STRATEGIC WHITE PAPER

Ultimate Wireless Broadband Solution for Public Safety

Delivering mission-critical services

Seamless data communication across multiple locations and disciplines is crucial during emergencies. To meet this need, public safety practitioners have endorsed Long Term Evolution (LTE) technology as the foundation for wireless networks. Besides offering nationwide interoperability in the 700 MHz band, LTE can support key broadband applications that accelerate response times, improve situational awareness — and increase the safety of all personnel. As a leader in the development of LTE, Alcatel-Lucent offers a public safety solution for local, state and federal governments. Overlaid on a traditional voice Land Mobile Radio (LMR) network, this LTE solution can enhance day-to-day operations, as well as emergency response work, by delivering digital imaging, streaming video, mapping, text messages and other capabilities that cannot be supported over narrowband wireless technologies.

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1. Introduction

Public safety practitioners and federal regulators are now fully engaged in ensuring that future public safety broadband systems align with a common standard, and that nationwide interoperability is achieved. In particular, lessons from previous tragic experiences have led state and local jurisdictions across the United States to recognize the importance of first-responder communications that are interoperable across multiple jurisdictions and disciplines without relying on patch-worked networks requiring proprietary gateways, multi-banders and other ad hoc measures. Their broad consensus is that Long Term Evolution (LTE) is the most appropriate technology to meet public safety broadband needs. LTE is expected to facilitate locally implemented, yet nationally compatible, highly survivable networks that are certain to accelerate the development of mission-critical applications.

Global wireless service providers are already adopting LTE as the evolution path for their current generation systems, which is facilitating the development of a strong ecosystem comprised of network infrastructure vendors, chipset vendors and device vendors. Following adoption of LTE by the largest United States-based service providers, major United States public safety organizations have also endorsed this technology for the public safety 700 MHz band. These endorsements come from the Association of Public Safety Communications Officials (APCO), National Public Safety Telecommunications Council (NPSTC), the Major City Chiefs (MCC), the 911 Emergency Number Association (NENA) and the Public Safety Spectrum Trust (PSST).

In times of emergency, the ability to communicate seamlessly is critical. Alcatel-Lucent has provided mission-critical solutions to the public safety industry for over 20 years and has been a driving force in transforming the United States public safety 700 MHz band to support broadband applications. Currently, Alcatel-Lucent is developing and deploying LTE broadband systems in commercial spectrum bands and designing LTE systems for the United States public safety 700 MHz band. This paper provides a detailed overview of the comprehensive Alcatel-Lucent Ultimate Wireless Broadband solution for public safety. This solution offers a unified communications infrastructure that can be shared across cooperating public safety agencies, while leveraging existing investment in public safety radio infrastructure and training. Because LTE technology uses standardized protocols and interfaces, users beyond the range of their home public safety network have the crucial ability to maintain a connection using a local public safety 700 MHz network or a commercial wireless network.

2. Market overview

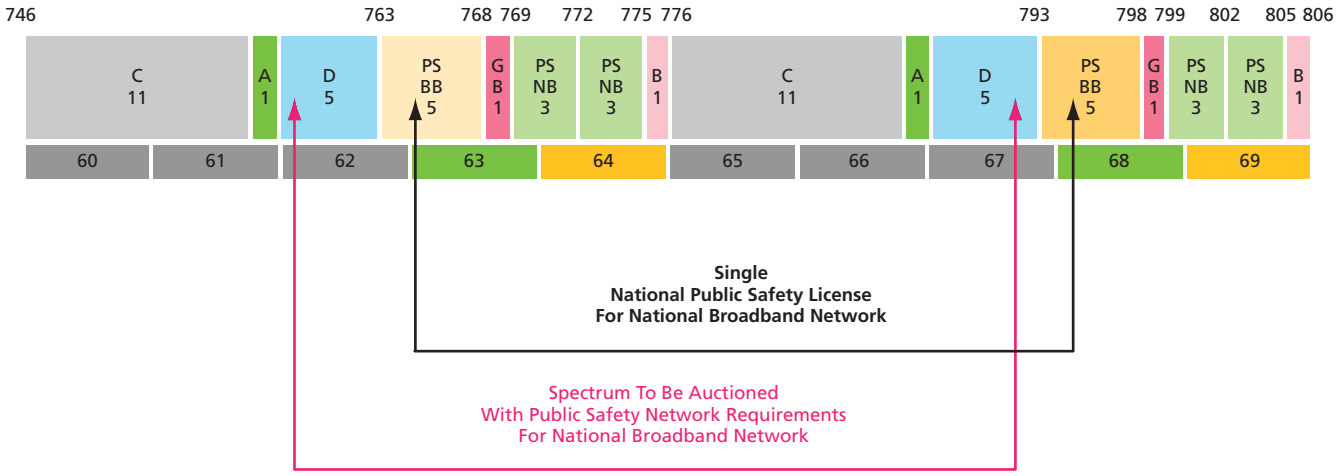
Mobile broadband wireless networks provide valuable services to public safety personnel as they carry out day-to-day operations, planned events and incident response. To enhance their access to mission-critical communications anytime and anywhere within a radio footprint, public safety workers need dedicated public safety networks. These must be built to stringent requirements for reliability, availability, quality of service and security in a dedicated spectrum band.

