The ReFLEX™ Advantage In Homeland Security/First Responder Applications

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1) Background:

Numerous individuals [1a, b, c] have recently observed that paging worked well during the 9/11 disasters in New York City and Washington DC as well as during the three hurricanes that hit central Florida in 2004 and the Katrina/Rita emergencies in the Gulf Coast in 2005. Generally, it is acknowledged, paging, particularly two-way paging, outperformed virtually all other forms of communication during these urgent situations.

In the belief that this superior performance is neither an accident nor a coincidence, but rather the direct consequence of a number of fundamental ReFLEX characteristics, this paper endeavors to describe the specific characteristics which allow ReFLEX to optimize the balance between functionality, cost and freedom from service interruption.

As indicated in the references at the end of this paper, a number of explanations for this "ReFLEX Advantage" have been advanced by others and are restated here in the interest of unity.

2) System Objectives:

By definition, first responder organizations operate in mission-critical, high risk environments and a communications system intended to support their activity must place the highest priority on:

- Comprehensive Radio Coverage—the system must work well throughout the area of concern;
- Dependability—the system must be redundant and ruggedized to guard against service-affecting failures;
- Verifiable Delivery—the system must confirm the receipt of messages;
- Flexibility—the system must accommodate multiple input sources and user-devices;
- Full Functionality—the system must support crisis activities (i.e. receiving and sending messages, data base queries while mobile, mobile-to-mobile communication etc.);
- Encryption—the system must be able to guard against surreptitious message interception;
- Interoperability—the system must operate in conjunction with multiple other systems, and user-devices such that a variety of agencies can coordinate their communications activities at the scene of any public safety event;
- Throughput—the system must minimize message latency;

- Traffic Volume—the system must support bursts of heavy traffic;
- Cost Effectiveness—the system must make maximum use of existing infrastructure, resources, utilities and facilities thus to safeguard public investment.

3) Public vs. Private Systems:

Many of the performance observations, referred to in paragraph 1 above, have been developed through the experiences of "subscribers" to systems that are available to the general public.

Although the technology used in "private" systems is identical to that used in "public" systems and therefore most of the advantages of the ReFLEX protocol would accrue to either public or private implementations. Private systems, however, inherently offer several advantages including customized radio coverage and dedicated, habituated user bases. Accordingly, this paper is focused on "private" systems devoted exclusively to Homeland Security organizations.

4) ReFLEX Advantages:

ReFLEX systems have been found to meet all of the objectives listed above and to do so more effectively than other systems. The following unique characteristics explain the advantages offered by ReFLEX:

4.1a) Backhaul Reliability:

Narrowband technologies, such as ReFLEX, require only narrowband backhaul support between base stations and the Central Network Operating Centers (NOCs). Thus, base stations can be, and most often are, supported by narrowband backhaul facilities, such as satellite, that are relatively resistant to interruption in the event of severe natural or man-made conditions (such as hurricanes or 9/11-type events). By way of contrast, as pointed out in a New York Times article of Sept 9, 2005, wideband technologies, such as cellular, require wideband backhaul facilities between cell sites and the serving switching center (Cellular Central Office) and cost considerations dictate that these are typically terrestrial (T1 lines, Fiber Optic lines etc.) that are inherently more vulnerable.

What millions of Americans do not realize is that cellphone service relies on land-based fiber optic networks to route calls. When customers place cellphone calls, their calls are sent to nearby antennas, which are connected to base stations operated by each mobile phone company. Those base stations pass on the calls using fiber optic lines to switching stations operated by BellSouth and other landline providers. BellSouth then sends the calls on to their destinations. If any of this equipment is out of service, whether because of fallen trees, cut cables or flooding, calls typically cannot be placed. "If we don't have landline connectivity to our equipment at the towers, it doesn't matter if it's running," said James J. Gerace, a vice president at Verizon Wireless. "Customers could be getting five bars on their phone and they can't get through." [New York Times 9/1/05]

4.1b) Mobile E-mail vs. Voice Vulnerability:

ReFLEX systems and keyboard equipped end-user devices are

optimized for sending and receiving e-mail messages which tend to be routed via the Internet and facilities other than those used for voice telephone traffic and, as outlined above, it is the voice telephone network which tends to become overloaded during emergencies.

