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Internetworking Satellite and Local Exchange Networks for Personal Communications Applications

Richard S. Wolff
Bellcore
445 South Street, Room 2M-293
Morristown, NJ 07962-1910
(201) 829-4537
(201) 829-5888 (fax)
rsw@thumper.bellcore.com

Deborah Pinck
Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Drive, Mail Stop 161-241
Pasadena, CA 91109
(818) 354-8041
(818) 393-4643 (fax)
pinck@zorba.jpl.nasa.gov

ABSTRACT

The demand for personal communications services has shown unprecedented growth, and the next decade and beyond promise an era in which the needs for ubiquitous, transparent and personalized access to information will continue to expand in both scale and scope. The exchange of personalized information is growing from two-way voice to include data communications, electronic messaging and information services, image transfer, video, and interactive multimedia. The emergence of new land-based and satellite-based wireless networks illustrates the expanding scale and trend toward globalization and the need to establish new local exchange and exchange access services to meet the communications needs of people on the move. An important issue is to identify the roles that satellite networking can play in meeting these new communications needs. The unique capabilities of satellites, in providing coverage to large geographic areas, reaching widely dispersed users, for position location determination, and in offering broadcast and multicast services, can complement and extend the capabilities of terrestrial networks. As an initial step in exploring the opportunities afforded by the merger of satellite-based and land-based networks, we are undertaking several experiments, utilizing the NASA ACTS satellite and the public switched local exchange network, to demonstrate the use of satellites in the delivery of personal communications services.

1. INTRODUCTION

The 90's and beyond will be an era of explosive growth in the demand for nomadic, ubiquitous and personal information exchange. This includes such fields as voice communications, data communications, image and video communications, multimedia, information services, position location services, and interactive communications to name but a few. Today's terrestrial networks are well on their way to supporting these applications. Currently, many different, and in some cases conflicting, and non-interoperable telecommunications networks are being deployed or planned. This is the case for both satellite networks as well as for terrestrial networks. Satellite system providers are designing LEO and GEO networks; terrestrial system providers are planning micro-cellular PCNs using low-power hand-held wireless "communicators"; wireless data network providers are deploying wide-area high-power packet radio networks; paging network providers are moving toward nation-wide alphanumeric messaging capabilities; cellular network providers are evolving towards digital and integrated voice/data services.

The unique strengths of satellites, such as large coverage areas, flexible network re-configuration, one-to-many communications and line-of-sight global networking, can be exploited to make satellites a critical element in achieving world-wide personal communications. Various satellite networks are now emerging, and it is important to insure their compatibility with each other and their interoperability with terrestrial networks. This effort should include a wide range of stakeholders including satellite and terrestrial wireless network providers, local exchange and interexchange carriers, terminal, computer and satellite equipment manufacturers and information service providers, and their associated research and long range planning organizations. An important issue is to identify the roles that satellite networking can play in meeting these new communications needs. The unique capabilities of satellites, in providing coverage to large geographic areas, reaching widely dispersed users, for position location determination, and in offering broadcast and multicast services, can complement and extend the capabilities of terrestrial networks.

As an initial step in exploring the opportunities afforded by the merger of satellite-based and land-based networks, we are undertaking several experiments to demonstrate the joint use of satellites and terrestrial networks in the delivery of personal communications services. These experiments utilize the complementary capabilities of the local exchange network and the NASA ACTS satellite, and fall into the following domains: satellite-based two-way messaging, satellite-based delivery of personalized information services, satellite-based messaging for call control and delivery, and satellite-based subscriber location updates.

In these experiments, the NASA JPL ACTS Mobile Terminal (AMT) is being used to provide the nomadic end user with connectivity to the ACTS, and the local exchange network is being interfaced to the ACTS ground station gateway. These experiments will provide a better understanding of the interfaces needed to provide a seamless merger of satellite and land-based networks and will assist in identifying exchange and exchange access services to meet the emerging demand for personal communications. Furthermore, ways in which satellite technology can be utilized by local exchange network providers in facilitating the delivery of access services will be explored.

2. EXPERIMENT DEFINITION

The experiments involve the integration of several communications systems: the local exchange network, including Bellcore prototype personal communications applications software, the NASA ACTS satellite, the NASA ACTS earth station, and the JPL ACTS Mobile Terminal (AMT) interfaced to commercial terminal equipment utilizing Bellcore prototype application software. The following subsections provide an overview of these systems.