To address this need, the United States Federal Communications Commission authorized a new spectrum-channelization plan on July 31, 2007. This new band plan redistributes the 700 MHz band (698 MHz to 806 MHz) vacated by television broadcasters as part of their conversion to digital broadcasting. For the upper 700 MHz, as shown in Figure 1, the plan established the following three spectrum blocks to help improve communications among public safety agencies:

- A 10 MHz wide commercial block (upper D) that, while subject to future FCC rules, is expected to provide additional resources to public safety in times of emergency
- A 12 MHz wide public safety broadband block (including a 2 MHz guardband)
- A 12 MHz wide public safety narrowband block

The paired broadband spectrum was introduced to enable provisioning of advanced public safety wireless communications services.

Figure 1. New band plan – Adopted by FCC on July 31, 2007



This new plan facilitates the build-out of a nationwide broadband network shared by commercial organizations (the general public) and public safety entities. It includes access to a combined D-block and public safety broadband (PSBB)-block, resulting in a total allocation of 20 MHz. The Commission expected future nationwide licensees of both the D-block and PSBB-block to enter into a network-sharing agreement following a successful bid on the D block. To help accomplish this goal, the Commission awarded the nationwide Public Safety Broadband License to the Public Safety Spectrum Trust (PSST), a not-for-profit corporation representing the interests of the United States public safety community[1]. The PSST was formed by the Association of Public-Safety Communications Officials, the International Association of Chiefs of Police, the International Association of Fire Chiefs and the International Municipal Signal Association. By FCC mandate, the PSST Board members are drawn from numerous different national public safety organizations.

In March 2010, the FCC indicated in its National Broadband Plan to Congress that other forms of public-private partnerships should be explored. In contrast with the bidding requirements on the D-block for auction number 73, the National Broadband Plan suggests that the D-block be auctioned with licensees required to take the following actions:

- Support Wireless Priority Service for the benefit of public safety personnel
- Provide end users with devices that support the public safety broadband band
- Allow roaming at fair commercial rates
- Use the same technology as public safety — that is, LTE

Beyond the D-block auction winners, the plan suggests that other commercial carriers operating in the 700 MHz band should also provide roaming and priority access to public safety users. It also calls for public safety access to about 80 MHz of spectrum previously sold to carriers. This goal would be accomplished by forming public safety/private partnerships to develop a shared, nationwide interoperable network for both commercial and public safety users. The network will give public safety entities access to new broadband technologies across the country. To ensure control by public safety operators, one approach could be to use privately held resources for mission-critical operations, offloading traffic that is not mission-critical to commercial networks.

[1] Eventually, the D-block was not awarded in auction (FCC Auction 73). The FCC's recently released National Broadband Plan report to Congress advocates that the D-block be auctioned and decoupled from the public safety block, while there are attempts to convince Congress in allocating that block to public safety.

To enable coverage across the partnerships, roaming between the public safety networks and commercial networks will be required; for example, to provide coverage in areas where public safety's own network facilities are not yet available. This inter-system roaming requires interworking at the business and operational levels, including authentication and bilateral roaming agreements between the Public Safety Broadband Licensee (PSBL) and commercial networks. It also requires some type of clearinghouse mechanism to settle accounts between parties.

In addition, under the partnership, the PSBL will have priority access to the commercial spectrum in times of emergency, and the commercial licensee will have preemptive, secondary access to the public safety broadband spectrum. As a result, proper policy enforcement will be needed to ensure that users are being afforded proper priorities based on subscriber or application requirements.

3. The need for broadband

In recent years, major incidents have shown that emergency management response teams need greatly improved situational awareness through access to the best technology and communication systems. Responders who are equipped with the latest technology can improve their response times to better protect their communities. Personal devices with mobile data links to command centers can also increase the safety of personnel through geolocation services and the ability to provide video feeds from incident sites. However, current Land Mobile Radio (LMR) networks, which are principally used for voice communications, cannot meet today's increased need for high-speed mobile data capabilities that can cross different agencies within a disaster area.

To meet today's broadband needs, Alcatel-Lucent has developed a solution for local, state and federal governments using the most robust wireless technology available — LTE. As the next-generation technology in the wireless evolution path, LTE provides faster broadband data rates, low latency and advanced quality of service (QOS) that can support a wide variety of applications with an open device ecosystem.

