Motorola's
Personal Networks Group

FLEX™ Technology
O V E R V I E W

Introduction

Paging has penetrated the mainstream consumer market. Paging has become a way of life that allows executives and teenagers alike to communicate wherever and whenever they choose. Up until recently, paging services consisted of mostly tone, numeric and short alphanumeric messages. The current trend toward consumerism has resulted in a surge in paging customers along with the need for increased capacity to satisfy the subscriber's demand for more pager features and longer alphanumeric messaging.

Paging seems like magic to many subscribers, as carriers provide seamless communication utilizing the most beneficial paging protocols (a set of rules which "make pagers page"). A paging protocol is a critical enabler to meeting the service provider's business needs. Without the ability to increase capacity, service providers will not expand their customer base and meet customer demand - probably resulting in stagnated revenue.

In the early 1990s, Motorola listened carefully to its customers worldwide and anticipated the need for a paging system that would address increased demand and committed a group of the world's best engineers to develop a paging protocol that would become the global standard for high-speed paging. The result of their collective efforts was the release of the FLEX™ paging protocol. The FLEX protocol is a multi-speed, high-performance paging protocol adopted by leading service providers worldwide. It is generally accepted as the global de facto standard for high-speed paging.

Components of a Paging System

The primary elements of a paging system are the input source (most often a telephone), the public switched telephone network (PSTN), one or more paging terminals and transmitter equipment, as well as the messaging unit (a pager). A paging system is typically operated by a service provider or "carrier" who incurs the cost of building and operating the system. Each service provider licenses spectrum from the authorized government body, i.e. the Federal Communications Commission (FCC) in the United States, to operate a paging frequency, or channel, within a regulated geographical area which is either local, regional or national in scope.

- *Input Source*
  The input source can be a personal computer, telephone, desktop entry device (leased or sold by the paging service provider), or an operator dispatch where someone is paid to take and enter a message.

- *Telephone Network*
  Pages are sent out over a local phone system, referred to as the public switched telephone network (PSTN), which is owned and operated in the United States by Regional Bell Operating Companies, or RBOCs. In many countries of the world, the Postal Telephone and Telegraph (PTT) still operates both local and long distance telephony. The PSTN provider owns the "local loop," which is typically a twisted pair of copper wires, and provides connectivity from the input source (telephone, fax machine, computer, customer owned PBX) to a PSTN-owned Central Office Switch.

- *Paging Terminals and Transmitter Equipment*
  Paging terminals and transmitter equipment, or radio frequency (RF) link systems, may be owned and operated by large institutions, e.g. hospitals, fire departments, state and local governments, for their internal operations, but more typically are provided by paging service providers who incur the cost of building and operating a paging system for organizations that do not want to invest in this type of equipment. The paging terminal serves as an interface to the public switched telephone network, or to a private switch (PBX) if public access is not required.

  The paging terminal, like private telephone switches, cellular switches, voice messaging systems, etc., are viewed by the PSTN as "just another switch," and are connected to one or more switches in the PSTN through one or more trunk circuits. The paging terminal is responsible for receiving, processing, storing and forwarding information from the caller. The paging terminal validates the type of call, determines the authenticity of the subscriber and serves as the interface to the RF network or to other paging terminals within a multi-city paging network. The RF network, often comprised of several transmitters, accepts the data from the paging terminal via telephone lines, RF link or satellite, and decodes the data streams containing the paging data. Upon decoding the data, the transmitter translates the paging data into signals that modulate the RF paging signal at the desired transmit frequency.

- *Pagers*
  Pagers can be leased from a paging service provider or purchased through various retailers. There are several ways a pager can receive a message including: tone only - the pager alerts only; numeric - the pager alerts the subscriber that he or she has received a message and a phone number appears on the pager (requires a touch tone phone - rotary phones will not work); alphanumeric - text and numbers appear on the pager either in real time or retrieved from memory like an answering machine; and voice - the message is heard audibly from the pager. The subscriber can often select the method in which he or she is alerted, whether it is through visual stimuli (an icon or LED flashes), audible stimuli (a standard alert is a beep, a pleasing alert can be a chime or sequence of musical notes) or silent stimuli (vibrate mode).

