Internet Services via PEACESAT

Norman Okamura <norman@elele.peacesat.hawaii.edu>
Al Blake < alb@ffa.gov.sb>
Reuben Lam < rlam@elele.peacesat.hawaii.edu>
Lori Mukaida<lmukaida@elele.peacesat.hawaii.edu>

Abstract

Access to information is a "critical success factor" for any organization, including public service institutions such as government, education, health and medical, environmental, emergency management, and other non-profit institutions. Access is a particularly important problem in the Pacific region where island countries are separated by millions of square miles of ocean. In this region, the "transport" of this information becomes a key access issue affecting the social and economic development of the Pacific region.

The purpose of this paper is to broadly discuss the current services and future plans of the Pan-Pacific Education and Communication Experiments by Satellite (PEACESAT) Program to deploy Internet as a public service telecommunications application. This paper describes the commitment of PEACESAT's to public service telecommunications, its current technologies, operating principles, and its Services Improvement Plan to extend Internet and other services to underserved areas through the establishment of eight (8) digital Hub Sites in Pacific Island Countries. The paper focuses on the Internet and public service institutions in the Pacific since they are the driving force for the use of Internet.[**]

1. Role of Internet in the Pacific

"Internet" is one of the most desired telecommunications services of government, education, and other non-profit institutions in the developing, Pacific Island region. It is viewed as one of the most important communication tools to help overcome some of the severe barriers to development, which include the geographic separation of the Pacific Islands by the vast Pacific ocean, the high cost of transportation, the low per capita income, and the traditional reliance on agriculture and fishery industries.

Traditional transport of correspondence, announcements of opportunities, requests for proposals, and other necessary resources such as diagnostics, library or news information could take anywhere from three days, special delivery, or one to two weeks and perhaps up to two months given the remoteness of the location to arrive at its destination in the Pacific Island region. Therefore, Internet is viewed by the developing countries of the Pacific Island region as a means to reduce disparities in access to needed resources. Internet is also perceived as a means to improve education, enhance health and educational services, facilitate the economic development of these countries, and to ensure participation in the global village. The growth of Internet and the information and services that are currently available suggests that Internet will be an important factor in reducing the "gap" between the developed and developing countries.

Unfortunately, the deployment of Internet in the Pacific has been stymied by the general high cost of communications and the monopoly control of services in most of the countries within the region. The cost for a telecommunications service, especially in the South Pacific, will often exceed 10-12 times the cost of comparable services in the United States. For example, the University of the South Pacific (USP) at the Suva, Fiji campus is currently paying $90,000 Fijian annually (about $60,000 U.S. Dollars) for a 4.8 Kbps link from Fiji to Australia.[1] The link is used solely for USP access to Internet. Due to the high cost of transport, none of the other USP campuses scattered throughout the region have Internet access on a 24-hour, 7 day a week basis. In the North Pacific, the cost of communications is lower but still beyond the financial means of many public service institutions, not to mention the general public.

Establishing a cost-effective telecommunications infrastructure for the transport of information is a difficult undertaking for most Pacific Island countries. Most of the telecommunication carriers in the Pacific Island countries are "corporatized," but not privatized. These corporations generally control both domestic and international communications. These monopolies are protected from competition or by-pass networks by their respective governments and national laws which discourage and often prohibit independent

[1] Telecommunications in the Pacific Island Region: Ministries, Service Providers, and Users, South Pacific Forum Conference Report, March, 1995, Suva, Fiji.

infrastructure investment. The major exception is Guam.

2. PEACESAT

The missions of the Pan-Pacific Education and Communication Experiments by Satellite (PEACESAT) Program are to support international distance education, research, telemedicine, emergency management, and economic development experiments and applications and to provide an experimental laboratory for research in the development and application of low-cost, communication technologies. PEACESAT achieves these missions and goals through the use of satellite communications and provides several non-commercial services. These services include access to Internet and other information services, and point-to-point and multipoint voice teleconferencing. Additional services, including compressed video, are part of the Services Improvement Plan.

2.1 Background

The PEACESAT program was initiated in 1971 to experiment with distance learning, emergency information, and voice teleconferencing and data applications through the use of a single push-to-talk circuit supported by the ATS-1 satellite for use by sites in the Pacific.[2] Between 1971 and 1985, PEACESAT was used by many different government and educational institutions.

Under the PEACESAT Program at the University of Hawaii, many different networks were established. The University of the South Pacific (USP), for example, established "USPNET" that used the ATS-1 system and earth station technologies to support distance education in the South Pacific. The Department of Interior Satellite Project (DISP NET) used the ATS-1 for territorial government communications. When the Department of Interior established other communications for territorial offices, the earth stations were turned over to educational institutions throughout Micronesia and formed a network to become known as "MICRONET." Users in Australia formed "Kangaroo Net" for voice teleconferencing and data services. The users in Japan, Indonesia, and Thailand formed "Asianet."

