***IntAlliance Partners*' Introduction to White Paper**

Paging networks have been affected by significant market shifts over the past ten years, primarily resulting from the growth and popularity of cellular networks. However, paging networks not only continue to support a wide range of existing services, but are continuing to innovate with a growing number of new services.

Extensive regional and national coverage, two-way communications capabilities, and the ability for paging networks to instantly and reliably broadcast messages to a large number of subscribers in a cost effective manner is leading to the creation of new and unique services. As the need for wireless energy monitoring and control, security, and emergency services continue to grow, the potential for new services using the paging network is also expected to grow.

This white paper by Norbert Snobeck, an Executive Advisor to IntAlliance Partners, provides a brief overview of two-way paging network technologies and architectures. For more information on paging networks and how IntAlliance Partners may be able to help your specific needs, please let us know by going to www.IntAlliance.com and clicking on the Contact Us button.

Typical 2-Way ReFlex™ Paging Network Architecture

By Norbert Snobeck, an Executive Advisor to IntAlliance Partners, May 6, 2009

Background

Most local and regional paging networks in the US today still use POCSAG and perhaps the earlier GOLAY and other now obsolete paging formats with POCSAG being the most common. These paging formats are strictly for 1-way paging operation. These are also relatively slow. POCSAG pagers must be pre-set to a specific data rate when the pager (or 1-way remote control telemetry device) is activated and issued to the customer. POCSAG supports 512, 1200 and 2400 bps operation. Most POCSAG pagers are activated at 1200 bps for customers located in good quality coverage areas. Customers located in poor quality areas, where rough or mountainous terrain in particular can come into play, would typically be activated at 512 bps to ensure the most reliable service and to minimize missed pages when roaming. The use of POCSAG at 2400 bps is not very common.

Motorola introduced the Flex™ paging protocol to permit more flexibility in providing paging services and features supported by higher data rates to the pager or telemetry devices. Flex pagers will automatically up-shift or down-shift to a supportable data rate depending on the quality of the coverage in an area. Strong signal areas will permit higher data speeds, whereas poor signal areas force the use of slower data speeds to minimize messaging errors or missed pages when roaming. Flex™ can support 1600, 3200 and 6400 bps operation. Most paging networks using Flex™ operate in the 900 MHz band. Several VHF and UHF networks were upgraded (or initially built) to also support Flex™ paging, but the expense of upgrading network infrastructure and offering a more expensive Flex™ pager, if available from manufacturers at the time, prevented many local and regional paging carriers from going this route.

The more sophisticated paging networks employ transmitters and control units which allow multi-channel operation to conserve costs associated with tower site leases, transmitter and infrastructure deployment and the resulting operating and maintenance costs. Channel loading must be very tightly controlled in these networks to ensure low message delivery latency in the busy hour for all channels.

1-way paging channels were typically assigned with 25 kHz channel spacing in the US in the past. The FCC is moving the paging industry to 12.5 kHz channel spacing with these new requirements becoming effective in 2011 and ultimately 6.25 kHz channel spacing for more efficient spectrum utilization (and so the Commission can re-farm and auction off more spectrum), but the expense of retrofitting existing networks and replacing or upgrading the entire installed pager and telemetry device base is considerable.

2-Way Paging Networks

Motorola introduced the ReFlex™ paging protocol to support 2-way paging services. ReFlex™ allows a user to reply to a message, allows a pager to acknowledge receipt of a message without user intervention, and can also allow a user (or 2-way telemetry device) to compose and transmit a message using the reverse channel of the 2-way paging network.

ReFlex™ 2.7 is the current ReFlex™ industry standard although this standard has not been uniformly adopted or implemented by all carriers.

Many local and regional 1-way paging networks still operate in the VHF and UHF bands, although some also operate channels in the 900 MHz band. VHF networks can provide superior coverage and signal penetration in rural and rugged terrain areas and when trees are present, an important consideration for emergency service responders in remote areas. Needles on pine trees can act as tuned antenna elements absorbing much of the 900 MHz paging signal in these areas, requiring a much more costly and closely spaced network of 900 MHz transmitter sites. These same problems and costs are among the reasons that cell phone networks have also been slow to expand into these same rugged, rural and remote areas with reliable coverage given their operating frequency bands.