Cellular systems, conversely, are primarily voice devices dependant on the frequently overloaded voice networks.

4.2) Radio Network Architecture

4.2a) High-Power Simulcast:[2]

ReFLEX systems typically utilize multiple high power base station transmitters each with up to 3500 watts Effective Radiated Power (ERP) with antenna heights of 300 feet or more in a simulcast network configuration[2]. In addition, the radio channels assigned to ReFLEX services by the FCC are in the 900 MHz range, which from a radio coverage and building penetration perspective, is highly idealized. The simulcast networks used by ReFLEX provide simultaneous delivery of radio signals from several base station transmitters and the overlapping radio coverage produced by this high- power simulcast technique provides inherent redundancy in the event of the loss of one or more base stations as well as wider coverage areas, increased average signal levels and improved in-building penetration.

In contrast, typical cellular systems use cell site transmitters of 100 watts ERP with 90-foot antenna heights. Operationally, cellular networks assign a single channel in a single transmitter to a mobile connection, typically with a much smaller range, and then rely on the network to "hand off" the call to another cell site (tower), but hand-off can occur only if a channel is available in the second cell site[2].

(It is noteworthy that several wideband systems currently being proposed for homeland security applications will operate at 2.4 or 4.9 GHz and propose **no in-building coverage** whatsoever!)

4.2.b) Stable Radio Coverage Areas:

ReFLEX systems use dedicated narrowband channels on which messages to individuals are transmitted sequentially. The radio coverage area in a ReFLEX system is, accordingly, a function of radio propagation factors including radio base station R.F. power levels, base receiver and transmitter antenna height, antenna gain, site location and terrain elevation along with several other classical radio propagation considerations. In all cases, however, ReFLEX coverage is totally independent of system traffic loading. If a ReFLEX device works once at a given location under any traffic loading condition, it will work in that location under all traffic loading conditions (light, moderate, very heavy etc.).

In contrast to ReFLEX systems, many cellular systems, as well as many wideband data systems, use a variation of spread spectrum communications technologies known as Code Division Multiple Access (CDMA) that shares a wideband channel among multiple simultaneous users. This sharing arrangement means that total available bandwidth

is effectively divided among all users such that, as the number of simultaneous users increases, the bandwidth available to each user is reduced which, in many instances, results in "coverage shrinkage" and the premature termination of calls (often referred to as "dropped calls").

Consequently, a cellular phone or CDMA based data transceiving device which had historically worked well at a given location, may completely cease to work during heavy traffic periods which are certain to occur during a disaster.

4.3) The Store & Forward Operating Mode

4.3a) Repeat Delivery Attempts:

ReFLEX systems intrinsically operate in a "store and forward/delivery retry" mode, which assures that multiple attempts will automatically be made to deliver both outbound and inbound messages (sometimes referred to as guaranteed delivery). These multiple delivery attempts are essentially invisible to and require no action by users and their ability to overcome failure of an initial delivery attempt cannot be matched by real-time systems such as cellular. In a cellular system, if an outbound or inbound call cannot be completed when initiated, the attempt has failed completely leaving the initiator no choice but to retry the call manually. During peak traffic periods, such as will occur during an emergency, frequent "retry" attempts can produce an "avalanching" phenomenon, which dramatically increase system traffic loading to leave cellular, and other real-time systems totally "gridlocked" and useless.

4.3b) Traffic Smoothing:

Stated differently, the Store & Forward ReFLEX operating mode tends to smooth the service demand peaks that are common during emergencies. While ReFLEX message delivery latency will be increased during emergencies, messages will be delivered in due coarse without aggravating or artificially increasing the traffic load.

Conversely, cellular and other broadband systems, will exaggerate the normal peaks in demand for service, which occur in any emergency. Conversely, cellular and other broadband systems will exaggerate the normal peaks in demand for service which occur in any emergency. The exaggerated peaks will result in gridlock, significant deterioration to the grade of service provided by the system, and the complete loss of calls.