In 1985, NASA announced that the satellite was drifting out of orbit and could no longer provide services to its users. The PEACESAT Program transferred its services to HF communication links and limited use of the ATS-3 satellite.[3]

In 1987, the program was re-established by the United States Congress, largely through the efforts of Senator Daniel K. Inouye of Hawaii, NTIA, users, and the Social Science Research Institute of the University of Hawaii.[4] The missions, re-establishment, use, and potential of PEACESAT are discussed in several documents and reports and are not described in this paper.[5]

The re-establishment was made possible through the repositioning of the National Oceanic and Atmospheric Administration's (NOAA) geostationary weather satellite, GOES-3, in 1990. GOES-3 was one of a series of satellites used by NOAA for weather data gathering.[6] As such, the satellite frequencies which are used by PEACESAT are non-commercial "S" and "L" Bands reserved for weather data communications. Through the repositioning of the satellite to 175 degrees West Longitude, the GOES-3 footprint covers parts of the West Coast of the U.S.A., most of the Pacific Rim, and all of the North and South Pacific Islands countries. **Figure 1** depicts the geographic coverage of the GOES satellite.

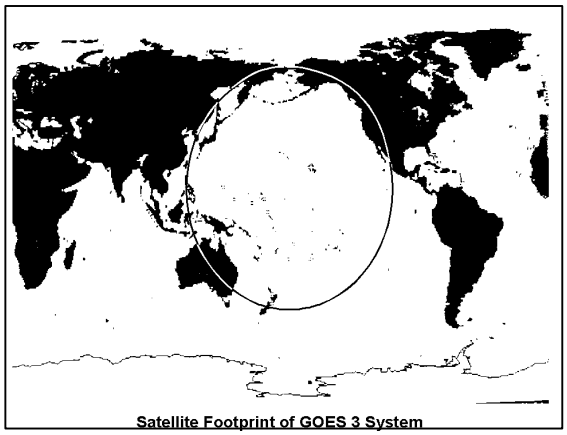


Figure 1. PEACESAT Satellite network footprint

Since the PEACESAT Program was formally re-established in 1992, the growth of the network has been tremendous. As of November, 1993, 36 sites in 20 countries had acquired PEACESAT

---

2 Mukaida, L., Topping D., 1989. "Appropriate Technology: The PEACESAT Experiment." Proceeding: Pacific Telecommunications Conference, Honolulu, Hawaii.

3 Cooperman, W., Mukaida, L., and Topping, D., 1991, "The Return of PEACESAT." Proceeding: Pacific Telecommunications Conference, Honolulu, Hawaii.

4 Ibid.

5 Documents, reports, and program materials are available through the PEACESAT Program, Porteus 704, 2424 Maile Way, University of Hawaii, Honolulu, Hawaii, 96822

6 Cooperman, W., Mukaida, L., and Topping, D., 1991, "The Return of PEACESAT." Proceeding: Pacific Telecommunications Conference, Honolulu, Hawaii.

earth stations (antenna, power, transceivers) to access voice and data services throughout the Pacific. By the end of 1994, there were 41 earth stations as part of the PEACESAT Network. Today, there are 44 PEACESAT earth stations in the network located in 22 different countries. 9 additional sites that will form the basis of an Emergency Management Net-work will be implemented by the end of 1995. In addition, more sites are considering becoming part of the PEACESAT network.[7]

2.2 Current Network and System Technologies

The current PEACESAT network supports the shared use of 9 simplex Narrow Band Frequency Modulation (NBFM) analog carriers and 3 full duplex circuits that support 9.6 Kbps of data transmission. The network is a "mesh" network that enables access to another site without retransmission. Users schedule sessions on Channel 1 and then switch channels accordingly. Thus, the current network does not require a "double satellite hop."

The earth stations consist of a 3m parabolic antenna, S and L Band transceivers, a 50 watt high power amplifier, a phone patch that enables users to call in for international voice conferences and point-to-point sessions, and a modem configured to work with the analog satellite carriers. Most PEACESAT sites also have microcomputers that are used for data access. A typical configuration of a PEACESAT earth station and indoor electronic technology is shown in **Figure 2**.