The large national paging carriers operating 900 MHz Flex™ (1-way) and ReFlex™ (2-way) networks and are slowly rationalizing (turning off) their older legacy and acquired/merged VHF and UHF paging networks after they have migrated their customer base to their preferred or "go-to" 900 channels. In many cases, they however willingly give up customers and revenue served by their VHF and UHF networks covering broader geographic areas and focus only on customers located closer in to their more limited but profitable urban/city-centric 900 MHz networks. The FCC auctioned off several nationwide and geographically exclusive regional 900 MHz paging channels in the past decade, hence the national carrier's business preference for using and migrating to these channels. Previously regional and nationwide channel coverage in the VHF and UHF and even 900 MHz bands often required the assembly of affiliate paging networks where perhaps one paging provider was the anchor in several cities and regional areas, but smaller carriers provided the other coverage through affiliate traffic interchange (and payment for carriage in some cases) agreements. The primary VHF channel (152.480 MHz) used by many regional paging carriers such as Unity Communications is an example of the affiliate approach. Metrocall (now USA Mobility; also combines the former Arch and WebLink Wireless networks) serves as the primary coverage provider and national affiliate traffic hub, followed by American Messaging (a combination of the former Verizon and SBC paging operations) as the second largest license holder followed by Unity Communications (now owned by Aquis Communications) as the third largest license holder on this particular frequency.

The national 900 MHz paging carriers will typically operate (or are actively reducing to) 3 paging channels in today's environment:

1. 900 MHz 1-Way Local/State Channel, Flex™ (some legacy POCSAG device support)
2. 900 MHz 1-Way Regional/National Channel, Flex™ (some legacy POCSAG support)
3. 900 MHz 2-Way Regional/National Channel, ReFlex™

The national 900 MHz paging carrier's 1-way networks can all typically support POCSAG from a technical perspective in addition to the Flex™ protocol, but all have taken the position in recent years of limiting new activations only to Flex™ devices and prohibiting any new POCSAG activations to maximize channel messaging capacity in the busy hour. For 1-way Flex™ networks, up to 64 regions or zones can be supported.

Note: Flex™ and ReFlex™ are Trademarks of Motorola.

Selected Paging Industry Reference Sources

Appendix A

The following provides a typical 2-way paging network configuration. The FCC defined 1 and 2-way paging channels as "Narrowband PCS" channels as compared to "Broadband PCS" channels as would be used for cell phone voice networks.

Source: Peter Kapsales, "Wireless Messaging for Homeland Security, Using Narrowband PCS for Improved Communication During Emergencies", March 2004, Retrieved from: BradDye.com, The Paging Information Resource, http://www.braddye.com/homeland_security.html, Retrieved on 2009-02-02.

The article excerpt follows:

The Narrowband PCS Network

A narrowband PCS system comprises the following:

- A network backbone
- An air interface
- End-user devices

Figure 1 depicts a typical system.

