Reprinted from *Communications,* July 1991 and August 1991.

THE MOBITEX TERMINAL SPECIFICATION

Evolution, administration and guided tour.

By Robert J. Fraser, PE

Does the publication of the Mobitex Terminal Specification spell opportunity for hardware and software manufacturers, big or small? Is Mobitex the network of choice for users ready to reap the benefits of a new age in wireless data communications? Will this two-part article answer the above questions? No, it won't. But we'll sure get one step closer.

To begin with, we'll review the evolution and administration of the Mobitex Terminal Specification (MTS). Where it came from, and who is doing what, might help us see where it's going. We'll also examine, from a technical view, four very different products, each addressing the needs of a separate market.

In part two (next month), we will use the OSI model to subdivide each of our four products into functional modules, then compare similar modules from each product and observe vastly different designs and costs due to application requirements. Throughout the comparison, we will be referencing the MTS to gain an understanding of the tasks which each module must perform.

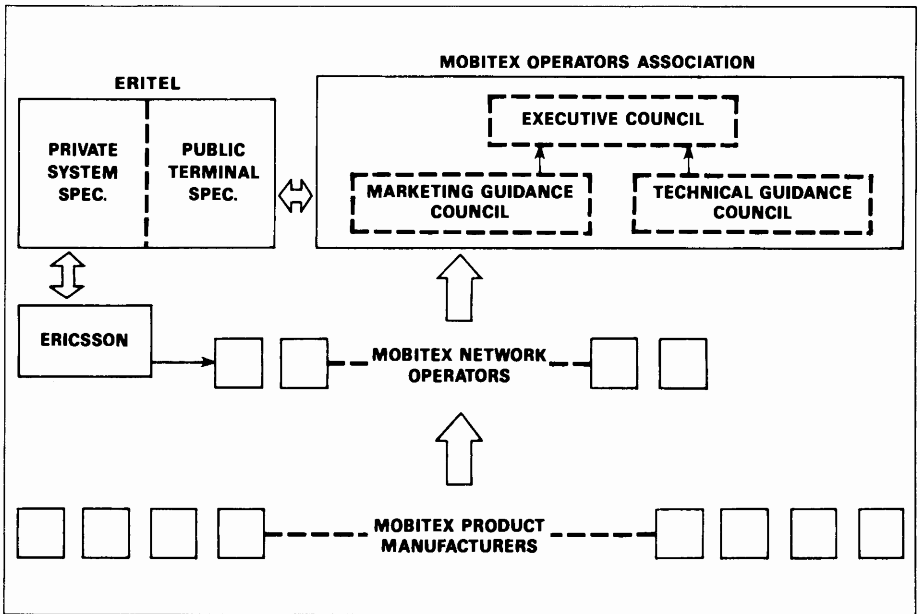
This article is not intended to be an introduction to the Mobitex network or business. There are many articles dealing with marketing, sales, and network architectural viewpoints (see "Mobile Data Mission," *Communications,* August 1990, page 41). The focus here is on the terminal products and technical considerations required to meet the needs of applications.

MTS EVOLUTION

The Mobitex Terminal Specification was originally released by the Swedish PTT in 1985. Swedish Telecom (PTT) had previously contracted Ericsson AB to manufacture and install the first Mobitex network, based on the PTT's prototype. Commercial operation of Mobitex, by Swedish Telecom, commenced in September of 1986.

Over the next few years, the MTS attracted many Scandinavian and European terminal manufacturers supplying Mobitex solutions to public safety, transportation, and forestry markets. Swedish Telecom was busy employing Ericsson in quick network expansion throughout the nation, while Finland and Norway were gaining increased interest in the new service.

With Ericsson entertaining Finland and Norway with new ideas, and manufacturers demanding changes to allow new market entry, Swedish Telecom was in a bind. Who was going



Hierarchical management structure for the evolution of the Mobitex Terminal Specification.

to plot the future technical enhancements of Mobitex? Was it the market-driven terminal manufacturer with the lion's share? The innovative network supplier eager for revenues from network enhancements? Or was Swedish Telecom itself going to regain custody of its prodigy?