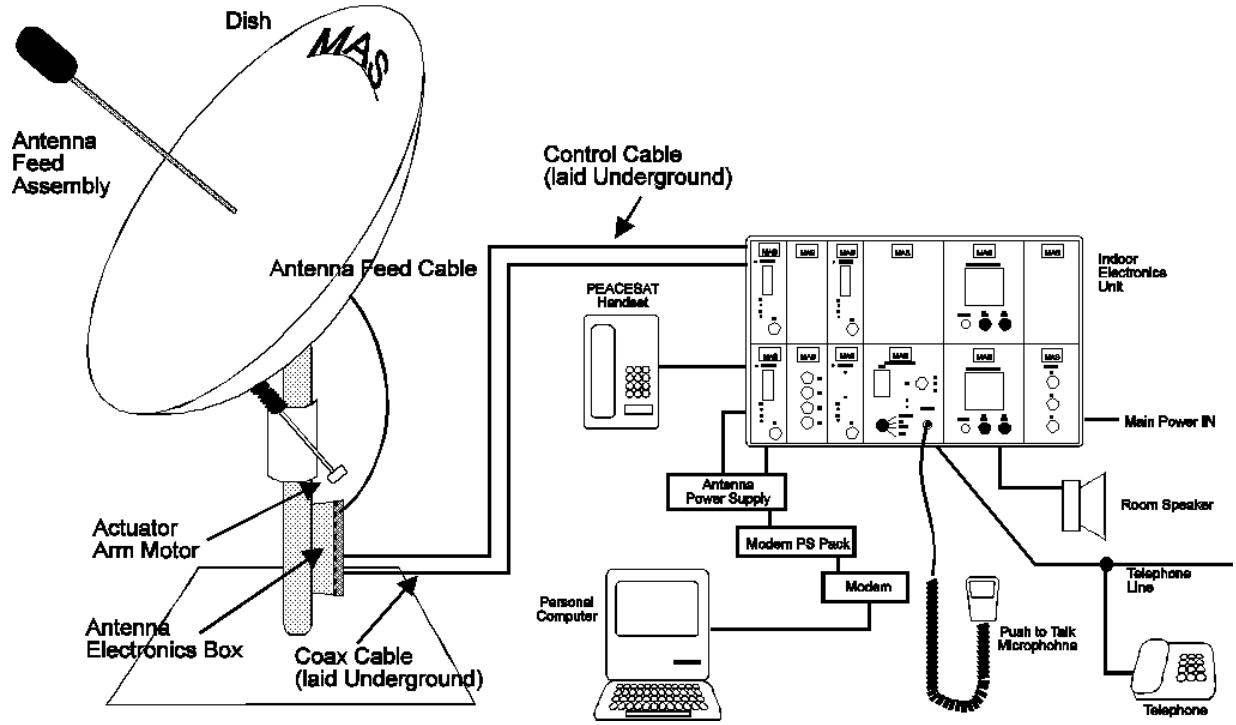
The cost of the earth station and ancillary technologies (i.e. phone patch and modem) is about $30,000 U.S. Dollars (USD). An auto-tracker that costs $5,000 is used for North-South tracking of the satellite since GOES-3 is in an inclined orbit to save fuel. Other costs for installing a system also include shipping, a concrete base, and installation. There are no charges by PEACESAT for the use of the "space segment." Users are responsible for their own maintenance of the system.

PEACESAT may not be used for commercial purposes and PEACESAT sites are not permitted to charge on a time-sensitive basis for services. PEACESAT sites may, however, establish cost-sharing and other agreements to cover the costs of operation and maintenance. Since there are no charges to users for the programs, it is very cost-effective for the Island countries of the Pacific region.

2.3 Limitations of Current Technology

There are several limitations of the current network and technology. First, the earth stations support only a single use at a time. Therefore, a site may support a single teleconference or a single data session, but not both at the same time. Second, the data rates supported by the analog carriers are

Figure 2: Typical PEACESAT Earth Station System Technology



[7] Okamura, N. and Mukaida, L., 1994, "PEACESAT: A Regional Telecommunications Alliance in Transition." Proceeding: Pacific Telecommunications Conference, Honolulu, Hawaii.

limited to 9.6 Kbps. This speed is not sufficient for some users and its use is inefficient since the circuit is not multiplexed. Third, there are only a limited number of circuits that may be used by the sites in the network. 44 sites sharing 3 circuits does not provide a single site much time to use the circuit. Finally, there are only 2 earth stations at the PEACESAT Headquarters in Honolulu. This means that it can only dedicate 1 earth station for data access since the other earth station must be used for scheduling purposes. This severely restricts user access to the network.

3. PEACESAT Roll Out of Internet Services

In January 1993, PEACESAT made Internet access available through PEACESAT Headquarters in Honolulu. The Internet host computer was funded by the U.S. Department of Agriculture (USDA). The USDA was interested in establishing a more effective means of data and electronic mail communications. At the same time, the Agriculture Development for the American Pacific (ADAP) Program of the USDA provided funds for several PEACESAT sites for a "remote access" capacity at selected sites in the Pacific. The remote access capability was intended to allow users not located at the PEACESAT earth station to dial-in through the local public switched telephone network to the Internet and other data services.

The PEACESAT Internet node is called "elele.peacesat.hawaii.edu." "Elele" means "messenger" in Hawaiian. The UH Office of Information Technology installed the network for PEACESAT Program in support of the PEACESAT and the Pacific.

The response to Internet was instant and overwhelming. PEACESAT received well over a 100 requests for user logins before the service was even advertised. Within a few months, PEACESAT Headquarters (HQ) in Honolulu began to detect some problems at user sites. PEACESAT voice and data users were having scheduling conflicts. PEACESAT HQ had to dedicate one earth station for network scheduling, management, and Hawaii programming. This left only a single earth station to support the Internet users in the Pacific.