How Does a Paging System Work?

A sender uses one of the above-mentioned input sources to send the message or page through the local phone system, or PSTN. The PSTN "switches" the page to a carrier paging terminal. Once the paging terminal receives the page, it processes, stores and forwards information from the caller. Additionally, it encodes the page for transmission through the carrier paging system. Typically, an encoder accepts the incoming page, validates the pager address and "encodes" the address and page into the appropriate paging signaling protocol. Once the page is encoded, it is sent to the RF link system which includes the link transmitter and link receiver. The link transmitter sends the page to the link receiver, which is located at the various paging transmitter sites along the channel. The transmitter then broadcasts the page across the coverage area on the specified carrier frequency.

Signaling Protocol - The Brains Behind Paging

At the root of all paging systems is the paging signaling protocol. A paging protocol is like a body's nervous system, controlling the messages sent to the brain which enables "thinking." A protocol is a type of language, or set of rules, that allows information to flow over a telephone network through the airwaves and connect with a pager. These rules dictate capacity, latency and signaling speed, pager battery life and data integrity, all critical qualities in the eyes of the service provider and end user.

The Evolution of Signaling Protocols

The Early Days of Paging

What we now take for granted from paging service providers in the 1990s with global, nationwide, regional and city-wide coverage, began as only on-site coverage systems 40 years earlier. The 1950s era of pagers responded to a transmitted audio tone signal which only provided the ability to selectively identify a few dozen subscribers on each channel. In the years that followed, the introduction of two sequential audio tones transmitted in the proper sequence provided service to a subscriber population of 870. As technology continued to evolve, the protocol developed into an updated version referred to as five-six tone signaling which allowed the subscriber population to climb to 100,000.

POCSAG (1981)

POCSAG (Post Office Code Standardisation Advisory Group) was considered a high-speed paging protocol when it was developed. It can handle up to two million addresses per carrier and supports tone only, numeric and alphanumeric pagers. Today POCSAG operates at 512, 1200 and 2400 bits per second (bps), and is the most widely used transport protocol. However, as paging has become more widespread and requires more robust code to transport messages effectively, POCSAG has been "maxed out" and is no longer considered a high-speed protocol.

Even at POCSAG's highest operating speed, service providers are below their future projected needs. In addition, increased reliability in receiving messages is considered a true necessity. POCSAG does not have the interleaved messaging capability which provides increased burst error and fade protection. FLEX technology gives service providers the increased capacity, added reliability and enhanced pager battery performance they need today.

Golay (1983)

Introduced by Motorola, Golay is a digital encoding mechanism which allows messages to be interpreted by a stream of zeros and ones. The pagers receive this data stream and extract individual pager-specific information from each transmission.

Golay is capable of transmitting tone only, numeric, alphanumeric and voice pages. This protocol is noted for its reliability because it maximizes the probability that messages being sent are received intact. Data is transmitted using error-correcting codes to allow the pager to determine if data bits are received incorrectly and if so, replace the data with the proper information. Another benefit of Golay is improved battery life. Golay divides pagers into groups and transmits a preamble code prior to the actual page, so only pagers that fall into a particular group need to "look" for their messages.

ERMES (1990)

The European community created a new paging service that covered all of the countries in their region. This new paging protocol code is called ERMES (European Radio Message System). The protocol is capable of delivering messaging for alphanumeric, numeric, tone and transparent data paging.

The ERMES code is structured to offer its subscribers coverage throughout the European community, which requires the system operators to utilize multiple RF channels and the pager to be able to scan all channels when the subscriber is away from their home coverage area. The major goals of the ERMES protocol is to have increased subscriber capacity for all types of service, improve messaging performance under signal fading conditions and to provide the potential for a high battery saving operating mode for the pager. The signaling speed of ERMES is a constant at 6250 bps.

