Using Satellite Communications for a Mobile Computer Network

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Patrol Car Automation

Law enforcement agencies are recognizing the requirement for Patrol Car Automation systems. Most currently available commercial systems for Patrol Car Automation are mobile data terminal systems that limit agencies to specific manufacturers of equipment. The currently available systems do not easily allow links to disparate information systems nor is the implementation of new processes or functions easily accommodated.

Mobile Computer Network

The Washington State Patrol (W.S.P.), in response to this need for Patrol Car Automation has developed a prototype Mobile Computer Network (MCN). The network uses "off the shelf" hardware to provide a file passing network environment for notebook computers in vehicles. This network links the officers with the W.S.P.'s information system, other Washington state agencies and the National Law Enforcement Telecommunications System. The system can provide direct links for messaging and inquiry between the Patrol cars, all other states and the Canadian Provinces.

Network Requirements

The W.S.P. troopers are responsible for a variety of administrative reports. There are also a number of software programs that assist the trooper in their tasks. This dictated the need for a system that incorporated a removable notebook computer. The current voice radio system has been at capacity for years; see Figure 1.
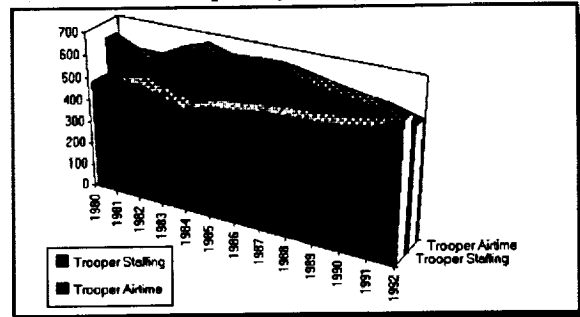

Figure 1 Trooper Airtime

The system will have to enhance the officer's effectiveness by reducing the amount of information the voice radio network is required to pass. The W.S.P. needs a system based on the existing microwave and UHF radio system for data communications but portions of the mobile network must be immune from terrestrial disasters due to the state's location on the Pacific earthquake zone and the threat of volcanic disturbance.

Network Design Overview

The Patrol's solution is the design of a Mobile Computer Network (MCN)

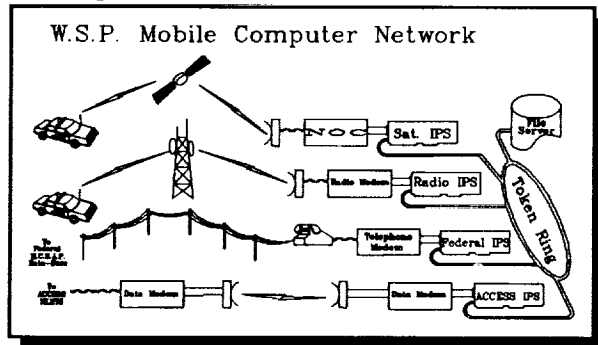including Mobile Satellite Communications; see Figure 2.

Figure 2 MCN Network

The network is designed around Imbedded Process Servers (IPS) which are single board I.B.M. compatible 80X86 computers linked on a token ring LAN. Each IPS operates in a client/server mode serving both network users and other IPS's. The mobile nodes on the network use background software that transfers all files deposited on the "network" directory back to the hub. These files carry a header designating destination, originator and other necessary information. The media location of the destination is transparent to the users. That destination can be on the UHF system, the physical LAN, the Patrol's SNA WAN or the satellite system.

MCN Mobile Network Software

The officer initializes the network software by loading two (2) background resident programs. The first is a short hardware specific program (HSP) that handles the placement on and retrieval from the communications media of the individual packets. This program has an Application Process Interface (API) that allows communication with other software. The second program loaded, called Radio Transfer (RXFER), is not hardware specific. It handles the presentation to the user and the operating system interface. RXFER is assigned a disk storage area as a network

"drive". It can be any drive or subdirectory. All files placed on this drive or directory are queued for transmission to the network hub. All files from the hub are placed in an inbox directory below the "network" directory. On initialization, RXFER insures the user is authorized network access and negotiates with the hardware program's API to establish packet sizes and inter-program communications areas of memory.

MCN Hub Operation

All IPS's have a network directory assigned in a table of directories. Each IPS monitors its directory for the presence of files. When a file is placed on its directory, an IPS will process the file in a manner prescribed by that IPS's process type and then delete the file. The file and directory method of process command permits sessionless server operation. The IPS controlling the UHF links to the officer monitors the radio data link. When data packets arrive, the system acknowledges each packet and, if necessary, reassembles packets into the complete transferred file. The completed file header is then examined for the destination address. The logical address is compared with a table of physical addresses. The file then is written to the directory indicated by the physical address. The individual packet acknowledgement synchronizes communication and insures completion and accuracy of file transmission.