Any user of Internet or other on-line information services knows the problems of trying to schedule time for the use of such circuits. A reservation system may be initially acceptable, but it will not be acceptable for very long, especially when the service is shared by 44 different sites. The contention for the use of the channel resulted in continued conflicts between and among voice and data users and were expected to grow.

It became painfully clear to PEACESAT HQ that provision of multiple, concurrent voice and data services for major users at the sites was necessary to fulfill user requirements and an ever-growing demand for Internet. It also became clear that users required increased circuit capacity and access to voice and data-driven information services that do not require operator assistance.

4. PEACESAT Responds to User Demand to Internet and Other Services

In response to the needs of users for concurrent voice and data and multiple data links, PEACESAT and user sites undertook several actions.

4.1 Services Improvement Plan

PEACESAT, in late 1993, developed a plan to optimize on the capacity of the GOES satellite and proposed a "PEACESAT Services Improvement Plan" (PEACESAT SIP). The PEACESAT SIP basically called for the use of the complete bandwidth and satellite power of the GOES satellite to:

- Establish 8 Hub Sites in the Pacific.

  Each Hub Site will support 3 transceivers: 1-standard PEACESAT analog transceiver for shared use of existing analog circuits; 1 digital transceiver for use of a dedicated 32 Kbps digital circuit; and 1 digital transceiver for shared use of the 2 full duplex 128 Kbps link for video teleconferencing applications.

  Each of the Hub Sites would be able to concurrently support a minimum of 3 compressed voice circuits (at 5.3 Kbps), multiple concurrent data sessions over a (X.25 packet data) over a 14.4 Kbps line (data compression at 2:1 yields an effective data link of 28.8 Kbps), and will share the use of 4-128 Kbps circuits for interactive and broadcast digital video communications. The 128 Kbps circuits may be also used for higher speed data transfer.

- Establish Digital Video Receive Systems
- The DVRS systems will permit a site to receive, but not transmit, compressed video communications for distance education. These sites will use the standard PEACESAT transceiver for voice communications over an inexpensive mesh network antenna.
- Create Digital Modem Interface Upgrade Options for Existing PEACESAT Sites

Existing PEACESAT Sites will be permitted to upgrade their sites to transmit at 32 Kbps through the purchase of a digital modem and digital modem interface upgrade options that interface the digital modem to the existing up and downconverters.

The technical details and other information regarding the SIP may be found in Okamura (1992) and Okamura and Mukaida (1993).[8]

Through the Hub Site Communications Network in the Pacific, PEACESAT and the User Task Forces of each country propose to: (1) make Internet services available to government, education, health and medical institutions; (2) experiment with compressed video-based broadcast and interactive educational programming; and, (3) create and implement a cost-effective information infrastructure to support voice, data, and compressed video distance education learning technology and applications. The PEACESAT Hub Sites will connect with the local telecommunications and information networks through the Public Switched Telephone Network (PSTN) and through other direct transmission media. The existing analog network of 44 sites and growing in number will not be interrupted in current services through this improvement plan, will have two-way network links into the hub site network, and will also have the opportunity to upgrade their current earth station with additional data capacity through the digital upgrade option.

Since the capacity of the SIP could only support 8 Hub Sites, a Request for Proposals was issued by PEACESAT and a Hub Site Evaluation Committee (HSEC) was formed to evaluate the proposals. The HSEC reviewed 11 proposals from Pacific Island countries and recommended that conditional awards be offered to: American Samoa; the Common-wealth of the Northern Mariana Islands; the Federated States of Micronesia; Fiji; Guam; the Republic of the Marshall Islands for Ebeye and Kwajalein; the Republic of Palau; and the Solomon Islands. It is expected that the PEACESAT Hub Site Communications Network will be implemented by the end of 1995.

Internet access is a major component of each countries' plan and for 6 of the 8 countries, public service institutions will have access to the full range of services on a 7 day a week, 24 hour a day basis for the first time through the Hub Site technology. The Hub Site technology and interfaces in each of the countries are shown in **Figure 3**. The use of Internet in these countries will be most interesting to observe.

PEACESAT is fully aware that the use of Internet will grow geometrically and will require additional circuit capacity from the Hub Sites. Additional capacity can be provided through both reallocation of voice circuits to data, increasing capacity as PEACESAT Sites using the analog carriers close for the day, and through the reallocation of the 128 Kbps circuits. PEACESAT is also exploring other satellite options as well. The optimization will be determined at a later date, as the Pacific Island Country use of Internet develops.