2.1 Personal Communications Applications Software

Bellcore has created prototype applications software that enables personalized information delivery. Two prototypes are being used in these experiments: Personal Telephone Management [1] (PTM) and Simple Information Filtering Tool [2] (SIFT).

The PTM prototype serves as an "intelligent agent" for end users, or clients, and assists in the screening and direction of telephone calls. With PTM, calls to a client are first screened, using the client's preferences contained in a personal profile, and then directed to the current location of the client. The client can, in real time, screen and re-direct calls, exchanging messages with the PTM. The prototype software runs on an experimental platform that interfaces to the local exchange network and to the NASA ACTS gateway.

The SIFT prototype uses client preferences, together with knowledge of the current location of the client, to screen, prioritize, summarize and deliver computer readable electronic messages. Designed to deliver information to people on the move, SIFT can forward a wide range of information in a form that can be read on conventional computer monitors and on the liquid crystal displays of portable or palm-top computers. This information can include the telephone numbers of callers, electronic mail, news summaries, weather reports, stock prices, etc. An easily modifiable client profile is used by SIFT to examine all incoming messages and to establish the priority of the information in relation to the current context of the client. The SIFT prototype can select from a variety of options including storing messages in electronic files, faxing them to preselected numbers, forwarding them to client colleagues, and converting them into speech for storage in an answering machine or voice mailbox.

2.2 The ACTS Satellite

The Advanced Communications Technology Satellite (ACTS) is an experimental K/Ka-band satellite that is being developed by GE under contract to NASA. It is scheduled to be launched in early July 1993 and will be placed in geostationary orbit at 100 degrees west longitude. In addition to its K/Ka-band operation, the ACTS has a multibeam antenna (MBA), a baseband processor (BBP) and a microwave switch matrix (MSM).

The MBA consists of an uplink receive antenna and a downlink transmit antenna. Basic antenna design is an offset-fed cassegrain configuration which has a subreflector in between the feed and the main reflector. The receive antenna uses a 3.3 meter main reflector to produce "spot" beams that are approximately 110 miles in diameter. The MBA produces three basic types of spot beams. First, there are 3 pairs of "fixed" spot beams to provide coverage for users in Cleveland, Atlanta, and Tampa. Second, there are two pairs of "hopping" spot beams that can be scanned "continuously" over two large sectors in the United States. Third, there are two pairs of "scanning" beams that can be moved continuously over two large sectors in the United States.

The ACTS can be operated with either the BBP or the MSM in the transponder path. In the BBP-mode, the received uplink signal gets demodulated, decoded, baseband-processed, coded, and modulated by the BBP. In the MSM-mode, the received uplink signal gets routed by the MSM at an intermediate frequency and the signal experiences no baseband regeneration. For these experiments, only the MSM mode will be exercised. The MSM has four input ports and four output ports in a cross-bar architecture. Its sole mission is to dynamically connect any one of the four receivers to any one of the four transmitters.

2.3 NASA and JPL Ground Station Equipment

The NASA ground station at Lewis Research Center will be used as the satellite/terrestrial network gateway (S/T NG) to the public switched telephone network (PSTN) and the Bellcore equipment described above. This ground station, termed the HBR-LET, interfaces with the MSM mode of operation of ACTS. On the uplink portion of the HBR-LET, a two stage upconverter converts the signal to the 29 GHz to 30 GHz range. The uplink power is provided by a traveling wave tube amplifier (TWTA) which has a saturated power output of 85 Watts. The receiver portion of the HBR-LET consists of a four stage low noise amplifier at the front end. This is followed by a MMIC mixer and amplifier that converts the received signal from the 19 GHz to 20 GHz frequency range down to the 3 GHz to 4 GHz frequency range, where it is converted to baseband.

The JPL-provided fixed terminal equipment will interface at baseband with communications gateway facilities that will exchange messages with the Bellcore personal telephone management platform, which will be located at Bellcore facilities in New Jersey.