More specifically, the deployment of a 700 MHz broadband data network, overlaid on a traditional voice LMR network, can enable applications that cannot be supported over narrowband wireless technologies. As a result, the solution will enhance day-to-day, task force and mutual aid response by supporting a wide variety of interoperable IP multimedia applications, including:

- Streaming video (surveillance, remote monitoring)
- Digital imaging
- Automatic vehicle location
- Computer-aided dispatching
- Web access
- e-mail
- Remote database access
- Report management system access
- Telemetry/remote diagnostics
- Mapping/GIS
- Text messaging
- Voice over IP (including interoperability with legacy and new LMR infrastructure through the use of appropriate gateways)

In addition, a broadband public safety data network can provide the following enhancements to operations:

- *Decreased narrowband channel load:* Tasks that previously required many tens of seconds of radio time to communicate with dispatchers and other personnel on narrowband voice systems — such as database lookups and dispatch messaging — can now be off-loaded to broadband spectrum, significantly reducing narrowband channel load.
- *Enhanced day-to-day operations:* Public safety staff efficiency can be increased through remote access to databases — such as Division of Motor Vehicles records — remote form entry and reporting. This web access decreases paperwork and increases the amount of time personnel spend on patrol.
- *Enhanced incident operations:* Wireless broadband networks allow mission-critical information to be exchanged in real-time, anytime, anywhere. Situational awareness and incident response can be enhanced through distribution of messages, images, such as floor plans, mug shots and incident stills, and videos, including surveillance feeds and on-scene video. By allowing key information from the field to be combined with data from incident management databases, the network can contribute to a more comprehensive common operating picture that helps improve decision making and overall safety.
- *Enhanced task force operations:* Broadband data networks allow secure, easy, interoperable sharing of information among members of a task force — in the form of voice, video and multimedia data.

First responders also gain the following advantages, by leveraging broadband technology developed originally for the commercial market:

- Leveraging the outcome of billions of dollars in technology R&D, invested by the commercial market
- Economies of scale through an enhanced ecosystem of vendors
- Greater variety of user devices — from multiple vendors in multiple form factors — as LTE grows in popularity
- Roaming onto commercial networks with a common user device
- Forward/backward compatibility as commercial technology evolves

Alcatel-Lucent is committed to developing broadband public safety data solutions which allow public safety to take advantage of the innovation and economies of scale offered by commercial broadband technologies.

4. Public safety applications and LTE

4.1 LTE – The right technology for broadband applications

LTE is uniquely suited to deliver high-data-rate services to public safety officials over wide coverage areas. The LTE air interface operates on paired blocks of spectrum, known as "carriers." LTE can be flexibly deployed with carrier bandwidths ranging from 1.4 MHz to 20 MHz. One block of this paired spectrum is used to carry transmissions from the network to the mobile (known as the down-link). The other carries transmissions from the mobile to the network (referred to as the uplink). Through advanced modulation, coding, interference management and other smart resource-scheduling techniques, the same carriers (frequencies) can be reused in every cell/sector throughout the network.

To allow for transmission of carrier bandwidths larger than 5 MHz, Orthogonal Frequency Division Multiple Access (OFDMA), an advanced form of modulation, is used on the downlink. This advanced modulation scheme has the added advantage of providing robust data transmissions when used over wide channels, because it allows the network to take advantage of frequency selectivity — that is, variations in transmission quality caused by frequency selective fading. To minimize battery drain on the end-user device, Single Carrier FDMA (SC-FDMA) is used for uplink transmissions. Multiple-Input Multiple-Output (MIMO) techniques are also used to increase data transmission rates further

and achieve high spectral efficiencies. Another key characteristic of LTE is its Flat-IP network architecture. By flattening (or minimizing) the number of layers in the transport network, latency from the user device to the server is reduced to approximately 8 to 16 ms.

With these innovations, LTE offers a quantum leap in peak per sector data rates, with up to 73 Mb/s download (network to user) and 15 Mb/s upload (user to network) with a 10 MHz-wide channel. Consequently, LTE can allow public safety field personnel to use bandwidth-intensive data applications, such as real-time video, high-resolution images and floor plans. Full mobility is also supported at much higher vehicular speeds than 3G networks can support. When combined with LTE's cost savings, these technological advances have resulted in wireless operators across the world choosing LTE as the technology for future mobile broadband, making it an appropriate choice for public safety networks as well.

Since LTE is the technology of choice for commercial 700 MHz spectrum deployments in North America, its adoption as a common technology for 700 MHz public safety broadband deployments would represent an unprecedented opportunity for interoperability across the United States. As a result, public safety users and first responders would have access to critical communications services wherever they may go, while leveraging common user equipment wherever they roam.

With LTE, the public safety community is afforded the required degree of control over their private network and services[2]. They can have flexible coverage through partnerships with commercial operators, roaming with other public safety jurisdictions, and optimized cost and control when operating at "home" in their private LTE network. A larger public safety entity may possess its own centralized equipment, enabling full control over its subscriber base and operations. Alternatively, core network equipment can be shared among multiple entities and managed by a service provider. This flexibility gives public safety entities a certain level of administrative control over their subscribers and network. The former approach may be practical for larger, state-run networks that have enough resources and budget to manage their own network, while the latter may be practical for smaller or rural areas that could rely on expertise of others to manage the network, thereby saving significant costs.