4.2 Current Efforts: Establishment of Electronic Post Offices via PEACESAT

To fully use the current bandwidth available through the existing network capabilities, PEACESAT has also been working with existing sites to optimize the delivery of Internet services. For example, PEACESAT has been working collaboratively with a regional organization that has diplomatic status - the Forum Fisheries Agency or "FFA." The diplomatic status of FFA exempts it from the local monopoly control of international telecommunications services. This makes it possible for FFA to obtain its telecommunications services from other sources. FFA, which manages the territorial coastal fishing zones in 14 Pacific Island countries in the South Pacific, needed to develop a cost-effective method of sharing information between their member countries and with the "outside world" and decided to optimize on PEACESAT to obtain these services.

In August of 1994, PEACESAT and the Forum Fisheries Agency in the Solomon Islands conducted experiments using a Unix-based system to provide local E-mail, file transfer, and batch mail through the use of UUCP to transfer mail to the Internet. Once the tests were conducted, the service was made operational and FFA became an "electronic post office" for its users. The creative use of the PEACESAT circuit has been an innovation that merits attention, especially since it provides an effective means for communication among Pacific Island Countries that do not have access to cost-effective electronic mail and file transfer services. For PEACESAT users, this application became known as the "Electronic Post Office" and other Pacific Island Countries are now attempting to replicate its approach. FFA became the first site to embrace this concept and develop and implement

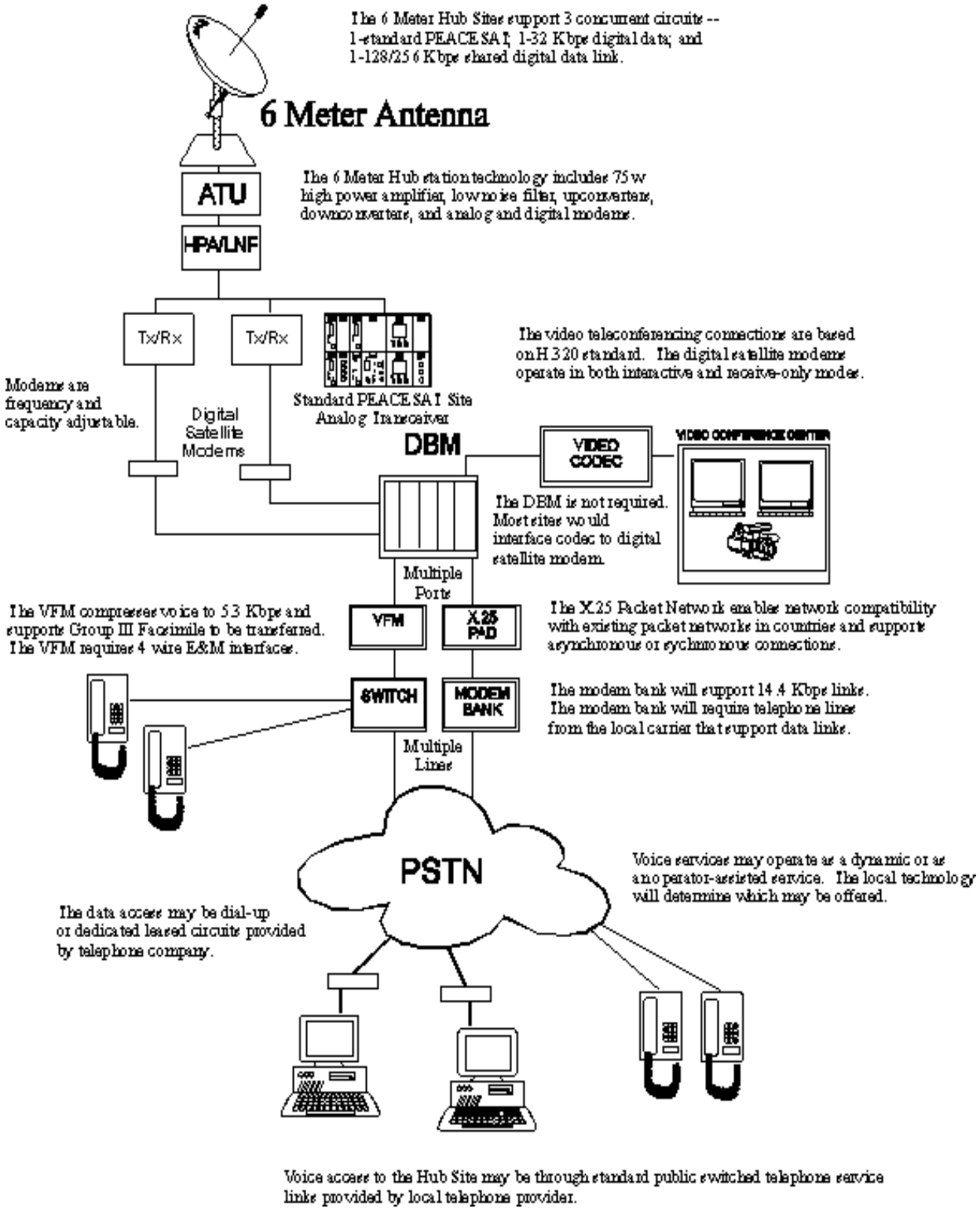
[8] Okamura, N., 1993. "Preliminary Assessment and Conceptual Design for the Use of the GOES-3 to Provide Improved Services to the Pacific." A Report to PEACESAT. University of Hawaii, Honolulu, Hawaii. Okamura, N. Ibid.

the technology to meet the needs of a regional organization in the Pacific. The concept and technology has become a model for PEACESAT and is illustrated in **Figure 4**.