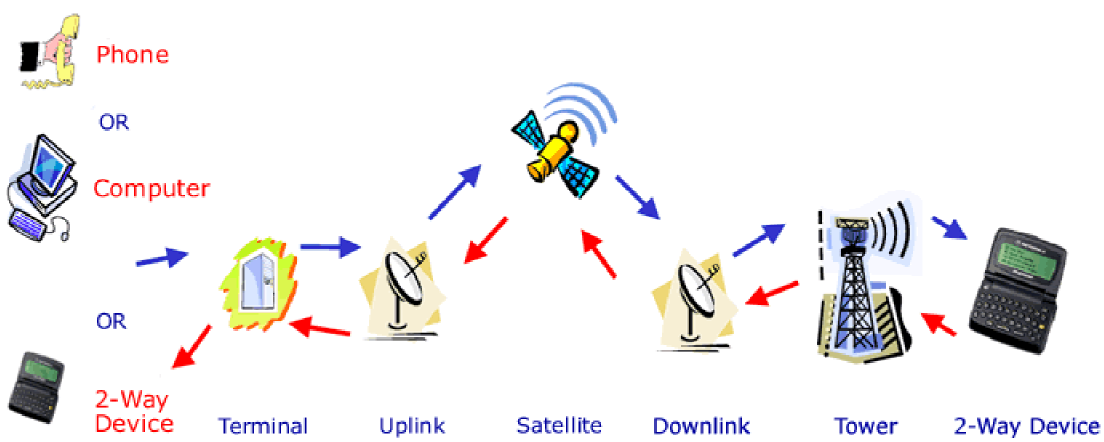


Figure 1

Messages enter the narrowband PCS system through any Internet Protocol interface into a messaging server. The messages may originate in three ways: (1) from a user who dials a narrowband PCS customer service operator, who will type the message for the caller; (2) from an Internet or email user who keys a message and addresses it to the narrowband PCS mobile user's address; or (3) from one mobile user to another using a two-way messaging device. The messaging server performs functions similar to those of a cellular network's mobile switching center, home location register, and visitor location register. The messaging server authenticates users, tracks their movement among base stations, and manages the delivery and receipt of messages. The Global Positioning System (GPS) is used at the sites for timing the forward and reverse channels of the air interface.

A telecommunications data backbone is required to transmit the message from the messaging server to the appropriate tower(s) for transmission. Most narrowband PCS systems use a satellite backbone, but transmission can be accomplished using any combination of transmission methods. Satellite systems are a favorite because of the speed and ease with which they can be deployed.

The narrowband PCS network uses an industry-standard air interface, developed by Motorola, called ReFLEX to manage communication between the base stations and user devices. The air interface is asynchronous, so it is well suited to handling the larger amounts of data broadcast from towers compared to the smaller volume that originates from a user's mobile device. Narrowband PCS networks are deploying encryption of both personal and broadcast messages based upon the National Institute of Standards and Technology's Advanced Encryption Standard.

The battery life for narrowband PCS devices is 3 to 4 weeks for an AA battery or up to 2 months for a lithium battery (depending on the device) under normal operating conditions. A narrowband PCS device can be designed to trade battery life against message latency. This trade-off can be accomplished throughout a service area for all mobile devices or for a specific subset of devices. Narrowband PCS already provides this capability, which was one of the recommendations for wireless carriers based on the 11 September 2001 Ground Zero rescue effort to maximize the chances of locating survivors.

Narrowband PCS has a far reduced dependency upon wireline telephony, since it uses satellites for both network communication and GPS timing and therefore is less subject to service outages from telephony infrastructure failures caused by a catastrophe. Service restoration is limited to bringing a power supply online, and the systems can use mobile base stations in emergencies if base stations are not operating. Blocking during emergencies is basically non-existent since narrowband PCS, as a packet data service, does not require a connection to be set up the way cellular or private radio systems do; at most it will experience latency in message delivery. Wireless packet data was the most reliable service used on 11 September by first responders and emergency managers.

Narrowband PCS Capacity

Narrowband PCS networks achieve capacity growth similar to cellular systems' growth by reducing the area covered in a serving region. In cellular telephony, this is called cell splitting; with narrowband PCS it is referred to as dividing a simulcast zone into sub-zones. The sub-zones do not have to have equal capacity. The number of channels can be adjusted for each sub-zone to accommodate traffic volumes and user density. The narrowband PCS forward channel is now at 6400 bps. The reverse channel from any given mobile device may operate at 800, 1600, 6400, or 9600 bps. Since sub-zones can support multiple forward channels, capacity is not a limitation of the service. Narrowband PCS can support 40,000 users on a single forward channel for the typical short messages that are sent on the system.

Data rates on forward and reverse channels do not have to be the same in a sub-zone. The forward channel (from the base station transmitter to the mobile user) most often operates at a faster rate than the reverse channel (from the mobile user to the base station receiver). This accommodates the need of most mobile users to have a large amount of data sent to them but to respond with only an acknowledgment or a short message. Most mobile devices (with small keyboards) are not conducive to creating a long, voluminous message; therefore, a short return message most often suffices.

If a user has a long inbound message, the network will usually reserve time on a reverse channel for transmission of the inbound message within the device's sub-zone. Those base stations associated with other sub-zones will still be available for other traffic, increasing the overall network capacity. In the latest versions of the narrowband PCS ReFLEX protocol (v2.1.1 and higher), networks can allow devices to effectively schedule their own long inbound messages and resolve any contention among devices that may be competing for the same inbound channels and time allocations. This increases capacity and reduces latency, especially for the messages using Instant Messaging or Internet Relay Chat.