Alcatel-Lucent is a market leader in LTE and has first-hand experience using commercial technologies to deliver the benefits of interoperable broadband public safety communications. For example, the company successfully constructed the first 700 MHz interoperable public safety broadband network in the United States, the National Capital Region system in the Washington, DC, area. This network successfully provided broadband service with seamless support for high-speed data and video that met the needs of first responders across numerous agencies.

In addition to facilitating effective communications during emergencies, the public safety broadband network will play a key role in cooperative communications plans that enable first responders from different jurisdiction and disciplines, such as police and fire departments, to work together in emergency preparedness and response.

4.2 700 MHz – The right band for broadband applications

While some public safety organizations have considered deploying 4.9 GHz broadband systems for localized coverage, 4.9 GHz is not an appropriate band for providing wide area coverage. Poor propagation characteristics limit its access range to, at most, a few hundred yards in line-of-sight conditions. The 4.9 GHz situation presents the following challenges:

- The large number of access points required adds to costs — for backhaul and site hardening at every access point.
- The use of utility poles to site access points is not wise, since poles are more likely to fall off in the event of a hurricane, tornado or even more moderate storms.

[2] In some regions, public safety may decide to partner with a commercial D-block service provider that will build for both the D and PSBB channels.

- Network delays and lower capacity can arise from meshing techniques used for backhaul.
- Inability to properly site access points may cause holes in coverage.
- Despite years of standardization effort in the Telecommunications Industry Association (TIA), the same standards body responsible for the ongoing development of the Project 25 standards suite, there is no accepted standard for 4.9 GHz operation.

Public safety 700 MHz systems provide two orders of magnitude higher radio range than is possible with 4.9 GHz systems, making them much better suited for wide area deployment. Because of the favorable RF propagation properties at 700 MHz, LTE at 700 MHz will provide high-capacity, high-data-rate coverage over wide areas. Consequently, the number of base stations needed to cover an area will be minimized, and costs for hardening and security will be considerably lower.

4.3 Public safety applications

In June 2009, the National Public-Safety Telecommunications Council (NPSTC) joined the PSST, APCO and NENA in endorsing LTE as the technology of choice for the nationwide public safety system. Thereafter, at the request of the PSST and in view of the many waiver applications to the FCC for a broadband deployment, NPSTC formed a 700 MHz Broadband Task Force (BBTF) comprised of representatives from the public safety community and industry[3]. The BBTF identified the following baseline level of public safety applications and service capabilities, categorized as "required" and "desired," to be supported when roaming across the network:

Required applications

- Global Internet access
- Mobile VPN access
- Universal network greeting capability
- Network messaging
- Land Mobile Radio (LMR) gateway
- NIMS/ICS compatibility
- Field deployed service

Desired applications

- Geolocation
- Multicast capability
- Land Mobile Radio (LMR)
- Public switched telephone network (PSTN) interface

Early deployment of LTE systems will rely on equipment that complies at a minimum with Release 8 of the specifications for the LTE standard. The majority of the listed public safety applications can be carried over a Release 8 infrastructure and devices. A full suite of multicast capabilities and LMR-like voice services are most likely to appear in subsequent releases. In other words, LTE networks already meet many NPSTC application requirements today, and forthcoming standards features will eventually fill the gaps. Throughout this process, Alcatel-Lucent will remain a strong supporter and advocate for introducing public safety-related features in the LTE commercial standard.

4.4 Security in LTE

Secure communications links are vital to the majority of public safety practitioners, together with infrastructure reliability and resiliency. Public safety practitioners may not widely know that security mechanisms are a major component of commercial technologies and their standardization. Specifically, security in LTE can be found in both the user and control planes, either for protecting confidentiality of the information or its integrity.

[3] Alcatel-Lucent was a major contributor to this effort.

Mutual authentication of network and user devices has been the norm since the introduction of third-generation wireless systems like CDMA and UMTS. Master keys used for ciphering are never transmitted over the air, and random challenges are the norm. In addition, LTE architecture relies on two security layers, which provide double protection for the access and core components of the network. For example, a successful intruder would need to compromise both security layers — which are present in the access component and the core. The use of IPsec on the transport (back-haul) network will help mitigate the lack of security or confidence in a transport pipe from a third-party provider.