Mobile Satellite Software

The integration of Mobile Satellite Communications into this network has both problems and benefits. The synchronous packet communications of the UHF system requires 2 messages for each packet. The near instantaneous transfer makes the

handshaking invisible to the user. The network software has timeout parameters for retransmission. The variable delays in transferring data packets over the mobile satellite make this method impractical. On the UHF system, the software has only the acknowledgement packet to guarantee that the packet transmitted has been received. In the mobile satellite system, once a packet is transferred from the mobile software to the satellite radio, accurate transmission is guaranteed by the satellite radio's firmware. this eliminates the need for an acknowledgement packet from the hub. One of our requirements is to have no hardware specific code in the RXFER program. This requires that the satellite specific HSP generate false acknowledgement packets. Since the addressing and modulation scheme of the mobile satellite radio system is inherently secure, the passing of sign-on packets with passwording and acknowledgement is unnecessary. The mobile satellite radio also offers a number of useful diagnostic functions. The HSP software examines packet requests and intercepts the specially encoded requests for diagnostic packets and returns packets with this information. It also mimics the sign on packet transfer sequences and all of the packet handshakes which the RXFER program requires for acceptance of this as normal network traffic.

Hub Satellite Software

At the hub, the use of the mobile satellite communications gives the added benefit of regular positioning information. The network's bindery of mobile node information is designed to make use of this information. At the hub end, a message accepted by the mobile satellite company's network operations center (NOC) may not be transmitted immediately to the mobile.

Parameters are set at the NOC to allow sufficient time for the mobile to be illuminated by the satellite, then to lock on and receive the packet. The NOC sets parameters for the amount of time to hold messages in queue before returning them as undelivered. Storage of messages at the MCN hub for extended periods awaiting either acknowledgement of receipt or an undeliverable message notice is required. Also required is a different method of triggering the mail store and forward function. In the UHF system, any loss of contact will transfer the mobile user's hub address into a mail directory. This is done because the user might have merely moved into an adjoining transmitter's coverage area. The user requires all undelivered messages to be immediately available to the new transmitter's IPC. The satellite system has only the one IPC and the timing of status transfer to mail depends on the size of the satellite IPC's message storage area and tables of message delivery status. On the UHF system, the HSP software is identical at each end. On the satellite mobile radio, the protocols required in the MCN hub to NOC communications are entirely different. The characteristics of mobile satellite radio required design changes from the traditional methods of mobile data transfer and modification in the expectations of the line trooper. These changes are not difficult and are eclipsed by the benefits of mobile satellite communications.

The Benefits of Patrol Car Automation

Currently, the W.S.P. prototype system offers the troopers all routine law enforcement query functions, a store and forward E-Mail function and outbound FAX from the car. Planned additions include image transmission, voice interface, heads-up display, ticket processing, driver's license

scanning, mobile docking ports and direct car to car interagency data communications. The benefits to the citizens of the state include the increase of stolen recoveries, quicker apprehension of wanted persons, reducing the delay for violators, greater recovery of fines and crime deterrence.

The Benefits of Satellite Mobile Computing

Incorporating satellite radio communications into the Mobile Computer Network has the benefit of providing a communications link that is virtually immune to terrestrial disaster. The Washington State Patrol intends to allocate sufficient satellite based mobiles to provide disaster backup links for the major public safety communications centers in the state. In the event that a disaster of any sort were to disable one or more of the public safety communications centers in the state, the assigned mobile would provide a link, for the communications center, to the National Law Enforcement Communications System (NLETS) and links to all units on the Mobile Computer Network. This backup would be provided not for the W.S.P. only, but for all public safety agencies in the state. The per officer cost of the terrestrial communications infrastructure makes mobile satellite communications the medium of choice for data communications in sparsely populated areas of the state.

National Law Enforcement Satellite

The Washington State Patrol has taken one of their MCN equipped cars to display at national conferences of law enforcement agencies. The use of satellite communications has sparked a great deal of interest in the national law enforcement community. The expense of establishing and maintaining a terrestrial communications infrastructure for the

disparate law enforcement agencies in the U.S.A. is sufficiently towering to inspire consideration of a mobile satellite communications network shared by law enforcement agencies nationwide; a system optimized for and dedicated to law enforcement.