4.3c) Benign Priority Assignment Capability:

Most messaging systems generally operate on a "first in/first out" basis but homeland security organizations occasionally need to establish several levels of priority controlling the transmission of messages such that certain individuals receive messages before others. Multiple levels of priority can be established in ReFLEX systems with each user assigned a specific priority level. Most importantly, however, the Store & Forward ReFLEX operating mode assures that, when priority is invoked, although messages intended for the highest

priority users will be transmitted first, all messages will be transmitted ultimately.

On the other hand, in real-time systems such as cellular, if priority is invoked during peak traffic periods, such as will occur during an emergency, any attempt to call lower priority users will result in failed call attempts leaving initiators no choice but to retry their calls manually. Not only will this produce a very unacceptable grade of service for those users assigned lower priority, but, as stated earlier, frequent "retry" attempts can produce an "avalanching" phenomenon increasing system traffic loading to leave cellular and other real-time systems totally "gridlocked" and useless. Although techniques have been suggested to assuage this issue within cellular services, priority service remains justifiably unpopular in cellular systems and has therefore rarely been implemented.

5) Independent Inbound vs. Outbound Traffic:

ReFLEX is asynchronous and asymmetrical and thus well suited to handling the larger volumes of outbound data (from base stations to mobile user devices) compared to the smaller volume that typically originates from the users' mobile devices.

Also, the asymmetrical, store and forward nature of ReFLEX technology makes inbound and outbound transmissions independent of one another. Thus, a ReFLEX end-user device can receive outbound messages even if it is temporarily unable to reply to the received messages or to originate inbound messages (a capability which becomes similar to one-way paging). In many homeland security situations outbound transmissions contain the most urgently required information and, while two-way communication is always desirable, the worst-case ability to receive information even under adverse conditions is a distinct advantage.

In contrast to ReFLEX systems, most cellular and wideband systems must establish bidirectional connectivity before communication can occur in either direction.

6) Efficient Group Call Capability:

ReFLEX technology, along with virtually all one-way paging technologies, support very efficient "Group Calling" that permits a message to be sent simultaneously to dozens, hundreds or even thousands of users on a single transmission. Most other technologies do not support similarly efficient group calling.

7) The Ability to Migrate From Private To Public Systems:

The ReFLEX technology and protocol used in private systems is identical to that used in public systems several of which are nationwide in scope. Also, the current ReFLEX protocol supports a feature known as "background scanning." If end-user devices move beyond the radio coverage area the private system with which they are affiliated, the background scanning facility will examine signals from other ReFLEX systems, (either private or public) and, when a useable signal is detected, the device will:

- Migrate to the system providing the useable signal (the alternate system),
- The alternate system central control will advise the private system of the migration such that future communications to the relocated end-user device will be routed via the alternate system.

Through background scanning capabilities, users can remain in communication if they move to an adjacent community, county, state or even to a more distant part of the country.

8) Summary:

Narrowband PCS has demonstrated compelling benefits in terms of functionality, geographic coverage, in-building penetration, and the ability to support reliable delivery in difficult environments. It is positioned to be extremely helpful to emergency personnel for public safety and other homeland security applications through its wireless instant messaging, broadcast messaging, email, and location capabilities. The inherent strengths of narrowband PCS features and functionality will provide an excellent means of communication as a primary or backup system for emergency personnel and homeland security.

References:

[1a] *"Wireless Messaging for Homeland Security"* Dr. Peter Kapsales, March 2004. http://braddye.com/homeland_security.html

[1b] "Message to the *Wireless Messaging Newsletter"* from Carter C. Blumeyer, Communication Specialist, FEMA Urban Search and Rescue, August 30, 2005 2:49:53 PM CDT.
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[1c] *"Fully Interoperable First Responder Alerting System Based on ReFLEX Two-Way Messaging Technology"*
Barrett M. Kanne October 2004. http://braddye.com/responder.html

[2] *"Mission Critical Paging and Messaging Capabilities,"* USA Mobility, Inc. September 21, 2005
http://braddye.com/usmo.html