Government of Canada Gouvernement du Canada

700TAG – Technical Advisory Note 1

Mission-critical voice services: a comparison of LTE versus Land Mobile Radio

700 MHz Mobile Broadband for Public Safety - Technology Advisory Group

Centre for Security Science - Public Security Science and Technology

July 22, 2011

Federal Lead: The Technology Advisory Group for 700 MHz Public Safety Spectrum (700TAG) is composed of a collaborative group of technical experts led by Centre for Security Science and includes scientific authorities from Communications Research Center, and technical experts from Federal/Provincial-Territorial/Municipal agencies.

Objectives

The objective of this Technical Advisory Note is to inform the Canadian public safety community on the differences between the nature of voice services carried over an LTE broadband network and voice services delivered over Land Mobile Radios (LMR). Specifically, the issue of whether Long Term Evolution (LTE) can deliver Mission-Critical Voice (MCV) services is analyzed. Pertinent comments and recommendations on the subject form part of this Technical Advisory Note. Recent efforts to define the operational requirements for MCV are summarized.

Technologies

LTE and LMR are fundamentally different technologies and each one handles the delivery of voice services differently. Voice over LTE is currently carried as Voice-over-IP (VoIP) packets. In the future, LTE will support voice services over its IP Multimedia Subsystem (IMS), which will transport voice more efficiently over the LTE Radio Access Network. LTE is primarily oriented towards broadband mobile data. Commercial operators view LTE as a means of off-loading the high volumes of data traffic from their voice-centric 2G and 3G cellular networks.

Public safety agencies in North America are converting their LMR equipment to the APCO-25 (P-25) standards, which have been developed with the participation of first responders. LMR is primarily used for voice. LTE standards have been developed by an industry forum known as the 3GPP. Its membership consists overwhelmingly of commercial operators and equipment manufacturers. The prime motivator for this group is to serve the demands of commercial operators facing explosive growth in data traffic.

Impact

First responders rely on their communications equipment during critical emergency situations and expect it to perform in a manner that supports their operational needs. The US National Public Safety Telecommunications Commission (NPSTC) has undertaken a study to define the operational requirements for "mission-critical voice" and in July 2011 concluded a draft set of requirements, which are expected to be approved in Q3 of 2011. The full text is embedded within this Technical Advisory Note. The requirements for MCV are summarized as follows:

a) Talk-around mode: ability to communicate directly between first responders by-passing the infrastructure.

b) Push-To-Talk (PTT): ability to seize a communications channel by the push of a button and set up a one-to-one call or one-to-many call. With PTT there is no need to compose a number.

c) Full Duplex Voice: Similar to conference call; several responders can be bridged into a session. Connection to the Public Switched Telephone Network (PSTN) is possible.

d) Group call: one-to-many communication within a pre-defined group of subscribers or the group membership may be established ad hoc. During emergencies, some talk groups could be pre-empted.

e) Talker Identification: ability to identify who is speaking at any given time and to display the speaker information on a User Interface.

f) Emergency Alerting: ability to alert all members within a talk group of an emergency. Alert is activated by a single action such as depressing a button. In case of congestion an emergency alert will pre-empt talk groups.

g) Audio Quality: the audio will be of sufficient fidelity to (i) understand what is being said without repeating, (ii) identify the speaker, (iii) detect stress in the speaker's voice, and (iv) distinguish background sounds such as children crying or sirens.

Commercial operators and equipment manufacturers are attempting to address some of the MCV requirements on LTE networks. For example, one can now have PTT capability on an LTE network directly from LTE user equipment. Gateways are available that interconnect LMR and LTE service domains such that a call that originates on one network can be terminated on the other. For example, a subscriber can initiate a PTT call using his LTE radio to communicate with an LMR talk group.

Among the set of operational requirements for MCV, the one that is the least congruent with commercial needs, and one of the most important for first responders is (a) the Talk-around mode. LTE cannot support talk-around mode, nor are there any plans to support it as currently identified by the 3GPP.