4.2.1 The FFA Electronic Post Office

The Forum Fisheries Agency has been trying to implement a connection onto the Internet for some

Figure 3: Representation of PEACESAT Hub Site System Technology



time. Connectivity to the Internet mail facility is immensely useful to FFA with an estimated Internet user base of 20 million growing at a rate of half a million a month. Even if this is an over-estimate it is an undeniable fact that most government departments and research establishments with whom FFA needs to share information are connected to the Internet.

The Electronic Post Office operates in the following way. Due to the decentralized nature of installing a useable Internet connection, the FFA is the administrator of the Solomon Islands (sb) national domain. The FFA maintains and manages a class-C Internet address that they have sub-netted to provide FFA domains to Fiji, Vanuatu, Papua New Guinea and Kiribati. With the help of PEACESAT headquarters staff in Honolulu, a twice daily connection is established between the UNIX computers at each site. These machines, which form the backbone of the Internet mail system world-wide, are able to transfer mail into and out of FFA to mail addresses in any country.

FFA users dial-in to or through the local area network access their local mail server to create and to receive mail messages. Mail addressed within the local domain are resolved and routed by the local mail server to the local mail accounts. Mail addressed outside their network domain is queued by UUCP protocols for transmission at a later time. All Internet mail bound for FFA administered domains are routed to the PEACESAT mail host and queued for the periodic UUCP transfer sessions.

Once a day, FFA's central mail host connects to and exchanges mail with other mail hosts within its sub-domain. Mail it receives from these sites addressed outside FFA's domain are added to FFA's central mail host queue. Twice each day, FFA's mail host connects over the PEACESAT satellite network to PEACESAT's mail host and E-Mail is exchanged. Mail outside the PEACESAT domain is forwarded over an ethernet fiber network to higher level mail exchange servers for routing.

For the past month, a gateway system has been in place that provides a connection between FFA's internal mail system (Microsoft Mail) and the UNIX (SMTP) Internet mail system. This means that all FFA's staff are now able to send and receive mail world-wide with no more difficulty that sending a message to a colleague within the same office. In addition, the Microsoft Mail system is operated in conjunction with an External gateway that allows remote staff to dial into the system. This allows them to send and receive mail when away from the office and abroad, greatly enhancing the effectiveness of staff that travel around the region. Due to the SMTP gateway, these remote staff are also connected to the Internet mail system when traveling and can mail world-wide from wherever they are.

The dial-in facility is currently being expanded to encompass connections using the X.25 multiple access protocol and to integrate mail from the Fisheries Departments within member countries. It is hoped that within a short period it will be possible to mail most countries in the region using this system.

The external gateway incorporates a connection to FFA's INMARSAT network systems also