The following two fundamental decisions thrust Mobitex to the level of international stature it enjoys today. In 1988, Ericsson and Swedish Telecom formed Eritel AB, staffing it with the chief architects of Mobitex. This put both the MTS and the network designers under one roof, with the mandate to research the evolution and maintain the integrity of Mobitex. It also put Eritel in a very precarious position. On one hand, they controlled Ericsson's proprietary network specifications (Ericsson wants to remain the world's leading voice and data cellular systems supplier) and on the other, administered the terminal specifications made public by Swedish Telecom.

Shortly thereafter, Swedish Telecom, Telecom Finland, and Norwegian Telecom formed the Mobitex Operators Association (MOA). MOA established the mechanism by which network operators mutually participate in the advancement of the technology and marketing of Mobitex, and assumed full administration of the MTS. To the relief of Eritel, their new responsibilities were reduced to technical.

The current MOA membership now includes, in addition to the above, Rogers Network Services Inc. (Canada), RAM Mobile Data Inc. (United States), and RAM Mobile Data Ltd. (United Kingdom). (Recently in Canada, Rogers Communications Inc. has shifted Mobitex from its regulated cellular operator Rogers Cantel Inc. to the above sister company.) Australia will be the next member, along with a new European member, rumored by the end of this year. Each member elects executive, technical and marketing representatives. Week-long meetings are usually held every four months. All MOA members are commercially operating Mobitex networks except for the United Kingdom, where operation is scheduled to begin in Q3 1991.

Network operators form a close partnership with system integrators, application developers and terminal manufacturers, creating a VAR channel for Mobitex. They provide the service of Mobitex to the end user, while the channel supplies product. Each network operator publishes an MOA certified MTS; provides marketing, sales and technical support to the suppliers; and certifies software applications and terminal hardware to ensure correct operation on the network. Technical support issues are usually confined to clarification of MTS requirements. Any issue regarding proposal changes to the MTS is brought to the MOA by the network operator.

The Technical Guidance Council of MOA then reviews the issue. If the issue is found to have sufficient merit, MOA presents it to Eritel for evaluation and recommendation. The final decision for change lies with MOA; therefore, the interests of all Mobitex product suppliers are maintained.

The current North American MTS ("the 8K spec") was first released in September 1989. It differs only in radio frequency (900 MHz) and modulation (8Kbps) from the other operators' specifications. After review by the manufacturers, clarifications and some minor changes were accepted by MOA, resulting in the R1A (Revision 1A) release of March of 1990. Eritel had been instructed by MOA in 1989 to prepare a specification for battery-powered handheld portable terminals. In early 1990, a draft was presented to manufacturers for review. The specification was released in August of 1990 (section 15 of the MTS) with a correction note issued in September.

Be forewarned, the MTS is not something you should "drill holes" in before close review. The more than 1,000 pages of terse description appeal to design engineers tasked with the creation of design specifications. To the marketing manager researching the technology, or to the program manager preparing budgetary estimates of manpower, duration, and technical risk, the MTS is extremely unpalatable. Both RAM and Rogers Cantel have published additional documents, such as the Mobitex Technical Brief, and RAM's Radio/Modem Reference Design Guide, to assist in presenting an improved view.

MOBITEX TERMINAL PRODUCTS

For illustrative purposes, I have selected (or created) four Mobitex products to allow for a meaningful engineering design discussion. These "terminals" are four application-specific devices which address the needs of four large and separate markets. The duration of this first article will complete an application review, making note of the variation in design from product to product. The second part will reference the MTS to discover the functional similarities.

The four products to be reviewed are: 1) the personal communicator; 2) the PC modem card; 3) the mobile data radio; and 4) the SCADA box.