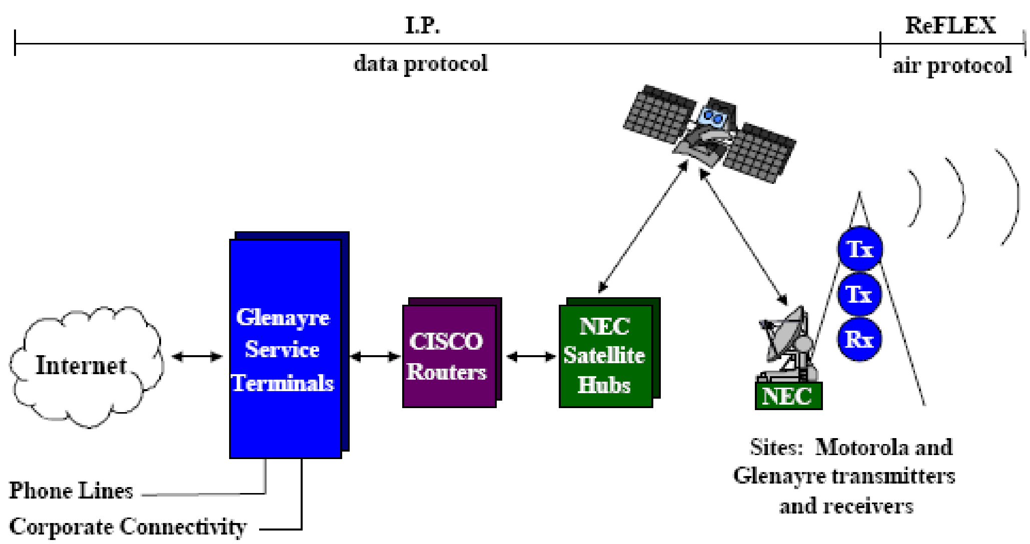
Using narrowband PCS provides better capacity than using cellular and broadband PCS to transmit data or using a private radio network. Police in the United Kingdom studied and tested General Packet Radio Service (used by existing cellular systems for data) and found that it's "too subject to overload at the time of a major incident, which is just when its needed." Third-generation cellular systems will improve data rates, but it will be years before they are deployed, and they will still be subject to overload and network failure conditions similar to what the current systems experience.

Appendix B

WebLink Wireless 2-Way ReFlex™ Network Configuration (now part of USA Mobility)

Source: N. Ross Buckenham and Allen Angus, WebLink Wireless, "ReFLEX™ Wireless Data Technology, Why ReFlex Has Become the Industry Standard for Wireless Data Delivery", September 05, 2000, ReFlex Network Design Figure on Page 14, Retrieved from BradDye.com, The Paging Information Resource, http://www.braddye.com/ReFLEX2.PDF, Retrieved on 2009-02-02.

The article excerpt follows:

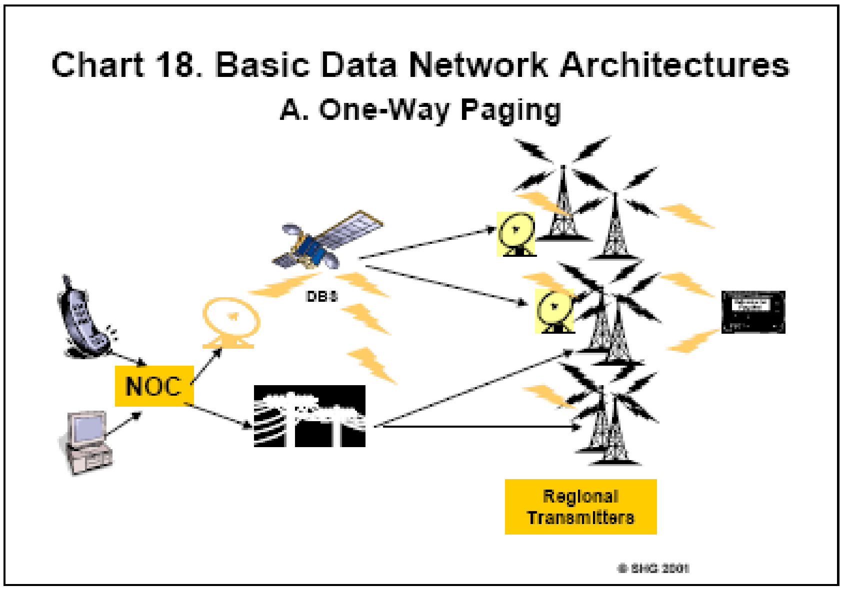


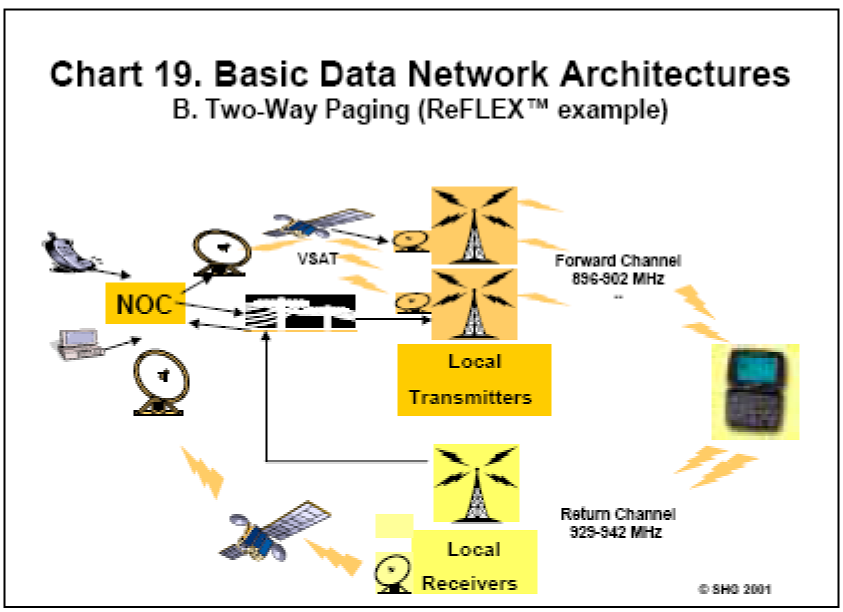
ReFLEX Network Design

Appendix C

Source: James S. Henry, Ed Resnor, and Dan Benderly, Sag Harbor Group, " ReFLEX™ Rules! The Role of Pervasive Low-Cost Networks and Devices in the Future of Mobile Data Messaging", a Sag Harbor Group White Paper, 2001, Chart 18 on Page 50, Chart 19 on Page 51, Retrieved from Content.Arch.com, http://content.arch.com/whitepaper/reflexwhitepaper.pdf, Retrieved on 2009-02-02.

The article excerpt follows:





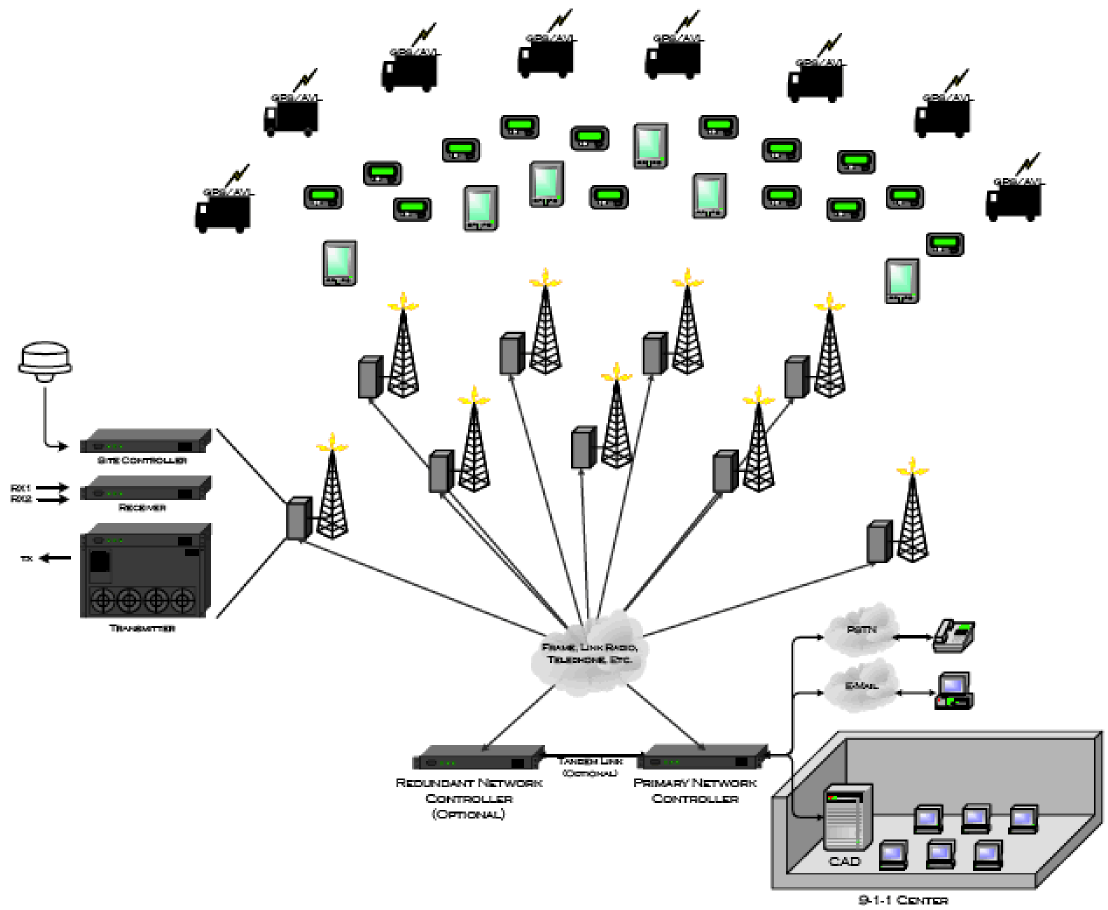
Typical 2 Way Paging Network Architecture