The FLEX Protocol

Recent trends in paging, such as the significant increase in users, as well as the tremendous growth in the volume of data being transmitted, have prompted the need for a new high-speed paging protocol. Service providers are demanding increased capacity levels and the ability to transmit higher quantities of data.

As the leader in the paging industry, Motorola predicted this trend and the limited capabilities of existing protocols, both from a channel capacity and performance standpoint. Motorola committed a group of the world's best engineers to develop a protocol that would address the need for expansion beyond the current limitations of other paging protocols, to lay the platform for advanced messaging, and to meet the needs of service providers and consumers. In June 1993, Motorola announced the FLEX protocol - a multi-speed, high-performance paging protocol which provides an upward migration path that is completely transparent to the end user.

Because the FLEX protocol is the global de facto standard for high-speed paging, leading service providers throughout Asia, North and South America, Europe and the Middle East who have adopted FLEX technology as the protocol of choice are well-situated to maximize their existing systems and move their businesses into the future of advanced messaging.

How Does FLEX Protocol-Based Technology Work?

Once data is received from the encoder, FLEX technology organizes the message into frames of data or a specific sized packet containing bits of data. There are a total of 128 frames in a FLEX protocol system numbered zero through 127. It takes exactly four minutes to transmit all 128 frames regardless of the FLEX protocol speed. The transmission of all 128 frames is called a FLEX cycle. Since one cycle has a duration of four minutes, 15 cycles may be transmitted in one hour.

FLEX Protocol Features and Benefits

The FLEX protocol code maximizes channel capacity and speed, the pager's battery life and data integrity, all key ingredients for a service provider evaluating a paging protocol.

- *Capacity/Speed*
  The FLEX protocol runs at three different speeds allowing service providers a choice in matching the potential capacity of a FLEX protocol-based paging system to their individual requirements. A fast protocol signaling speed allows lower latency for potential messaging as well as increased subscribers per channel.

  The FLEX protocol operates at speeds of 1600, 3200 or 6400 bps. In a system operating at 6400 bps, the FLEX protocol gives the service provider a capacity increase of greater than 10 times that of a POCSAG 512 bps system. When compared to POCSAG 2400 bps, the same 6400 bps FLEX protocol-based system provides a capacity increase of greater than two times. Utilizing the FLEX protocol, service providers can handle more than 600,000 numeric pagers per channel, significantly more than POCSAG. And while POCSAG has a limit of two million addresses, the FLEX protocol supports over five billion.

  Aside from the higher speeds, on a FLEX protocol-based system a pager can operate at any of the assigned channel speeds, eliminating the need to stock separate pagers for each signaling speed used in the system. Effectively, "one pager does it all" with the FLEX protocol-based pagers.

- *Battery Life*
  The POCSAG protocol is "asynchronous" in nature, necessitating a start-up preamble signal to alert the systems pagers that messages are forthcoming. This requires all pagers to be in a periodic search and decoding mode even when no messages may be sent. This excessive on-mode searching activity consumes valuable battery life.

  The FLEX protocol, on the other hand is a "synchronous" time slot protocol designed to increase the battery life of pagers. This is a key benefit for the end user. FLEX protocol-based technology extends battery life by minimizing the pager's power consumption. Instead of sending out messages at random, all paging data intended for a particular pager is scheduled into a pre-defined time slot. This allows a FLEX protocol pager to selectively decode one or more frames over each four minute FLEX cycle, so that the pager does not need to waste its battery life decoding data intended for other pagers. Depending on the subscriber's message latency preference, this active frame position can be as often as every frame, a select number of frames or as seldom as once per each FLEX cycle. This significantly reduces the power a

pager requires to operate which in turn improves battery life and permits smaller batteries and, therefore, smaller designed pager units.