THE PERSONAL COMMUNICATOR

To provide an illustration of a personal communicator application, most of which have yet to be imagined, let's assume that Mike wishes to book a meeting with Sue next Tuesday at 10:00 a.m. Mike pulls out his palm-top communicator from his jacket pocket and accesses Sue's appointment calendar, stored in her communicator. He sees "busy" or "open" on a calendar graphic, and sends a request for Sue's open slot on Tuesday at 10:00 a.m.

Sue has just completed a review of her stock portfolio—stored on her broker's computer—and is currently transferring funds from her brokerage account to her savings account. She now sees Mike's request and decides to cancel the request and book Mike's open slot for Thursday. Mike confirms, and the meeting is set. Both have access to a vast array of public and personal information, including weather, airline reservations, office mail, and fax communications through the Mobitex fax gateway (text messaging only).

First of all, the Mobitex Network Operators are committed to providing the necessary gateway and database connectivity illustrated in the above scenario. That's the easy part. More difficult is the expansion of radio coverage to adequately provide this type of service. In-building penetration of 900 MHz through the metalized windows of today's office towers is no trivial task. It is unlikely the personal communicator will function from within an elevator, or parking garage, unless a micro-cell radio base station is dedicated to the building. This level of radio coverage commitment by the operators is still a few years away.

Secondly, the necessary components, such as microprocessors, nonvolatile RAM, display tablets, and radio/modem technologies readily exist today. The major engineering obstacle is one of packaging and manufacturability, although antenna design and power supply deserve honorable mention. To cram it all into a 6 x 3.5 x .75 inch space is an enormous undertaking that only well-capitalized industry heavyweights can accomplish. I'll hazard a guess that it would take a team of 20 seasoned specialists at least 18 months to produce a lab prototype close to what manufacturing would require. Recent advancements in the cellular telephone technologies of PCN (Personal Communications Networks), small pocket telephones, and advent of personal information managers will go a long way to assist development.

The above demands a significant level of capital investment by both the manufacturer and the network operator in order to successfully commercialize the personal communicator. No doubt both will require sufficient guarantees from each other before embarking on such an escalation.

On a technical note, the operating temperature range of the communicator is far less than the mobile data radio or the SCADA (Supervisory Control and Data Acquisition) box. This relaxes the requirements for temperature stability of the receiver's local oscillator, thus reducing cost. The Mobitex base station has a carrier stability of 0.1 ppm at 900 MHz (very expensive oven stabilized crystal). The MTS requires a maximum 1.5ppm for terminal radio transmitters and only states a bit error rate sensitivity for the receiver, side-stepping the issue of receiver frequency drift.

This is a wise move for the author of a requirements specification, because in actual fact, the BER sensitivity is a function of quality of the modem demodulator, the noise floor and stability of the frequency synthesizer, and the phase linearity of the I.F. filters. Each of these components can cost from a few dollars to hundreds of dollars.

It is essential that the designers of the modem, synthesizer and receiver work together to cost optimize the design. In isolation, each can justify using a "Lambourghini," ultimately destroying the cost feasibility of the product. This commercial product with a modulation of 8Kbps at 900 MHz in a 12.5 KHz channel is not boilerplate to an RF engineer.

THE PC MODEM CARD

If you haven't noticed, the PC has become mobile. Laptops, pen tablets, and notebooks running 386 enhanced mode—amazing. Obviously, mobile data communications has found another partner.

One manufacturer is already supplying laptops with built-in high speed cellular modems. I won't be tempted here to enter into a debate on the efficiencies of packet switched versus real-time data transmission while using one of our most limited resources.

Some believe an external Mobitex modem is the way to go for a commercial product. After all, it could connect to any PC. Others believe that since an internal modem can operate on a PC I/O port it can offer more functionality.