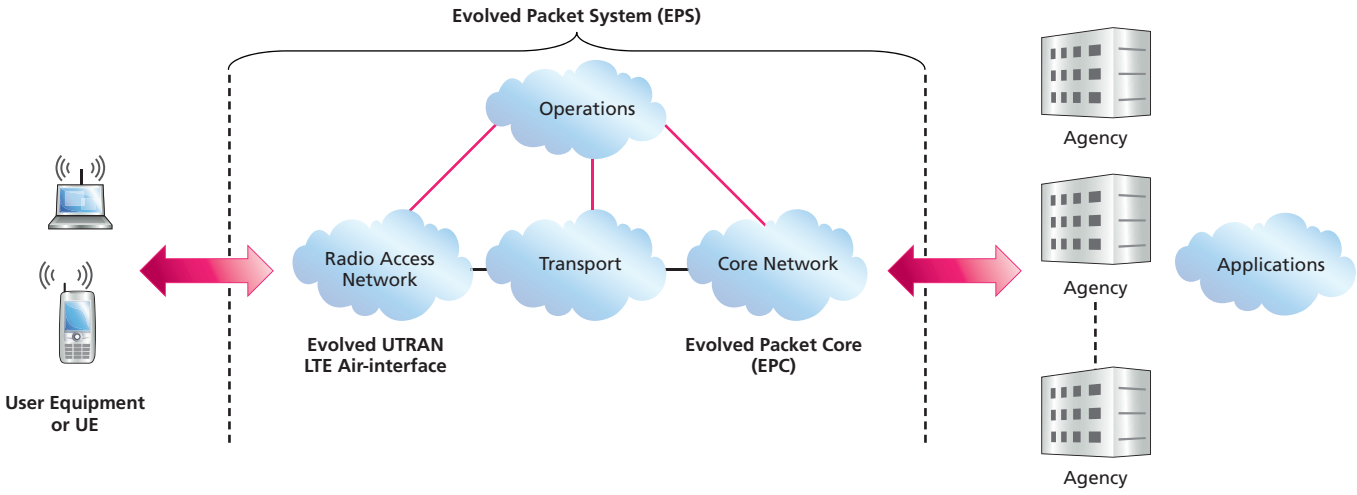
Finally, the availability of the Advanced Encryption Standard (AES) crypto-algorithm with 128-bit or 256-bit key length, acceptable for "classified" information, should help comply with Criminal Justice Information Service (CJIS) and other Federal Information Processing Standard (FIPS) standards.

5. Alcatel-Lucent Ultimate Wireless Broadband solution for public safety

The Alcatel-Lucent Ultimate Wireless Broadband solution for United States public safety leverages the new 700 MHz broadband channelization plan and an open-standard technology. As a result, the solution is uniquely suited to provide cost-effective high-data-rate services to public safety personnel over wide service areas. Leveraging LTE capabilities, the solution delivers high-throughput, low-latency data services over a Quality of Service (QOS)-enabled broadband IP network, which allows real-time transmission of high-throughput data. The expected wide-scale deployment of LTE will also promote an equipment ecosystem that will, among other capabilities, allow first responders to use streaming video for surveillance, digital imaging to catalog crime scene photos and automatic locating devices to track down vehicles.

Figure 2 shows a high-level view of an LTE system, which provides wireless access from user devices in the field to applications in their home or visited agencies. The solution can be broken into five logical domains, including the device ecosystem, RAN, backhaul, Evolved Packet Core, and operations support environment[4]. In the following sections, these domains are described in further detail, as they relate to public safety communications.

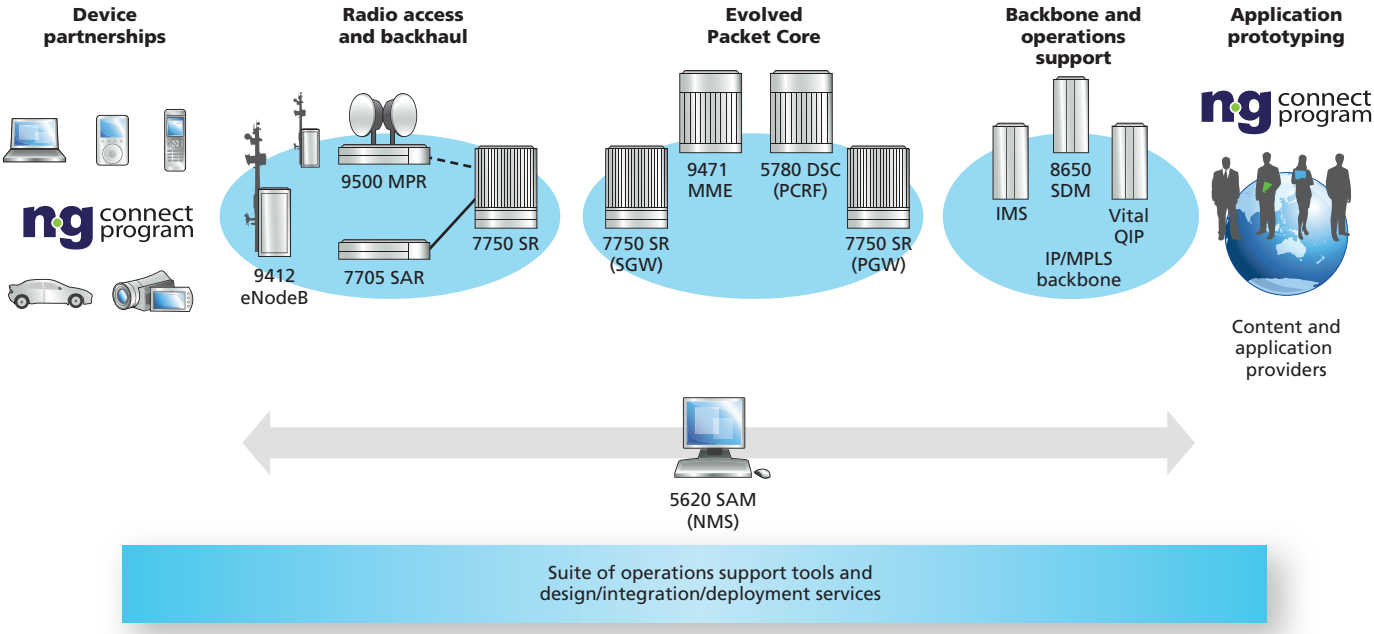
Figure 2. High-level architecture of LTE network for public safety