Figure 4: Solomon Islands Internet Access via PEACESAT

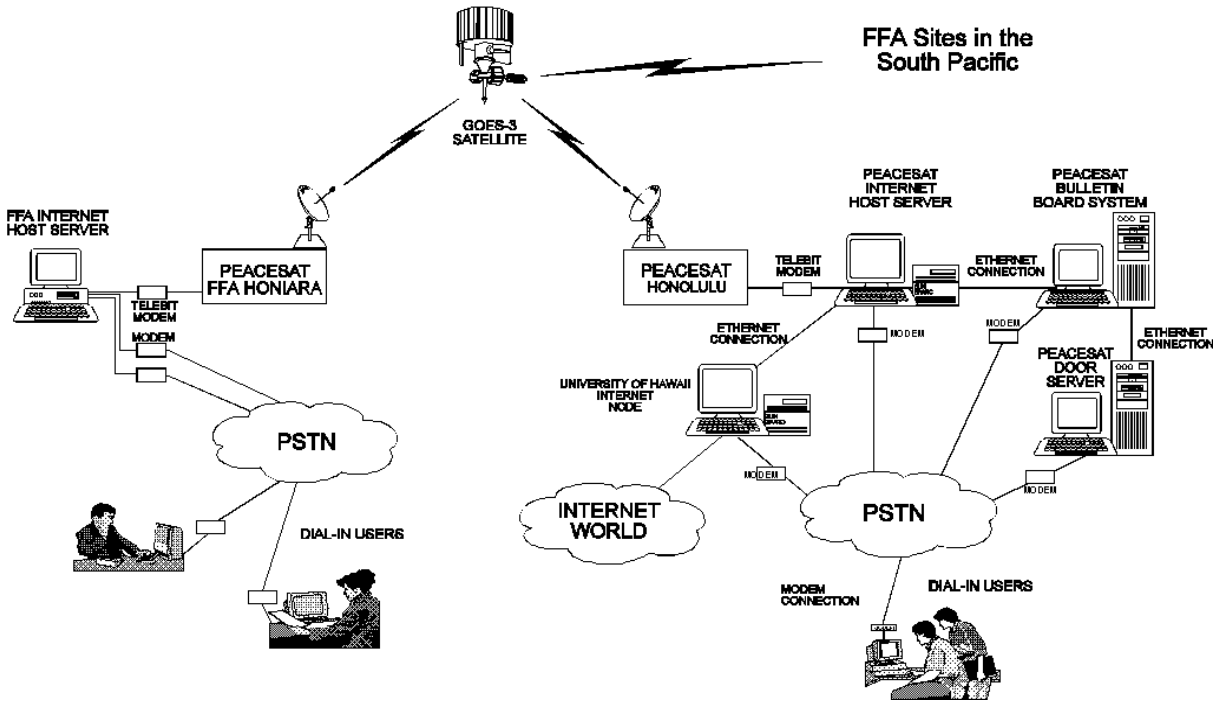
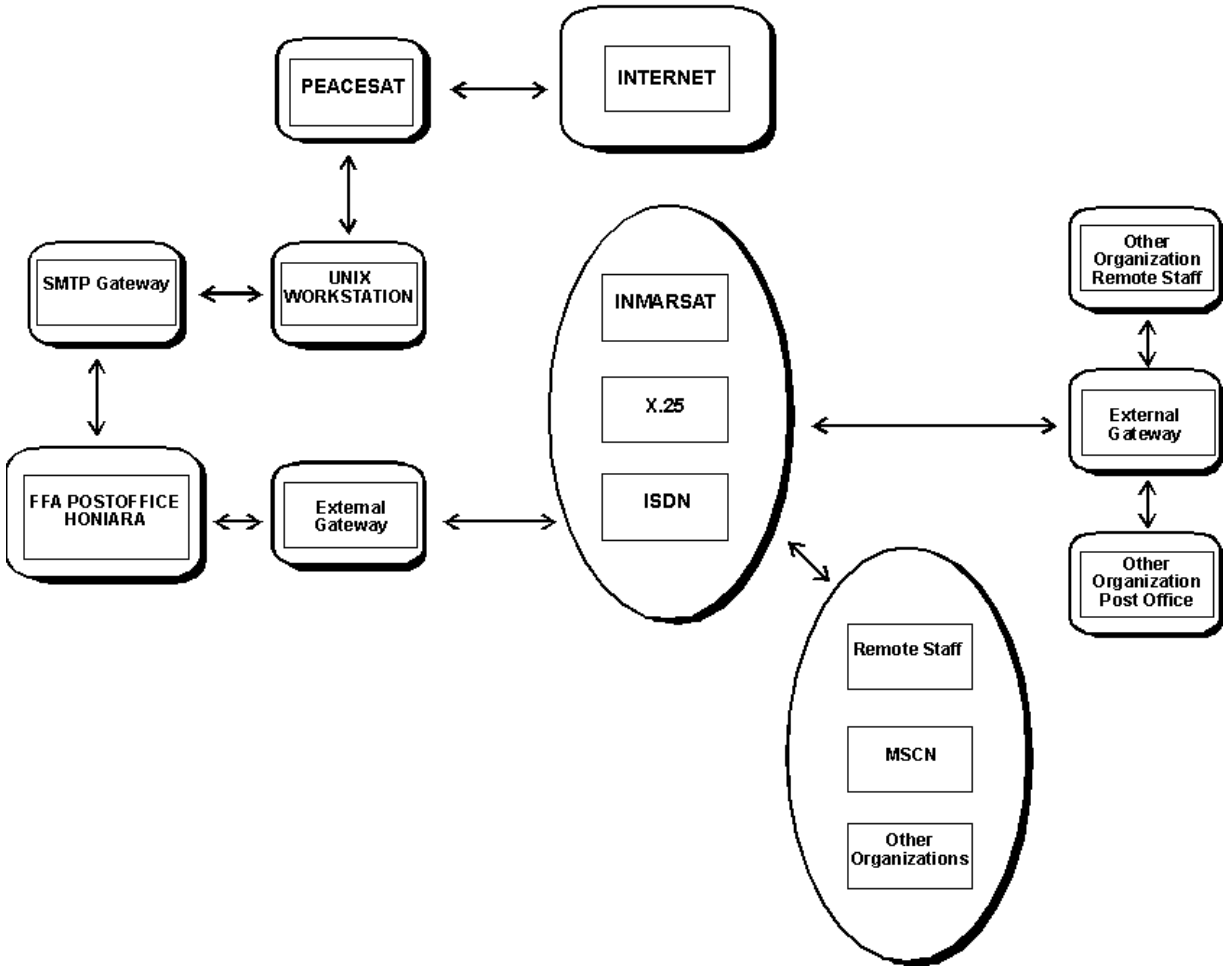


Figure 5: Block Diagram of the Forum Fisheries Agency E-Mail Network Connections



installed in most member countries and allows INMARSAT supported links to maintain contact with each other and the central headquarters through Internet.