- *Flexibility*
  A major advantage of FLEX protocol-based technology is its graceful migration path. The FLEX protocol easily coexists with a POCSAG or Golay system if an operator elects to operate their channel with the two protocols prior to dedicating an entire channel to the FLEX protocol. Operators currently using POCSAG 1200 or POCSAG 2400 systems on their channel would require only upgrades to their paging terminals and control equipment to introduce the FLEX protocol at 1600 bps. Since all FLEX protocol pagers can operate at all three speeds (1600 bps, 3200 bps and 6400 bps), the operator may move to 3200 bps or 6400 bps as the subscriber demand increases.

- *Data Integrity*
  FLEX technology provides accurate message delivery by offering protection from fading conditions, such as bridges or overpasses. It provides 12 times the fading protection of POCSAG 1200 and 24 times the fading protection of POCSAG 2400.

Family of FLEX Protocols

In addition to the FLEX protocol, Motorola has developed the ReFLEX™ two-way and InFLEXion™ voice protocols to create a family of FLEX transport protocols. The ReFLEX protocol is the world's first two-way paging system and the InFLEXion™ protocol, which enables the transmission and storage of voice messages, is the first advanced voice paging system. Paging carriers operating FLEX protocol-based systems are finding that two-way and voice paging are the obvious next steps for their customers. FLEX technology's graceful growth and cost-effective systems allow carriers to offer these capabilities to their customers inexpensively and conveniently.

FLEX Technologies - A Family of Products

In addition to the FLEX protocols, the FLEX Technologies offer a robust product portfolio of pagers, components, infrastructure, test equipment, enabling protocols and software. Today's Motorola offerings include:

- *FLEX Protocol-based Pagers*

  A varitety of FLEX protocol-based one-way products are available today, including numeric pagers and word message pagers.

  ReFLEX protocol-based two-way products include: PageFinder™, an advanced alphanumeric pager with the added benefit of Confirmed Message Delivery; and the PageWriter™ 2000, a two-way pager with a keyboard and based on the FLEX Operating System which enables customization and upgradeability.

  The Portable Answering Machine is an advanced voice messaging device, which is based on the InFLEXion protocol.

- *FLEX Protocol-based Infrastructure*

Motorola manufactures an array of information management, network management and radio messaging products to maximize the capacity of paging systems.

- *FLEX Protocol-based Components and Software*

  Motorola's family of FLEX protocol decoder chips, as well as one- and two-way FLEX technology receivers, modules and transceivers, are enablers of FLEX technology, aimed at making it easily available to the wireless marketplace. The FLEX decoders are available through a number of OEM manufacturers. FLEX Stack software is provided with the family of FLEX decoders for easy integration and programming of a host microprocessor.

  The FLEXsuite™ of enabling protocols provides common services such as message routing, encryption, and compression to enable applications to send messages reliably, securely, and efficiently over FLEX technology systems. FLEXsuite provides tools for application message routing, efficient information services, canned messaging, and basic message security. FLEXsuite also expands two-way paging applications to enable telemetric applications such as remote meter reading, vending machine monitoring, and other industrial control applications.

Paging Today and Tomorrow - FLEX Technology

Motorola is the leader of the worldwide telecommunications industry. For nearly six decades, Motorola has driven this vital industry sector, and will continue to lead the charge well into the 21st century. The Messaging Systems Products Group of Motorola is committed to making FLEX technology "living protocols," meeting service provider and end user requirements now and in the future. The increased usage of computers, consumer products and communication is opening up new applications for pagers. Pagers are rapidly becoming multi-tasking communication devices, giving users page, fax, voice and financial management capabilities at their fingertips plus the benefits of reliability, convenient size and low cost. FLEX technology is at the forefront of this growth, evolving from a paging protocol to a complete wireless messaging operating environment.

Visit our Web site at http://www.motorola.com/FLEX for more information on FLEX technology.