The JPL ACTS Terminal (AMT), including a global positioning system (GPS) receiver, has been mounted in an experiment van and will serve as the mobile element for these experiments. The terminal controller (TC) controls the operation of the AMT. It contains the algorithms that translate the communications protocol into the operational procedures and interfaces among the terminal subsystems. For example, it executes the timing and handshake procedures for the interaction among the speech coder, modem, user interface, and any external device (i.e. data source or data sink) during link setup, relinquishment, or data rate change. The TC also has control over the operation of the IF and RF electronics. The TC, in addition, is responsible for providing the user with a system monitoring capability and supports an interface to the Data Acquisition System (DAS). Finally, the TC will support the test functions required during experimentation, such as bit stream generation, correlation, and bit error counting. In this experiment, the audio interface will be used as an "order wire" to support coordination and management of the experiment activities. Real-time, two-way voice over the satellite link is not part of the personal applications being examined.

The DAS will perform continuous measurements and recordings of a wide variety of propagation, communications link, and terminal parameters (e.g., pilot and data signal conditions, noise levels, antenna direction, etc.). The DAS will also provide real-time displays of these parameters. For this experiment, the DAS will be used to log and time stamp all messages exchanged between the TC and the user baseband terminal equipment.

2.4 User Terminal Equipment and Application Software

The experiments will utilize end user terminal baseband terminal equipment consisting of portable personal computers, telephone hand sets, and display and other input/output devices selected to emulate the functionality of future end user personal application appliances. This equipment will be designed to interface to the AMT. The Bellcore user terminal has been designed to interface with a GPS receiver located in the AMT or attached directly to the user terminal. The data collection capabilities and monitoring functions of the DAS will be used in conjunction with the Bellcore equipment to carry out the experiments.

Bellcore has created prototype application software that runs in the user terminal baseband equipment to provide user/network signaling and user information transfer. The software makes use of standard IP datagram protocols for communication with the personal telephone management platform. This software has been designed to interwork with the

AMT and with the GPS receiver.

3. EXPERIMENT PLANS

There are two different configurations for the Satellite/PCS experiments. In configuration 1, the user equipment is physically connected to the AMT equipment in the experimental van. There are four separate application scenarios for this configuration, each of which is described further in the remainder of this section. In configuration 2, the user equipment is remotely connected to the AMT via a local area terrestrial wireless network. The same four application scenarios as with configuration 1 will be tested. The attached figures provide high-level overviews of the proposed experimental setup. Figures 1 and 2 show configurations 1 and 2, respectively.

3.1 Satellite-based Two-Way Messaging

The objective here is to use satellite connectivity to send and receive electronic mail messages to nomadic end users equipped with portable computers. These computers would be capable of communicating directly with the satellite for data services. Prototype electronic mail sorting, filtering and routing software (SIFT) will be used to route high priority messages to a hybrid satellite terrestrial network gateway. Prototype application software will be used for the end user interface to the e-mail.

This experiment is shown in Figures 1 and 2 starting with the e-mail icon on the lower left. E-mail is sent to the nomadic user via the PSTN and the Bellcore software. High-priority messages are then forwarded to the satellite/terrestrial network gateway and transmitted up to ACTS. ACTS then forwards the message to the nomadic end user via the AMT (either directly or via a local area terrestrial radio link).

The experiment is designed to support the following application scenario. E-mail is sent to User A who is not in the office. The e-mail goes through the SIFT software which uses User A's personal profile to discover that this is high priority mail and must be forwarded to User A immediately. SIFT then checks the location data base to determine how to route the message to User A. If User A cannot be reached via a terrestrial network, SIFT then sends the mail to the S/T NG for transmission through the satellite to User A. When User A turns on the satellite-equipped PC, it identifies itself to the satellite and this information (user name, location, etc.) is stored in a location database at the S/T NG. Thus, when the mail for User A comes into the gateway, the gateway consults the location data base and determines where to send it. It sends the message through the satellite directly to User A who can now access the message.

If User A now wishes to originate a message the same scenario occurs in reverse. The e-mail is sent via the satellite to the S/T NG for routing to the PTM. The message is then sent to SIFT for transmission to the recipient.

3.2 Satellite-based Delivery of Personalized Information Services

The objective here is to use satellite connectivity to deliver personalized information (e.g., headline news, financial data, weather reports, etc.) to nomadic end users equipped with portable computers. These computers would be capable of communicating directly with the satellite for data services. Prototype personal message summarizing, sorting and prioritizing software will be used to interface between information data bases and the hybrid satellite-terrestrial delivery networks. Prototype application software will be used for the end user interface to the personalized messages.