For now, let's follow Tony, a field service technician, on his way to a customer's site. He smiles at the reception clerk because he has his 386 PC laptop with an integrated CD-ROM reader and Mobitex modem. No longer does he have to carry his technical manuals, diagrams, or invoice clipboard. He gets introduced to the problem and immediately checks with his office computer, querying the last few service reports at this site. He discovers that Fred was in last week and fixed the identical problem.

Realizing he was about to do the same thing that Fred did, he now searches through his technical diagrams for the real solution, finds it, and fixes it for good.

Reducing his knowledge-based service application to an icon, he clicks on the Mobitex program and calls up a blank invoice form on his central office computer. He fills out the service report and invoice. Remembering the fax machine at the reception area, he instructs the computer to immediately send a copy of the invoice. By the time he requests and reviews his next assignment, the invoice is waiting in reception for his endorsement.

The above suggests an internal Mobitex modem. Tony should not have to carry an additional piece of equipment and should only be concerned with the battery charge of his laptop, not an additional modem. The cost of development is far less than the personal communicator—there is far less to develop. The PC modem is just that—only a radio/modem. Packaging considerations remain high on the list.

With a larger enclosure, a better antenna can be designed. Also, since the unit will not be in operation while resting near the human body (like the communicator), the receiver will function better. The transmitter will have a larger battery to consume, so transmit power can be greater. All this results in relaxing the network RF coverage demands suggested in the above communicator example. The network is ready for this device today.

Software and hardware development companies, big or small, can leverage existing company expertise and make this product a real success. Early entry into an industrial market has been from specialized, handheld terminal manufacturers supplying inventory stocking and transportation management systems.

THE MOBILE DATA RADIO

The vehicular use of wireless data communications is a classic example of use of mobile data radio products. Public safety organizations such as police, ambulance and fire, as well as taxi, transportation and courier services, have been using data radio products for years. Most operate on private systems.

Many large terminal manufacturers offer a wide variety of terminals to marry with data radios. Currently, Ericsson is the only supplier of a 900

MHz, 8Kbps Mobitex data radio. The price is higher than what would be expected from an American supplier. Ericsson is not a volume radio supplier. They have publicly stated they will not expand their production facilities to meet the rising demand. They have also shown their commitment to the "generation of wealth philosophy" of Mobitex by offering assistance to other manufacturers.

In Sweden, there is a very interesting application called MobiMed. In an ambulance, a mobile data radio is connected to an array of monitoring equipment. A patient's vital signs are transmitted to the hospital while the ambulance is onroute. The vital sign data is efficiently compressed and inserted in the 512 byte Mobitex packet for transmission. At the hospital, a complete ECG graphic is reassembled, along with other critical parameters. All this is accomplished on a 1200 bps packet switched channel.

This is an extreme example of data compression and efficient use of the Mobitex communication channel. Nevertheless, all application developers must utilize the channel in the most efficient way possible. After all, it is the end user who pays the network operator for the ongoing traffic charges. I am quite sure that when users evaluate competitive applications, this will be an issue.

THE SCADA BOX

A SCADA box can be big and ugly. Who cares? Nobody sees it. It sits on a pole top ready to switch an electrical power grid. It counts cars, people, or connects point of sale systems. It measures wind velocity, water flows, or functions in your home as an alarm system, while metering and possibly controlling electricity, water and fuel.

Environmental considerations may include RFI from industrial equipment and wide operation temperature range. There is no need for the highly integrated ASIC circuitry needed in the PC modem and personal communicator devices. A discrete circuit approach will make the unit cost-effective, even in low production volumes. Virtually all components of this unit can be purchased off-the-shelf. Benefitting from economies of scale is essential—the SCADA market is cutthroat.

Developing and supplying application software, GMSK modems, and radio transceiver modules to this market is an entrepreneur's gold mine. The capital investment for development and production is minimal, and within the reach of most small organizations.

With the above four illustrations in hand, we will move on to part two next month. □

THE MTS—PART II

The second half of a series on the Mobitex Terminal Specification looks at the modules which compose four terminal products.