LMR handsets transmit at higher power levels than LTE subscriber devices – typically 2 to 5 Watts vs. 0.2 to 1 Watt, respectively. When in Talk-around mode, the LMR handsets can better penetrate buildings and other structures due to the higher power.

There is the possibility that at some future date, a multi-mode handheld device that incorporates the LMR radio and an LTE modem will become available. Such a device will be able to support MCV and have high-speed data capability. It does not, however, alleviate the need for an LMR and an LTE infrastructure to communicate with that handheld device.

Outcomes

While there are vendors and commercial operators that claim their LTE solutions support MCV, no one is currently able to meet the full set of NPSTC's MCV requirements, not the least of which is the critical requirement for Talk-around mode. Furthermore, proprietary products that purport to offer MCV capability are at risk of not interoperating with other proprietary products. Innovative solutions that will undoubtedly appear on the market in the future need to be adopted by internationally-endorsed standards, such as the 3GPP as a minimum pre-requisite for interoperability.

Notwithstanding the limited ability of LTE to support MCV, LTE will provide first responders the tools to exchange data at high speeds and to interoperate in ways that enhance their ability to respond to emergency situations. New applications will be supported that enable more effective use of incident video, GIS data, medical information, collaborative workflow tools, etc. As such, LTE will fulfill an important role for the communications needs of first responders.

The conclusion of this assessment is that voice services over LTE will not supplant LMR in the foreseeable future for mission-critical voice applications since it is not known if or when the 3GPP will adopt the relevant standards for Talk-around mode. It is also not known if or when manufacturers will implement this capability on LTE once the 3GPP releases the specifications for it.

Attachments: *NPSTC Draft Document (July 2011) Mission Critical Voice Communications - Public Safety - NPSTC Broadband Working Group*

Mission Critical Voice Communications
- Public Safety -
NPSTC Broadband Working Group

Executive Summary
The following functional, qualitative descriptions were developed in the NPSTC Broadband Working Group to provide a consistent basis by which the public safety community can discuss mission critical voice as it relates to future public safety communications operating over mission critical broadband networks. Each of these functions was discussed at length within the working group, and these definitions capture the essence of what the public safety community expects when using the term mission critical voice while explicitly not defining or specifying particular solutions. Many different functions were considered in the development of this list. This set of functions constitutes the core functions public safety requires in order to achieve mission critical voice. This is not to say that other functions enhancing voice services aren't also desirable, but that these are the minimum set required currently. This definition is expected to evolve as public safety's use of mission critical voice over broadband evolves. Some of the features listed below contain descriptions of technology solutions and functionality that are meant to provide an understanding for how these features have been addressed by today's technology, but are not meant to constrain future solutions.

Although no specific interoperability requirement is included in this document, it is expected that the functional requirements described in this document will lead to standardized technical solutions enabling such interoperability and providing efficient mutual aid mechanisms.

The features described in this document are not prioritized. Instead, public safety users selected each feature listed as a component of what must be included in any solution for mission critical voice. As such, there is no one feature considered more important than another.

One important aspect of these descriptions to note is that while the working group expects all of these functions to be present for mission critical voice, it doesn't expect that the same technology and spectrum will necessarily be used to address each feature.

Follow on efforts related to this document will include quantifying appropriate aspects of the functions described in this document. Additionally, a more detailed discussion on underlying system level attributes and assumptions as they relate to these functions, such as reliability, availability, and interoperability, will be documented.

Direct or Talk Around

Direct Mode is ad hoc form of radio communications in which both the transmitter and the receiver operate without support from infrastructure. Users cannot talk and listen simultaneously, and only one user can talk at any one time, while other users listen. This mode is essential to public safety operations as it allows public safety users to communicate with each other outside the existing public safety communications network coverage area.

Typically, public safety users may choose this mode to support tactical operations within limited geographic or operational areas. Due to the lack of external communications network infrastructure, it is important that the range of usability for a UE in this mode be established and specific requirements developed. Public safety users will consider range of usability when evaluating the use Direct/Talk Around mode.