This experiment is shown in Figures 1 and 2 starting with the database icon in the center (bottom). Personalized database information is sent to the nomadic user via the PSTN and the SIFT software. It is then forwarded to the satellite/terrestrial network gateway and transmitted up to ACTS. ACTS then forwards the message to the nomadic end user via the AMT (either directly or via a local terrestrial wireless link).

The experiment is designed to support the following application scenario. This is a one-way information service initiated by User A. When the end user's satellite-equipped PC is turned on, its identity and location are sent (via satellite) to the location database at the S/T NG. User A maintains a personal profile of requests for the latest headline news, weather reports, stock quotes, etc. The profile is used by the SIFT software to filter and prioritize information received from appropriate data bases. Personal messages containing the data are then forwarded to the S/T NG for transmission to User A. The S/T NG consults the location data base to find User A and then sends the information to User A's satellite-equipped PC, enabling the end user to access the information.

3.3 Satellite-based Messaging For Call Delivery

The objective here is to use two-way satellite-based messaging to alert nomadic end users of incoming telephone calls. The message is received on a personal computer capable of communicating directly with the satellite. Prototype call management and screening software, PTM, will be used to screen incoming calls to the end user's home location and send messages to the satellite network alerting a nomadic end user of incoming calls (name of caller and number). The end user responds via the satellite by returning a message regarding preferred call disposition, which is then processed by the PTM software. Call dispositions include routing the incoming call over the terrestrial public switched network to the current location of the end user, deflecting the call to another number, sending a text message to the caller (PTM converts to voice), etc.

This experiment is shown in Figures 1 and 2 starting with the caller icon on the lower right. A call comes in for the nomadic user via the PSTN and the PTM software. High-priority messages are then forwarded to the satellite/terrestrial network gateway and transmitted up to ACTS. ACTS then forwards the message to the nomadic end user via the AMT (either directly or via a local area terrestrial wireless link).

The experiment is designed to support the following application scenario. User A is called when he is not at his home location. The PTM software takes the call and queries a personal profile to find that User A is currently reachable only via the satellite network (i.e., User A is in a region that is not served by a terrestrial network). The PTM software then forwards information about the call (such as name of caller and number) to the S/T NG for transmission to User A. The S/T NG locates the user by consulting the location data base and passes the information along to User A in the form of a brief message. User A can then decide how to handle the call. The call handling information is then sent, via the satellite, back to the S/T NG for transmission to the PTM. The PTM can then take appropriate action to complete the call.

3.4 Satellite-based User Locating

The objective here is to use satellite connectivity plus GPS location capability to locate nomadic end users, update network data bases, and route calls and/or messages to their current location.

This application scenario is similar to several described above. However, in this case, the location of the nomadic end user A is not known to the terrestrial network. When a message (call or electronic message) is to be sent to User A, the terrestrial network queries the S/T NG for location information. A global paging message is sent out via the satellite, and User A's terminal responds with location data derived from the GPS receiver. This data is returned to the terrestrial network location database, and the scenario continues as described above. This use of the GPS location capability has great potential in complementing terrestrial network functionality (e.g., subscriber registration) necessary to provide ubiquitous personal communications services.