[4] IP Multimedia Sub-system (IMS) is another critical network component that could be added to the picture. IMS provides a framework for delivering IP multimedia services with the right QoS over LTE when working in collaboration with the EPC (see the Policy, charging and rules function section of this paper). Since SMS or VoIP services are likely to be IMS-based, IMS is expected to find its way into the future public safety network.

More specifically, the architecture is supported by a full suite of products in the Alcatel-Lucent LTE portfolio, as shown in Figure 3.

Figure 3. Alcatel-Lucent LTE solution



5.1 Ecosystem of public safety devices

To ensure the early availability of end-to-end LTE solutions, including the network and associated terminals, Alcatel-Lucent has developed strategic collaborations with various device companies. For widespread device development specifically targeted at the public safety community, it is critically important to leverage commercially available devices. Based on known LTE commercial device roadmaps, and depending on the deployment window, a USB dongle, PC card or modem are the most likely form-factors anticipated at launch. In the minimum configuration required for public safety, user devices will support the public safety broadband block and the upper 700 MHz D-block; that is, per 3GPP Band 14 operation. Other devices, such as cell phones, Smartphones and other multimedia-capable devices, will be available in a later phase. It is also anticipated that multi-band/multi-mode devices will be available to provide roaming capability onto commercial networks for extended coverage and services.

Most of these commercial devices will have the capability to add specific clients for public safety operators when a new application server is developed to meet their needs. Alcatel-Lucent will work with public safety operators to develop or to partner specific applications to support the needs of the first responders over the next-generation wireless infrastructure.

5.2 Radio Access Network

The LTE Radio Access Network (RAN) is based on the Alcatel-Lucent 9412 enhanced Node B (eNB), which is designed to support both the public safety broadband spectrum and the 700 MHz upper D-block. Depending on upcoming FCC rulings, the Alcatel-Lucent flexible base station solution will accommodate either two 5-MHz LTE carriers or a single 10-MHz carrier. The system offers extensive self-organizing network capabilities, leveraging the open-standard interfaces between Alcatel-Lucent 9412 eNBs. These capabilities simplify operations and maintenance and make it easier to re-arrange networks when needed; for example, when adding deployable units for disaster scenarios.

The Alcatel-Lucent 5620 Service Aware Manager (SAM) is the management system for the eUTRAN component. This next-generation management system enables IP management functionality all the way to the eNodeB. The distributed architecture of the software application allows for a large variety of deployment options suited to agencies' potential installation constraints.

5.3 Backhaul transport network

Because of its faster data rates, reduced latency, improved spectral efficiency, and a simpler, flatter IP network, LTE requires an order of magnitude increase in backhaul bandwidth. The proposed solution leverages the Alcatel-Lucent Mobile Backhaul solution to offer a comprehensive portfolio of backhaul options spanning microwave, fiber and copper facilities. Through this solution, LTE backhaul can be aggregated and shared efficiently on a single Ethernet backhaul network while giving public safety operators the flexibility to use either leased or private backhaul. For example, options include deployment of microwave (using 9500 Microwave Packet Radio) for private networks, which avoids monthly leasing costs, or leased Ethernet and T1 facilities. These options enable public safety network operators to select the most cost-effective network transport.

Since LTE is expected to carry mixed data traffic types with differing priority levels, the backhaul network must be QoS-aware to cope with different priority traffic. The backhaul solution provides advanced QoS capabilities to manage and prioritize LTE applications. Real-time services, such as video or VoIP, introduce new requirements for the transport layer, in terms of QoS management and end-to-end delay management. To meet these stringent QoS requirements, the IP backhaul network must integrate many of the qualities and attributes of switched networks, including predictability, reliability and manageability. In that respect, the implementation of Multi-Protocol Label Switching (MPLS/MPLS-TP) provides the QoS, traffic engineering and management capabilities necessary to support all mobile services over an IP/Ethernet network. Deterministic QoS provides equitable treatment for individual traffic streams and appropriate priority, for example, for high-delay-sensitive applications. It also allows synchronization mechanisms to converge rapidly across the packet RAN.

The Alcatel-Lucent IP/MPLS portfolio, a key component of the backhaul solution, is managed by the Alcatel-Lucent 5620 Service Aware Manager (SAM). This management system provides end-to-end network management across backhaul and the LTE packet core, assuring end-to-end management of QoS for data.