By Robert J. Fraser, PE

Last month, in Part 1 of this article, we reviewed the evolution and administration of the Mobitex Terminal Specification (MTS) (See *Communications*, July 1991, page 33). We also looked at four possible terminal implementations: 1) The Personal Communicator; 2) The PC Modem Card; 3) The Mobile Data Radio; and 4) The SCADA Box. In this issue, we will examine the modules which construct these four "terminals," and identify module functionality by reviewing MTS requirements. (In this article, the term "terminal" refers to a Mobitex access device with an integrated radio and modem.)

FOCUS ON TERMINALS?

Why focus a Mobitex article on terminal products? Why not other crucial technical ingredients to the mobile data solution, such as: application software, system architecture and features, or network protocols? First, the above issues have been addressed in various publications, whereas radio/modem issues have little press. Second, it is the open publication of the radio/modem specifications and protocols within the MTS which differentiate Mobitex from other mobile data networks where these specifications are proprietary. Finally, it is my personal belief that Mobitex will advance from its current North American position of market competitor to market dominance, with the introduction of many suppliers offering a wide variety of highly functional and cost-competitive terminal products.

Before we explore and compare the functional components of our four terminal products, we must first take a step back and do an overview of some basic Mobitex network concepts.

NETWORK OVERVIEW

Before diving into the MTS, get a copy of the Mobitex Network Overview published by both RAM (United States) and Rogers Network Services (Canada). Better still is a two-day seminar offered by both RAM and RNS, prepared and presented by Eritel, entitled "Mobitex System Overview Course." The course notes are worth the price of admission.

Without going into detail, the network can be described as a distributed intelligence architecture consisting of many hierarchical levels. At the lowest level are the radio base stations. A number of base stations are connected to a MOX (Swedish acronym) or area exchange. The MOX is also the connection point for fixed terminals (FST) and other land-based application data links. In turn, a number of MOXs are connected to an MHX (main exchange), which finally connects to the Network Control Center (NCC).

There are two fundamental concepts regarding this architecture which will assist the beginner. First, all communication with the network is facilitated by the use of Mobitex Packets (MPAK). An MPAK is up to 532 bytes in length (512 information bytes) and contains all text, data or status communications plus source and destination Mobitex Address Numbers (MANs). If an FST is connected to a MOX using, as an example, an X.25 PDN link, then the FST is responsible for parsing and encapsulating the MPAK within the X.25 packet(s) for communication to the MOX.

In recognition that the above, in some cases, may be a burden to interoperability, both RAM and RNS are adding a gateway to allow session management for standard X.25 and SNA networks, and encapsulation of asynchronous streams on a limited basis.

Second, each network node maintains subscriber information of the node(s) below it. For example, if a terminal decides to roam to a new base station because of poor signal quality from the current base, the network will move the subscriber information from the old base to the new base station node, once the new base receives a roam message from the terminal. The concept of where the subscriber data resides assists in understanding how all messages are routed, including group calls, emergency calls, mailbox and personal subscription features. Furthermore, the prevention of catastrophic network failure, due to node link failure, can be more readily understood because nodes have both the intelligence and the data to operate autonomously.

APPLICATION SOFTWARE

The primary ingredient to successful application development is an intimate understanding of the end user's requirements. This equates to understanding the user's minute-by-minute communication needs, and designing suitable presentations of forms and keyboard sequences to simplify the transactions. This is the most critical part of any application. Success or failure rides on how comfortable and confident the user is with his/her new tool, regardless of how sophisticated and elegant the underlying network and technologies are.

To assist in interfacing applications with the network, there are many Application Programmers Interface (API) tools available either from third-party vendors or the network operators. Some of these are: ACUTUS from Ericsson, MOBILIB from RAM or RNS, and AVITEX from AU Systems AB. In addition, the network operators, with the assistance of Eritel, present an application developers seminar. This three-day course addresses all aspects of developing a Mobitex application.

