will be color-coded to indicate the current percent utilization of the bandwidth over the link.

Figure 7 shows a snapshot of the web page of the Quezon City network. A green link would indicate that the link has minimal traffic whereas a red link would mean that the link is congested. Naturally, a black link would mean that the link is down.

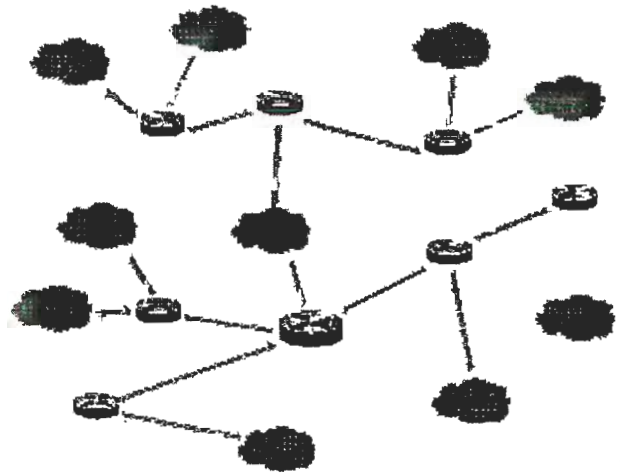

Figure 7. Animated Traffic Map

A very nice feature of this web page (which was made through INANNA, Interface Animated Traffic Analysis Software) is that it caches the image on the web page every 5 minutes. These images could be made into an animation where one can see how the links behaved for the past few hours or so. Below the web page is a link that leads to this animation feature. When this link is clicked on, the web page opens into another page where some options could be set for animating the web maps. After setting the desired options, the animation could be run and what you will see is the web map changing with regards to the color of the links.

C. Multimedia over IP

In recent years, multimedia transmission over the packet networks such as the Internet has been gaining popularity. As a result, multimedia applications such as audio and video streaming are taking much of the bandwidth in the networks. One technology called IP Multicast allows one source of digital information (e.g. video stream) to be received by multiple receivers simultaneously.

Normal traffic in IP networks is unicast, which is a point-to-point transmission. Multicast transmissions are point-to-multipoint. With IP Multicast, one copy of the same data is transmitted to a group address, which goes to one router that sends to multiple receivers. Significant bandwidth savings across the network can be realized by using IP Multicast. Even this entails investment in the upgrade of existing networks. The return of investment can be realized by the efficient utilization of the network.

Multimedia Network Testbed

PREGINET has recognized the need of the network users for data streaming applications such as videoconferencing and distance learning. The PREGINET team is currently evaluating and testing different protocols and applications that can be run over the network. The team have tested and evaluated VIC, VAT and SDR for Windows. These applications are usually run over MBONE (www.mbone.net). A connection to the MBONE using a tunnel through the PhNet has already been established.

Several clients utilizing videoconferencing tools such as NetMeeting and MeetingPoint were tested for interoperability and stability. These multimedia applications will then be used over PREGINET as a means of Teleconferencing and other research undertakings.

E. Other Research Undertakings

Research initiatives for the PREGINET project are not limited to these technologies. The project will engage in further networking research activities such as Network Security, Network Simulation, Unidirectional Link Routing (UDLR), Web-caching, High-speed Parallel Computing, Quality of Service, Digital Libraries, Tele-Medicine, Tele-Education, and Satellite Image Distribution.

V. FUTURE PLANS

The PREGINET project through the Advanced Science and Technology Institute (ASTI) and in coordination with the Department of Science and Technology (DOST) is proposed for foreign funding to the Official Development Assistance Program. The proposal named "KnEc Philippines: Philippine Research, Education, and Government Information Network" is currently under evaluation by the National Economic Development Authority.

The proposal seeks an expanded network utilizing optical fiber backbone and bandwidth up to 622 Mbps backbone capacity. The network will consist of a national backbone optical fiber transmission network covering Luzon, Visayas and Mindanao, in addition to the spur networks to cover the sites scattered in the nation and far from the backbone route. It has a wider coverage consisting initially of 3 exchange points, 16 access points, and 95 initial points of presence across the archipelago.

The project is proposed to be implemented in two (2) phases, to be preceded by a pre-implementation phase funded by DOST and currently being implemented by ASTI.

Phase 1 includes the establishment of the 3 exchange points, 16 access points, and 95 total points of presence to be located in the identified universities and colleges, and research institutes. During Phase 1, government offices can

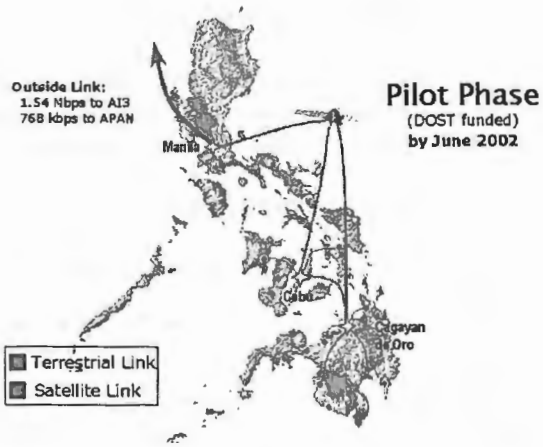

Figure 8. Expanded PREGINET

already connect to PREGINET. Phase 2 is the full development of the network with the establishment of connections for the 141 high schools. The 141 high schools are targeted as pilot sites to develop methods and practices on how a project and infrastructure such as KnEc and PREGINET can be used for improving secondary education in the country.

The expanded PREGINET boasts of offering transmission speed that is at least 100 times faster than present Philippine ISPs at 622 Mbps using the STM-4 interface of the Synchronous Digital Hierarchy standard. SDH is a standard technology for synchronous data transmission on optical media. Redundant links offer an assurance of reliability because it provides alternative paths when dead links occur. This is a fault-tolerance measure that is a characteristic of a well-designed network. Furthermore, because it is IP-based, a global standard, obsolescence is avoided.

VI. CONCLUSION

Advanced networking research being conducted over research and education network testbeds is important for the continued development and expansion of the Internet into the next generation Internet. It is important for the Philippines through its research and academic institutions to continue to participate in the activities being conducted over these networks in the interest of national development.

Next Generation Internet projects such as the PREGINET provides an opportunity for the Philippines to have universal access to information. However, it demands multi-agency, academic and industry input, collaboration and coordination. The government has a very important role in cultivating collaboration among academe, industry and government.

VII. ACKNOWLEDGEMENTS

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