4. SUMMARY

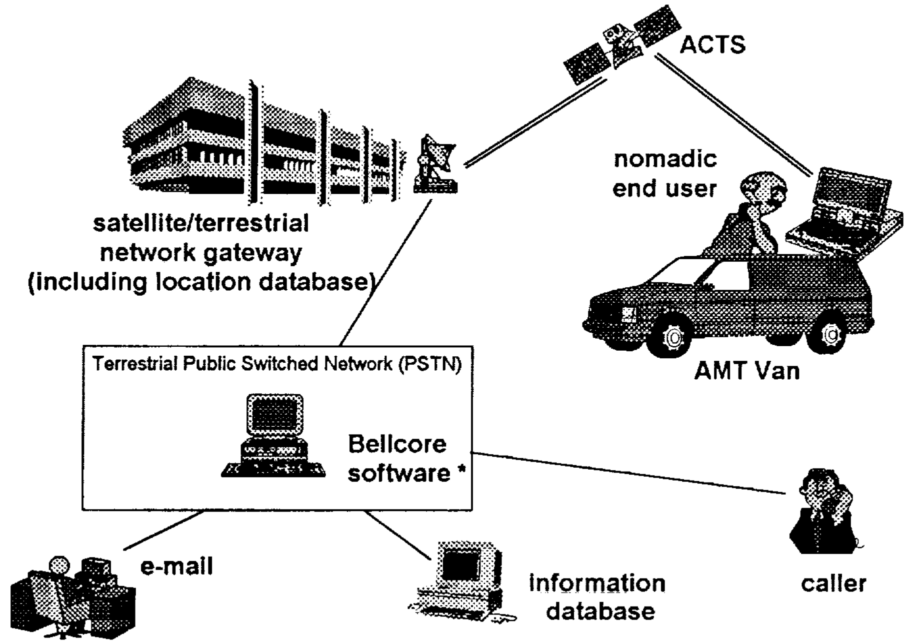
The ACTS satellite launch is scheduled for summer, 1993, and the user experiments, as described above, are planned for summer, 1994. Effort is now under way to interface the system elements and test the applications software. Independent tests of the subsystems have been carried out, including extensive use of the SIFT and PTM prototypes in terrestrial personal communications applications experiments.

These experiments will provide a better understanding of the interfaces needed to provide a seamless merger of satellite and land-based networks and will assist in identifying exchange and exchange access services to meet the emerging demand for personal communications.

REFERENCES

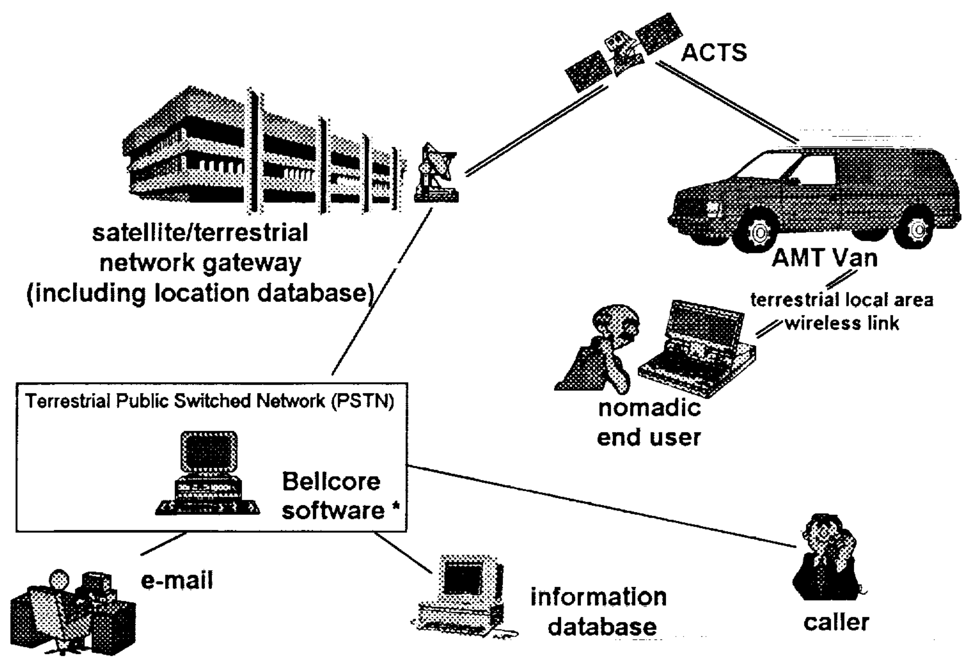
[1] W. S. Gifford and D. L. Turock, "The Electronic Receptionist: A Knowledge-Based Approach to Personal Communications", *ACM Conference on Computers and Human Interaction*, Monterey, CA, May, 1992.

[2] D. L. Turock and R. S. Wolff, "Making Telecommunications Nomadic", *Bellcore Exchange Magazine*, January, 1993, pp. 3-7.



* Bellcore software includes 1) SIFT software, 2) personal message summarizing, sorting and prioritizing software, and 3) call management and screening software

Figure 1 Experimental Setup - Configuration 1



* Bellcore software includes 1) SIFT software, 2) personal message summarizing, sorting and prioritizing software, and 3) call management and screening software

Figure 2 Experimental Setup - Configuration 2