OSI MODEL

The key to unlocking the content of the MTS is a solid understanding of the International Standards Organization's Open Systems Interconnect standard. The standard is a guide which assists developers of communications technology to categorize various levels of protocol and functionality, in order to facilitate connectivity between hardware or software modules. In fact, the 20-chapter MTS table of contents, for the most part, is based upon this model. If you are not familiar with the OSI model then stop reading this article, and any other Mobitex literature, until you are.

The MTS fully documents the requirements of the first three layers, physical, data link and network, for both fixed and mobile terminals. It combines OSI layers 4 to 7 (transport, session, presentation, and application) in one Mobitex application layer, and suggests the functionality of these layers should ideally be in the hands of the application developer. In other words, the network will not guarantee the in-order transport of consecutive packets, manage temporary virtual sessions, or has rules relating to the format of pages and forms. Those who want everything complain that there is no fully implemented Mobitex OSI stack. Those who see the competitive benefits of proprietary data compression, forms handling, and LAN interfacing, applaud Eritel. MOBILIB and AVITEX provide a network layer API, where ACUTUS, in addition, provides a true application layer API.

With the above introduction of some vital concepts inherent to Mobitex, we can now move to further analyses of the modules which make up our four terminal products. Obviously, each requires a radio, a modem, some form of microcomputer or processor, and some sort of I/O, whether it be a human interface or a machine

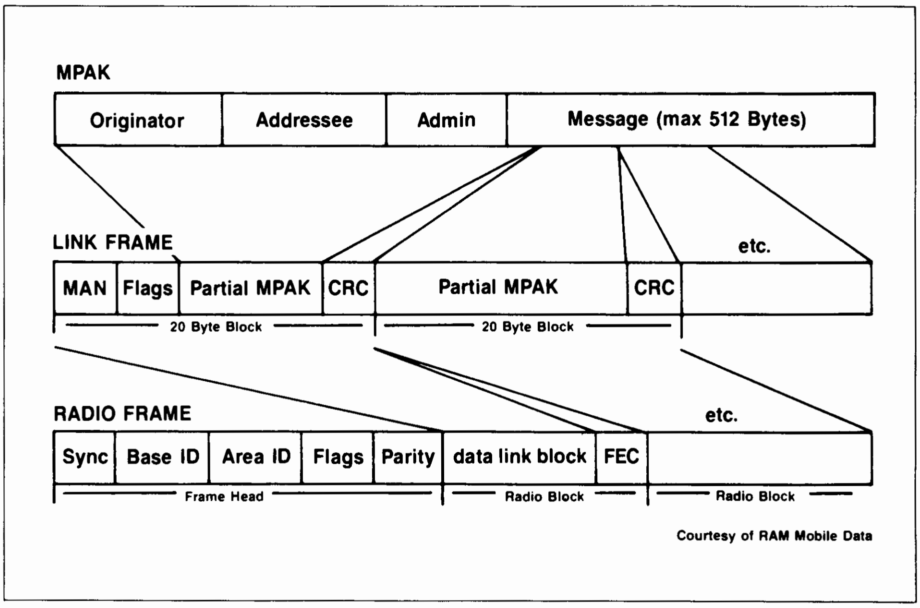


Figure 1.

	OSI Model	Mobitex	Terminal
7	Application		
6	Presentation		
5	Session		
4	Transport	Application	Human Interface Application Module
3	Network	Network	Network Module
2	Data Link	Data Link	MCU
1	Physical	Physical	Radio/Modem

Table 1.

interface. If we use the OSI model, then the functionality of each module becomes more apparent.

Table 1 compares the Mobitex layers with the OSI model, and further identifies hardware and software modules associated with each layer. We see the full OSI stack along with the Mobitex stack stopping at the application layer. We also see how each module of the terminal associates with the Mobitex stack.