Appendix D

Source: Jim Weichman, [ex] Assistant Director of Communications, Monroe County, NY, "An Improved Alerting Solution for Public Safety", Attachment I, Retrieved from BradDye.com, The Paging Information Resource, http://www.braddye.com/npcs_alerting.html, Retrieved on 2009-02-02.

The article excerpt follows:

Attachment I — Typical Agency N-PCS System Implementation



Appendix E

The following excerpt provides some paging channel capacity estimates for POCSAG and Flex networks. Most paging carriers limited message sizes to 240/256 characters or less for alphanumeric messages. Unity Communications' recent experience found that average message sizes for numeric pages were on the order of 7-8 characters and in the mid-to-upper 60s for alphanumeric messages. Some national 2-way paging carriers will consider (for billing purposes) messages to be 100 characters or less. A single 280 character 2-way message would be counted as three (3) 100-character messages for billing and monthly message limit (or over-charge billing) purposes.

Source: Brad Dye, "Marketing Plan", VIII, The Future of Paging? B. New Paging Protocols, Retrieved from BradDye.com, The Paging Information Resource, http://www.braddye.com/engmktg.html, Retrieved on 2009-02-02.

The article excerpt follows:

B. New Paging Protocols

As mentioned above the speed of the information sent out to the pagers is a critical factor in figuring out the capacity (number of subscribers that can be served) of the radio channel. A difficult question, often asked is: "How many pagers can you have on one radio channel?" An accurate answer must take several factors into account such as: Busy Hour Call Attempts, average message length, paging code type, signaling speed, Grade of Service, speed of message entry, and batching efficiency. The following estimates are based on a theoretical analysis which makes "standard" assumptions. The practical limits in a real operating paging system are considerably less than the theoretical, as can be seen from the Practical Limit column under Number of Subscribers On One Radio Channel. Remember the following are only rough estimates:

Theoretical and Practical maximum numbers of paging subscribers per radio channel:

Code	Speed	Mode	Digits Characters	Theoretical	Practical
POCSAG	512 b.p.s.	Numeric	10	62,784	34,000
POCSAG	1200 b.p.s.	Numeric	10	147,456	80,000
POCSAG	2400 b.p.s.	Numeric	10	294,336	160,000
FLEX™	6400 b.p.s.	Numeric	10	668,200	426,000
POCSAG	512 b.p.s.	Alpha	40	10,464	8,500
POCSAG	1200 b.p.s.	Alpha	40	24,576	20,000
POCSAG	2400 b.p.s.	Alpha	40	49,056	40,000
FLEX™	6400 b.p.s.	Alpha	40	131,000	106,000
POCSAG	512 b.p.s.	Alpha	80	5,412	4,300
POCSAG	1200 b.p.s.	Alpha	80	12,712	10,000
POCSAG	2400 b.p.s.	Alpha	80	25,374	20,000

