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Data Delivery

Although voice conversations have been the driving force behind the development of cellular and PCS networks, demand for data services is on the rise. Legions of mobile office workers and the explosion of the World Wide Web have created a demand for reliable, high-speed data connectivity, and network operators are fielding a variety of solutions. This month we'll take a look at three data delivery solutions available with current cellular systems in the 800 MHz band.

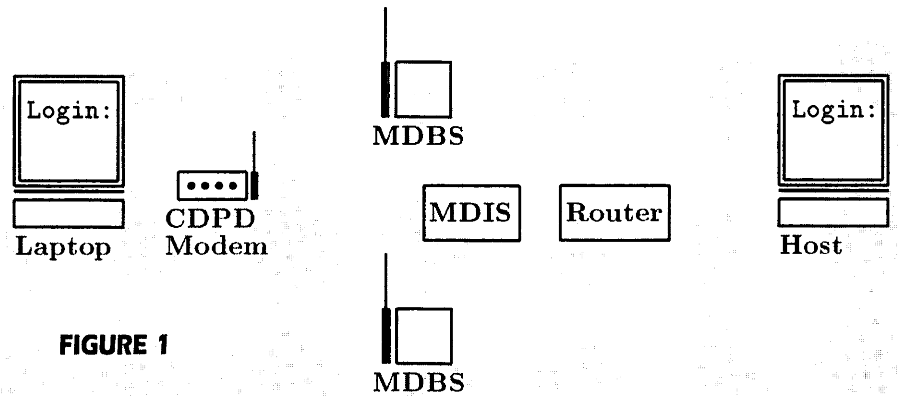

FIGURE 1

■ Cellular Circuit Switched Data

Just as a landline modem call dedicates a circuit for the duration of the connection, a cellular circuit switched data connection uses a cellular channel for the length of the call. Although the actual channel may change as the mobile user is handed off from one cell site to another, one channel is devoted for the exclusive use of a single data connection. The cellular system doesn't know the difference between a voice call and a data call and provides the same 30 kHz bandwidth channel for data use that would normally carry voice.

In a manner identical to their landline counterparts, cellular modems convert the bits from the computer into analog signals that fit within voice frequencies. These signals are then transmitted just as a cellular telephone would transmit a human voice. Analog signals coming into the modem are converted back into bits and delivered to the computer.

Because data calls suffer from the same audio quality problems that plague voice calls, most current cellular modems incorporate industrial-strength error detection and correction. The two most popular methods are enhanced throughput cellular (ETC), developed by AT&T Network Systems (now Lucent Technologies, Inc.), and microcom networking protocol 10 enhanced cellular (MNP-10EC), from Rockwell International.

ETC-capable modems can send data up to 14,400 bits per second (bps), and a newer version called ETC2 has an advertised speed of up to 20,000 bps. Depending on whom you believe, MNP-10EC is either just as good or somewhat worse than ETC, but each of these protocol enhancements detect and correct errors in the transmitted data, and can dynamically adapt speeds and other parameters to changing environmental conditions. Despite these efforts, however, real-world data transfer rates fall far below the advertised modem speeds due to interference, fading, and other hazards inherent in a mobile radio platform.

A cellular circuit switched data call goes through four phases: setup, where an available cellular channel is found and the call is placed (the number is dialed); handshaking, where the far end modem negotiates with the local modem on speeds and coding methods; session, where data is exchanged; and teardown, where the modems disconnect and the call is terminated. The setup and handshaking time can average 20 to 30 seconds or more, and for small amounts of data this can be a significant portion of the cost of the call.

Cellular circuit switched data has the advantage of being widely deployed and utilizing mostly standard equipment. Almost anywhere a cellular voice call can be placed, circuit switched data may be used, with no additional equipment investment required by the cellular system operator. Drawbacks include lower data transfer speeds and high error rates due to radio link noise and interference. Calls are also billed at the voice rate, which can be rather expensive.

■ Cellular Digital Packet Data (CDPD)

CDPD optimizes the use of cellular frequencies by transmitting data on idle voice channels. If one of the many voice channels at a cell site is not in use at a particular time, the cellular operator may temporarily transition that channel to CDPD service. If the cell site needs the channel to handle a voice call, it can quickly transition back. In this way the cellular operator need not permanently dedicate a lucrative voice channel to provide data service.

Several new items are required to implement a CDPD network. The mobile CDPD user needs a subscriber unit, consisting of a cellular radio, a modem, and a computer that creates and receives packets. This setup is referred to in "CDPD-speak" as a Mobile End System or M-ES.

In contrast to a standard modem, a CDPD subscriber unit uses the channel only intermittently to transmit short bursts of data, called packets. These packets have a fixed amount of space, called the payload, in which user data may be placed. The packet also contains addressing information that identifies the source and destination of the data. Postcards sent through the mail are a good analogy to packets—each has a destination address, return address, and a place to put a short message.