5.4 Evolved Packet Core

The Evolved Packet Core (EPC) is a new mobile core network for next-generation wireless systems. Comprised of gateways as well as mobility and policy management functions, it provides a converged framework for packet-based, real-time and non-real-time services. It provides mobile core functionality in a single domain and the solution is all-IP end-to-end — from mobile handsets and other user devices with embedded IP capabilities, over IP-based eNodeBs, across the EPC and throughout the application domain, which can be IMS and non-IMS. The solution's EPC capabilities enable new innovative services and applications that help support public safety.

5.4.1 Serving gateway

The serving gateway (SGW) is an element of the EPC that provides a local mobility anchor for data sessions, as a user moves from one Alcatel-Lucent 9412 eNB to another. It terminates the S1-U (user plane) interface from the Alcatel-Lucent 9412 eNB, and supports IP packet routing and forwarding functions for user plane traffic. It also supports packet buffering for downlink traffic towards idle users when there is a network initiated service request, ensuring no data loss while the user's radio bearer session is being set up.

The EPC's SGW is built on the Alcatel-Lucent 7750 Service Router (SR), a scalable service-aware IP routing platform. The Alcatel-Lucent 7750 SR is already field proven across multiple market segments, including enterprise VPNs, triple play, mobile backbone and backhaul, and it also plays major role in the solution, as a backhaul aggregation router in the core network.

5.4.2 Packet Data Network Gateway

The Packet Data Network Gateway (PDN-GW or PGW) provides the IP address anchor for bearers and terminates the (SGi) interface towards (external) packet data networks (PDN). It supports user IP address management (allocation), includes the policy and charging enforcement function (PCEF) and enables per-service data flow (SDF)-based packet filtering. As an anchor point for sessions toward external packet data networks, the PGW supports:

- *Policy enforcement features:* by applying agency-defined rules for resource allocation and usage
- *Packet filtering:* for example, by providing deep packet inspection for application type detection
- *Charging/usage reporting support:* such as completion of per-URL usage measurements

Like the Alcatel Lucent SGW, the Alcatel-Lucent PGW is built on the successful and field-proven Alcatel-Lucent 7750 SR platform.

5.4.3 Mobility management

The Mobility Management Entity (MME) is a control and data session management network element. It performs signaling and control functions to manage user equipment access to network connections, assigns network resources and manages mobility states to support tracking, paging, roaming and handovers. MME handles all control plane functions related to subscriber and session management.

For example, it is responsible for initially authenticating a user who requests access to the LTE network by querying the Home Subscriber Server (HSS) associated with the user equipment. If the user is successfully authenticated, the MME will communicate with the Alcatel-Lucent 9412 eNB and the serving gateway to set up a default data bearer channel for the user equipment. Then it will associate that bearer channel with an IP address and an associated PGW. Once the user equipment is attached to the LTE network, the MME is responsible for maintaining session information, as well as finding and paging the user equipment for incoming data calls.

The Alcatel-Lucent 9471 Mobility Management Entity (MME) platform is built on a high-availability ATCA-v2 platform, and it leverages extensive Bell Labs experience in optimizing mobility management and paging in 3G cellular networks.

5.4.4 Policy, charging and rules function

The policy charging and rules function (PCRF) is required when application servers in the network require dynamic QOS control. Using a receiver interface to application layer servers, the PCRF coordinates session QoS with services provided by the application layer. To authorize and prioritize user traffic flows based on their provisioned service profile, the PCRF interacts with an application function and subscriber profile repository, typically in the HSS, to provide the necessary information to policy enforcement points in the network, such as the PGW and SGW. The Alcatel-Lucent PCRF is built on the Alcatel-Lucent 5780 Dynamic Services Controller (DSC) high-availability ATCA v2 platform.

All components of an Alcatel-Lucent EPC are managed by the Alcatel-Lucent 5620 Service Aware Manager (SAM), as is the Service Router portfolio of IP/MPLS products, including the Alcatel-Lucent 7705 Service Aggregation Router and the 7750 Service Router. These IP routing platforms are key elements of the solution, providing end-to-end management for flat IP/MPLS transport networks as well as the Mobile Service Layer provided by the EPC.

5.5 Operations support environment

As part of the Alcatel-Lucent solution for public safety, the operations support environment lets network operators provision, personalize, deliver, bill and manage services across different platforms and networks with the quality expected by end users. Drawing on an unrivaled telecom expertise and extensive partnerships with leading IT vendors, Alcatel-Lucent has developed an operations support environment that allows a balanced approach to handling latency-sensitive and latency-insensitive services. As a result, applications can be closely integrated with the intelligence and distributed control services of the network.

The Alcatel-Lucent operations support environment eliminates service-related data silos to help create reusable, multi-dimensional user profiles critical to public safety services. Due to fine-grained QoS and Service Level Agreement (SLA) enforcement, it also helps ensure that the network can always meet first responder requests and requirements, as well as capacity demands.