FLEX™	6400 b.p.s.	Alpha	80	65,500	53,000

The obvious point here is that the faster protocols will allow for much larger subscriber bases. As you probably know, POCSAG is an acronym for the Post Office Code Standardisation Advisory Group. This was an inter-industry group that worked with British Telecom in London, England to define and recommend a nonproprietary high-capacity paging code in 1980. After this code was adopted by several international standards organizations, its official name became the "CCIR Radio paging Code No. 1." It is still mostly known by its nickname: POCSAG. As the requirements for faster signaling occurred because of the rapid growth of paging worldwide, the speed of the POCSAG code was increased from 512 bits per second to 1200 and then 2400. For technical reasons 2400 is about the maximum that this code can operate reliably. The new FLEX™ code developed by Motorola and licensed to other manufacturers, is not only faster but more reliable as well. In very large market areas where channel capacity will likely become a problem, it is important to plan for the eventual migration to the FLEX™ code. Both FLEX™ and POCSAG can coexist on the same channel, so there should be no problem in starting with POCSAG and then adding FLEX™ later.

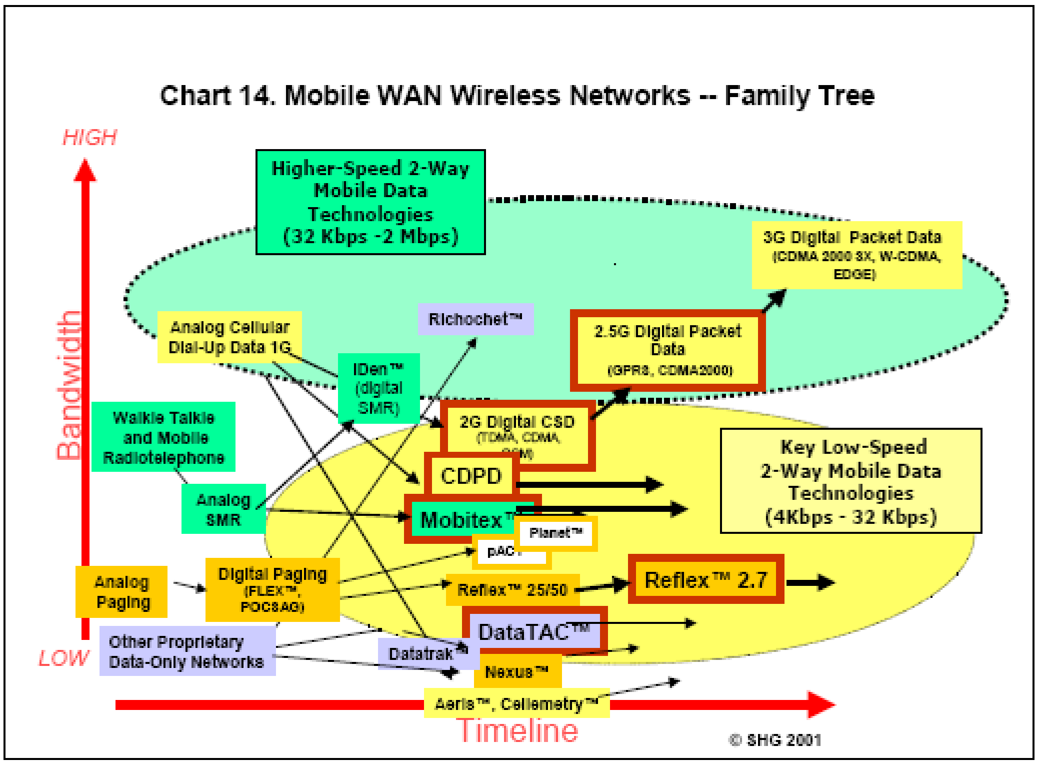
Appendix F

Source: James S. Henry, Ed Resnor, and Dan Benderly, Sag Harbor Group, " ReFLEX™ Rules! The Role of Pervasive Low-Cost Networks and Devices in the Future of Mobile Data Messaging", a Sag Harbor Group White Paper, 2001, Chart 14 on Page 44, Retrieved from Arch.com, http://content.arch.com/whitepaper/reflexwhitepaper.pdf, Retrieved on 2009-02-02.

Major Paging Protocols Noted in the Chart below:

Analog Paging (1-way)
Digital Paging – POCSAG (1-way)
Digital Paging – Flex™ (1-way)
Reflex™ 25/50 (2-way)
Reflex™ 2.7 (2-way; current industry standard)

The article excerpt follows:



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