A typical example of the Direct/Talk Around mode would be a Fire Department unit responding to a wildfire outside the network coverage area or a structure fire in a poor coverage area. In this example, the Firefighters radios would no longer have access to a network repeater, or trunked radio base station, and therefore they will not be able to communicate on their network channel. By switching their radios to Direct/Talk Around mode, the Firefighters would now be able to communicate in simplex mode, radio to radio; however they would have no contact to other users on the network. Once they leave the scene or exit the building and return to network coverage, the Firefighters would switch their radios from Direct/Talk Around mode back to the network channel and resume normal operation.

An example of an upgraded Direct/Talk Around capability would provide the ability, at the system level, to enable a radio to automatically switch to a predefined Direct/Talk Around channel when it detects that it no longer has a connection to the network. An audible or visual alert would let the user know that they are now out of the coverage area and on the Direct/Talk Around channel. When the radio returns to the network, it would then automatically switch back to the last channel or Talk Group it was on before leaving the network. This would be a feature that the Network Administrator could either enable or disable based upon the agency's policies.

Push-to-Talk (PTT) Voice Systems

Mission-critical Push-to-Talk (PTT) voice systems utilized by public safety personnel allow them to selectively and sequentially transmit messages to one another, either on a one-to-one or one-to-many basis.

The sequence of events for normal PTT operation is as follows: A user wishing to speak on a particular voice path listens to that voice path, and when no one else is speaking, the user presses a button either on the radio itself or on a remote control device. The user device may communicate channel grant or denial status to the user via visual and/or audio cues. When the user is finished speaking, he releases the PTT button, which places the radio in the listen mode. This action makes the voice

path available so that another user on the same voice path may speak. Often, the system provides the identity of the speaker to listeners via a digital display.

Mission-critical voice uses include announcing incidents to responding agencies or individuals; requesting and/or assigning resources to events; declaring an emergency and requesting assistance by field units; announcing or updating incident, unit or agency status; and coordinating responses and activities.

Full Duplex Voice Systems

Public safety personnel often switch between half duplex mission critical PTT systems and full duplex wireless voice systems (usually cellular), which are interconnected to the Public Switched Telephone Network (PSTN.)

When using a full duplex voice system, once a conversation begins, the voice path remains open for all parties to communicate simultaneously, without regard to whether another user is currently speaking. Multiple users can talk and listen at the same time, meaning they can "talk over" one another. A voice call is ended when all users finish their conversation by terminating the call on their subscriber devices. Public safety users increasingly rely on cellular-style voice systems in mission-critical situations to communicate with parties outside their own PTT systems, including citizens with emergencies, language translation services and other outside agencies providing service to an incident or event. Even within an individual responder agency, full duplex conversations carry detailed or more fluid conversations than are easily achievable in half duplex PTT systems.

Most users assume that full duplex cellular-style conversations cannot be monitored by citizens using scanners and are usually not recorded. In reality, although almost all full duplex commercial wireless networks employ digital modulation and may be difficult to monitor, they are not truly secure communications, since they are not encrypted.

Ideally, both half duplex PTT systems and full duplex voice systems used by public safety agencies should provide a method for ensuring voice privacy if desired by system implementers. In such systems, voice privacy should be assigned to a voice path or user-selectable prior to the start of the conversation.

Group Call

Group call provides one-to-many communication between members of a talkgroup. The user may manually control membership in a talkgroup by selecting a specific talkgroup of interest. Talkgroup membership may also be infrastructure driven where existing talkgroups are patched together to form a new group. In this case, the system may optionally provide the ability to delay the start of a call until all the relevant talkgroups are idle. Talkgroups may consist of 10's or even 100's of users who may be concentrated at a single location or distributed over a large geographic area.

Today, a group call employs half duplex voice, using an infrastructure component to limit voice conversations to one talker at a time. Conference calls with no floor arbitration and duplex voice calls are also possible but issues with intelligibility may arise when multiple simultaneous talkers are mixed together. In addition, many users employ encryption to protect their voice communications from being intercepted.