As a result we can now explore the functionality of each module. For the case of the Personal Communicator, the application function resides within the unit, whereas with the other terminals, a machine interface is required to communicate with an attached unit which contains the application functions.

If we begin at the network module, we see it interfaces the application layer with the link layer. Consulting the MTS, we discover the prime function of the network layer is to form an MPAK from data, text or status information passed to it from the application layer, and send the MPAK to the link layer. Furthermore, if for any reason the MPAK cannot be delivered, the link layer returns it (negative acknowledgement). In the other direction, the information portion of the MPAKs arriving from the link layer, for the terminal, must be passed to the application layer.

With these basic functions in mind, the rest is almost intuitive. In order for the network layer to create the MPAK, it must be aware of its own MAN number, and must receive the destination MAN from the application layer. In order for the network layer to know why an MPAK has been returned from the link layer, all MPAKs have a status field called traffic state. Some traffic flags are: no transfer, illegal destination MAN, in mail, and OK.

The rationalization of other Mobitex features, such as mailbox, group lists, and personal subscriptions, fall in place following the basic network layer rules.

THE MCU

The Mobile Control Unit (or Modem Control Unit—whichever you prefer) is the brain behind the radio link. The MCU controls the radio, the modem, and provides the functionality of the data link layer. It sends and receives MPAKs to/from the network layer and formats the MPAK for transmission over the radio channel. The radio link protocol is referred to as ROSI (Radio OSI) and the construction of an ROSI frame is illustrated in Figure 1.

In general, the MPAK is parsed into 18 byte blocks. Each block is terminated with a 2 byte CRC 16 calculation. The block is then fed into a 20 by 8 matrix and a 4 bit, (12,8) shortened Hamming code is calculated for each . row, producing a 20 by 12 matrix. The radio frame block is then constructed by reading the matrix columnwise, thus interleaving the data. The sequence of blocks are then XORed with a scrambling code to reduce the consecutive 0s and 1s. A frame head is then added, consisting of a 2 byte bit sync pattern followed by a 2 byte word sync pattern, Base ID, Area ID, flags and parity. The entire radio frame is then passed through a level shifter at 8 Kbps, producing a 4 KHz waveform which is lowpass filtered by a "Gaussian-like" filter and presented to the radio VCO for direct modulation of the transmit carrier, which is not allowed to deviate by more than ±2 KHz.

The bit sync allows the demodulator time to train on bit boundaries, while the word sync (also network ID) yield the byte boundaries. The scrambling code is added to reduce DC in the modulation waveform. By interleaving the blocks with Hamming coding, an RF noise burst can destroy up to 20 consecutive bits in a block without loss of data. When the block is placed in the receive matrix, only one bit per row will be lost and it can be reconstructed from the Hamming coding. Finally, the CRC coding of each block provides a last check of data integrity before the MPAK is produced.

A smart MCU/Modem will decode the first block. Extract the MAN and compare it with the mobile MAN, group list and personal subscription list, to determine if it is the intended receiver of the frame. If not, the MCU has better things to do than to decode someone else's message.

Besides managing network and physical layer message encoding/decoding, the MCU must periodically instruct the radio receiver to scan in search of a better base station and measure the signal quality of each channel, keep in constant synchronization with the current base transmissions so it knows what time-slot it is allowed to send a frame in, and correctly react to special control messages sent by the base.

The design of the various modules which make up our four terminal products can be of many forms. The component choices are primarily a matter of cost and packaging. A discrete circuit modem with an inexpensive MCU is possible and may prove to be the most cost-effective. Another option may be implementing the entire MCU/modem and network module on a single DSP. With today's new DSPs with high level compilers and multitasking operating systems, there may be enough real-time left for all the non-modem functions. Besides, the modem is only simplex.

A good team effort between the radio design group and the MCU/modem design team is essential for a positive outcome. □

About the Author

Rob Fraser is an independent wireless data communications specialist. He can be reached in his Toronto office at (416) 470-1408.