At each cell site is a mobile data base station (MDBS), which retrieves packets from the M-ES and creates packets to be transmitted back to the mobile unit. The MDBS units are controlled by a mobile data intermediate system (MD-IS), which routes packets between MDBS sites and other networks, including the Internet. It also keeps track of where a particular M-ES is located so that packets destined for a mobile user are delivered to the appropriate cell site.

Since a subscriber unit does not need to transmit continuously, the selected CDPD channel may be shared by more than one user. CDPD subscriber units listen to the forward channel (cell site to mobile) before transmitting. The forward channel, when being used for CDPD, contains sychronization and timing information for every subscriber within range. It also contains the reverse channel status, whether busy or idle. A CDPD modem with data to send listens to the forward channel and waits for an idle indication. It then transmits a packet on the reverse channel and waits for a status message from the MDBS. If another subscriber unit transmits on the same reverse channel at the same time, the MDBS will report a collision and each subscriber will wait a random amount of time before attempting to retransmit. This is very similar to the method used to send information on Ethernet local area networks. Packets from outside networks destined for a subscriber unit are routed to the nearest MDBS and sent over the forward channel.

CDPD subscriber units are capable of transmitting at up to 19,200 bps, and the equivalent call setup time is only few seconds. This makes CDPD very efficient for sending small amounts of data. Since multiple users share a single CDPD channel, it is also an efficient user of channel capacity for short data packets.

Since CDPD uses only idle voice channels, cellular operators are able to more fully utilize expensive radio equipment and provide data service to users without needing an additional license from the FCC. Operators are hoping that the World Wide Web will be the "killer application" for CDPD, since the short-query longer-response pattern of web access fits CDPD capabilities well. Manufacturers are already producing handheld computers designed to use CDPD and handheld device markup language (HDML, a subset of the common hypertext markup language used on web pages today) to allow mobile users to access the text portion of web pages.

CDPD is currently available in more than 100 markets in the United States, and many providers have interconnection agreements allowing customers to use their CDPD equipment in any of those systems. Since additional expense is required on the part of the cellular operator to install CDPD equipment, it may never be available in some remote or low use cell sites. Also, in some high demand cellular markets such as Los Angeles, CDPD may not be available from some cell sites because all the channels are in continuous use carrying voice calls.

Modem Speeds

Speed (bps)	ITU-T standard
300	V.21
1200	V.22
2400	V.22*bis*
9600	V.32
14400	V.32*bis*
19200	V.32*ter*
28800	V.34

■ Cellemetry

Not all users need to move large amounts of data. Some applications, such as alarms, meter reading, or package tracking, have only a few bytes of information that need to be moved. BellSouth is promoting a data delivery method to meet such needs called Cellemetry, short for cellular telemetry.

As discussed in the November 1996 column, control channels in a cellular system are devoted exclusively to support functions: locating and paging phones, collecting customer calling information, and registering roaming phones. Since a single control channel can handle more than 30,000 registrations each hour, often these channels are actually carrying data less than ten percent of the time. Cellemetry uses small, inexpensive cellular radios to transmit and receive very short messages on these underused control channels. Cellemetry radios mimick a roaming phone and use a phantom phone number to register and send data.

Cellemetry needs only a single additional piece of equipment, called a gateway, at the mobile telephone switching office (MTSO) to interface the cellemetry network to the radio equipment, allowing data to pass between the cellemetry radios and the customer. The system is also attractive to cellular operators since the entire region is covered from the first day of installation. Cellemetry data is carried on existing equipment and connections between cell sites and the MTSO, and does not interfere with other traffic.

The radios are inexpensive, since less hardware is needed than even a cellular telephone—just the radio portion and a small microprocessor. No speakers, microphones, keypads, or other human interfaces are necessary, and current cellemetry radios are just slightly larger than a thick credit card.

In a typical installation, a cellemetry radio is installed in a vending machine and transmits when the machine is running low on supplies or needs more change. The vending machine owner may also query the machine to get status information. Since the amount of data to be transmitted is very small and the cost of the equipment is minimal, cellemetry may be an attractive option for those who would otherwise be unable to afford wireless data connectivity.

■ Which to Use?

Which cellular data solution to use depends on the application and the amount of data to be sent. Circuit switched cellular data calls are billed by the minute, just like voice calls, and are generally better for sending amounts of data greater than about 2 kilobytes. Cellular digital packet data, where it is available, is billed according to how much data was transferred, not how long it took. CDPD is almost always cheaper for amounts of data under 2 kilobytes. This threshold is subject to change, of course, as cellular operators change pricing strategies and compete for business.

Speaking of competition, cellular is not the only solution for mobile data connectivity. Several other frequency spectrum users offer data services, and we'll take a look at some of them in future columns. Until then, comments and questions are welcome at **dan@decode.com**, and more information is available on the Grove Web Server at **http://www.grove.net/~dan**. Happy monitoring!