For mission critical applications, users have an expectation of "immediate" communication with low call setup times and low end-to-end audio delays. In order to provide a predictable and consistent experience, RF and other resources should be acquired for all talkgroup members (or a critical subset) before permission to talk is granted. If resources are not available at the start of a call, a call request may be granted, denied, or temporarily busied depending on resource availability and system policy. This may require that other active talkgroup calls be preempted to free up resources due to emergency conditions or other priorities. There is also the expectation that once a call is granted, the resources will continue to be available until the call is ended and a hang timer expires.

A scan feature provides the ability to monitor several conventional channels and/or trunked talkgroups, including talkgroups associated with other systems, without having to change modes on the subscriber unit. The scan feature typically supports primary and secondary priority modes.

Talkgroups may also have data features directed towards the group members. These may include identification of the current talker as well as alarms, status, messages, and alerts.

Mobile radios, portable radios and wired consoles are used for talkgroup communications. Mobile and portable radios normally have specialized controls for PTT and group selection as well as a microphone and speaker. Portable radios often have external speaker microphones optimized for operation on the user's belt or in another location away from the user's head. Wired consoles typically support multiple simultaneous calls, as well as the ability to patch and otherwise manage talkgroups. Consoles may also be configured to prioritize their transmit audio over talkgroup members in the field equipped with portable or mobile radios.

Talker Identification

Talking identification is considered a mission critical voice feature. Talker identification provides the ability for a user to identify who is speaking given information provided to the listener through the device. This information may be comprised of alphanumeric characters and/or may contain the UE ID and/or any customized character string designated by public safety users for a given UE.

Emergency Alerting

Emergency call alerting and activation indicates that a user has encountered a life threatening condition and requires access to the system or a system's talkgroup

immediately. This may require that another user or talkgroup member be instantly removed from the system or system talkgroup. This feature is the highest level of priority and is referred to as ruthless preemption. Activation of the emergency alert is typically achieved by momentarily depressing a button on the subscriber unit or devices attached to the subscriber unit such as a lapel microphone, wireless tether, or other device. The emergency function is typically deactivated either by resetting the activation button on the subscriber unit or by a console operator monitoring the talkgroup. Upon activation of the emergency feature, the subscriber unit transmits its location in standard coordinates (e.g., NAD83, NMEA 0183, etc) to the console operator monitoring the talkgroup. In addition, the subscriber unit may transmit other data such as video or telemetry.

Once activated, today's emergency alerting function alerts members of a talkgroup (or multiple talkgroups) to the presence of a life-threatening emergency by the activation of audio and visual cues such as an emergency tone and text or other visual indicators. If the subscriber unit is set for vibrator alerting, the audio emergency alarm overrides the vibrating notification, alerting other users of the emergency condition.

The microphone of the subscriber unit declaring an emergency is capable of transmitting voice and/or data for a predetermined number of seconds without the user depressing a push-to-talk button. This feature is sometimes referred to as a "hot mike". In such cases, the dispatch console operator shall have the ability of over-riding the open or hot microphone of the user declaring the emergency, and communicate with members of the talkgroup(s) in which the emergency has been declared. The activation of an emergency, as well as all data related to the activated emergency, shall be recorded in the system's operating log of system events and conditions.

If a member of a talkgroup is transmitting voice and/or text during the time in which an emergency (on that talkgroup) is declared, the microphone of the user not transmitting the emergency shall be instantly disabled and immediately returned to receive mode, making the user aware of the emergency in progress.
The emergency alert feature shall not require registration. This feature enables the system to accept an emergency alarm from a user in distress prior to registration and/or authentication with the target system. The UE then proceeds with the normal registration and/or authentication procedure. The system operator has the ability to disable this feature if emergency alerts by unregistered or unauthenticated SUs are not desired.

Audio Quality
The transmitter and receiver audio quality must be such that, in order of importance:
1. The listener can understand what is being said without repetition
2. The listener can identify the speaker (assuming familiarity with the speaker's voice)

3. The listener can detect stress in the speaker's voice, if present.
4. The background environment audio shall be sufficiently clear to the listener that sounds such as sirens and babies crying can be determined.