The dial-in facility has also been extended to other non-profit organizations operating in the Solomon Islands. For the cost of a local call, these organizations are able to transfer mail via the FFA gateway. These organizations include the Solomon Islands College of Higher Education, the United Nations Development Program (UNDP-Solomon Islands) and the International Coastal Aquaculture Center (ICLARM). For other FFA country sites, a full-duplex link is used between the country and FFA, thereby avoiding the use of a circuit to Honolulu. FFA takes the mail and then passes it through the normal post-office exchanges.

FFA has also experimented with File Transfer Protocol by E-Mail. This allows them to request file listings of FTP sites on the Internet and later to request files to be enclosed in mail messages. This gives FFA FTP access to many sites without having a direct interactive connection and allows file transfers to occur during the batch mail exchange with PEACESAT. **Figure 5** is a diagram of the FFA E-Mail Network.

PEACESAT and FFA are currently looking at other communication solutions such as Point-to-Point Protocol (PPP) over the PEACESAT network. This will allow FFA to become an extension of PEACESAT's link to the Internet and they will be able to maintain "live" access to all Internet services.

FFA has also taken an important step - it provides a limited dial-up capability into its own network for education and health and medical users. These users now have a local electronic mail facility and interfaces to Internet for world-wide connectivity. FFA provides this service as its own public service to the Solomon Islands.

4.2.2 Setup and Technical Issues Surrounding Electronic Post Offices

Implementing the Electronic Post Office in the Pacific took a lot of effort and involves coordination and communication between nodes on the UUCP network. UUCP protocol was chosen because it provided a tested method for unattended batch transfers of mail and files between hosts and because most UNIX implementations have UUCP built into the basic operating system. The term UUCP denotes the complete range of files and utilities that comprise the remote communication suite.

The first step to establishing the electronic post office is to obtain and customize the UUCP configuration files. The descriptions below provide a few details of the files that were updated.

- Devices -- Contains information concerning the location and line speed of the transmission medium (the modems).
- Dialers -- Contains character strings required to negotiate modem connections.
- Systems -- Contains information needed by the UUCP software to establish a link to a remote computer. It contains information such as the name of the remote computer, name of the connecting device, when the computer can be reached, login ID and password.
- Sendmail.cf -- Although not a UUCP specific file, this file provides rules that route and queue mail intended for a remote host.

In addition to the software setup, the hardware also needs configuration. Finding the right modem initialization string, initialization of the computer's serial ports, setting the proper file permissions, and network and mail gateway setup are all crucial elements to a successful UUCP transfer.

The use of the PEACESAT satellite network introduced other issues that normally would not affect land line type connections. The delay in the time it takes a signal to be transmitted to and received from the satellite needed to be accounted for in the UUCP scripts and configuration. The connection reliability is also reliant upon atmospheric conditions and alignment of the earth station antenna. Additional operational procedures were created to insure that the physical connection is optimal.

4.3 Internet via Packet Radio in the Pacific

PEACESAT is also exploring the deployment of an HF/SSB High Speed AX.25 Packet Circuit interface to its earth stations to support low-cost continuous access to Internet for extremely remote areas and for emergency management purposes. Since many users in the Pacific have the HF/SSB radios, the ability to interface into a data network is substantial. PEACESAT initially conducted these explorations in 1988. However, the throughput at that time was not sufficient over the simplex circuits. PEACESAT is currently re-examining the use of HF/SSB. One approach PEACESAT is examining is the interface to Internet nodes that would permit E-Mail and FTP applications to be provided to very remote sites. The second approach is directed at use of digital satellite modems for the existing 3m network sites. It is PEACESAT's hope that the digital modems will support a higher-speed capability. When interfaced with a local HF/SSB AX.25 connection, even remote islands would be provided access to Internet.

* * * * * * *

In summary, the deployment of Internet via PEACESAT has permitted countries in the Pacific to become part of the Global Information Infrastructure -- an infrastructure that we hope will continue to lessen the disparities to access that currently exists at local and international levels. Although the infra-structure that PEACESAT supports is not the giga-byte superhighways that excites technologists, PEACESAT provides a cost-effective infrastructure that satisfies some of the desires of public service institutions to have access to Internet and other advanced telecommunication services. Efforts such as PEACESAT continue to have make a difference - at least until universal access to POTS and to Inter-net becomes a reality.

** This paper is based in part on research conducted on behalf of the Hawaii Information Network Corporation of the State of Hawaii. We wish to acknowledge the efforts of Thomas Okamura, the Program Development Manager of PEACESAT who prepared all of the graphics and also manages the information services and Internet services of PEACESAT.