5.5.1 Subscriber data management

Public safety can leverage the same authentication and mobility mechanisms used in commercial networks to enable seamless roaming across jurisdictions, as well as within commercial networks. The Home Subscriber Server (HSS) contains user information related to service provisioning, and LTE network elements use this information to handle calls or sessions, to locate and authorize users, whether they are roaming in home networks or visiting other networks. In particular, the HSS is responsible for storing the following user-related information:

- *User identification:* Numbering and addressing information
- *User security information:* Network access information for authentication and authorization
- *User location information at inter-system level:* supports user registration, and stores inter-system location information, etc.
- *User service profile information:* For example, priority levels for access to network services or information about a user's application configurations

The Alcatel-Lucent HSS is based on the popular Alcatel-Lucent 8650 Subscriber Data Manager.

5.5.2 IP address management

Alcatel-Lucent VitalQIP® DNS/DHCP IP Address Management Software is a market-leading solution for automating IP address management across networks. This software helps public safety operators efficiently configure, automate, integrate and administer IP services across a local or national network. Through proven performance in high-volume network environments, it has demonstrated its ability to support applications with millions of individual IP addresses and thousands of domains.

The Alcatel-Lucent VitalQIP Appliance addresses the shift in the IP Address Management (IPAM) market towards appliances for increased reliability, manageability, scalability and security, and it is the only appliance solution on the market that seamlessly integrates with Alcatel-Lucent VitalQIP DNS/DHCP and IP Address Management Software. This software is widely deployed in high-volume distributed network environments, where it has demonstrated its ability to support demanding applications with millions of individual IP addresses and hundreds of thousands of domains.

Built-in support for "master and slave" DNS servers, as well as dynamic DNS updates, means network operators can avoid network outages and automate address and name assignments. Using the Alcatel-Lucent DHCP server also eliminates any single point of failure with many-to-one failover capability. In other words, a single secondary DHCP server can serve as the back up for multiple primary DHCP servers. This capability helps ensure that IP services are delivered to users as specified, reducing network hardware requirements and simplifying network administration.

5.5.3 Integrated Operations Support System

Today's public safety networks require umbrella alarm management, including powerful cross-domain event correlation, streamlined work process and central inventory management. Integrated Operations Support System (OSS) solutions give public safety network operators the tools they need to maintain high service availability by providing real-time network views of the Land Mobile Radio (LMR), LTE broadband overlay and transport infrastructure that supports multivendor, multi-technology and multi-domain environments. Standardized network equipment checks help reduce skill requirements for first-line operations staff. Real-time views of local LMR and broadband services availability directly support user organizations in their mission planning. And user self-care functionalities, such as service provisioning and request management, help minimize operation centers' daily work.

In crisis situations, radio network performance management also improves the real-time visibility of network performance. A large number of user groups are interested in measuring the performance of public safety networks, especially when peak loads occur during a crisis.

With knowledge of real-time network use, operational users can change and fine-tune their network. Trend analysis can also be made available for new applications added to the network, such as Automatic Vehicle Location System (AVLS) and mobile data. Historical data provides good insight into radios' traffic usage, based on call detail records. This information can be used to fine-tune radio traffic during peak usage.

5.6 Application Prototyping

With the performance, resiliency, and quality of LTE networks, there is an opportunity for application developers to take advantage of LTE as a technology and provide ground-breaking solutions to the public safety community. As a key stakeholder in this market as well as other markets, Alcatel-Lucent runs several ecosystem-oriented programs that provide application developers the opportunity to work with LTE as the technology matures and becomes commercialized. In particular is the ng Connect Program, which focuses on engaging device, application, and content companies in generating new solutions focused on a better connected user experience. By providing these companies early access to LTE as a technology, they are able to evolve their solutions to the next generation while exploring new areas that their capabilities are relevant. Additionally, the Alcatel-Lucent Application Exposure Suite (AES) and Open API Service (OAS) provide these application developers access to specific network assets and enablers such as location, presence and security. By providing these programs to application developers, Alcatel-Lucent is enabling this open ecosystem to create new value in both the networks upon which public safety solutions are run on as well as the solutions themselves.

5.7 Alcatel-Lucent – Your trusted partner for public safety broadband

A full range of services

From initial project analysis to final deployment and beyond, Alcatel-Lucent provides a full range of services:

- *Consulting:* Alcatel-Lucent works closely with each public safety agency to determine its service requirements and define the optimal path for LTE broadband overlay. Consultation can be provided on a wide range of issues, including network migration, transport network upgrades, radio spectrum and LMR integration.
- *Project management:* Alcatel-Lucent can act as prime contractor for the turnkey delivery of LTE for public safety solutions — providing services such as initial scope of work description, project plan development, risk management, procurement management and quality management.
- *Design and integration:* Based on customer requirements, Alcatel-Lucent selects the optimal end-to-end solution, incorporating all needed redundancies. Services include radio network design and architecture, transport network architecture, OSS design, solution customization, end-to-end integration and comprehensive testing.

- *Network deployment:* To ensure successful deployment, Alcatel-Lucent handles site acquisition and preparation, product sourcing, installation and commissioning — and seamless integration into the customer environment.
- *Operations and maintenance:* Alcatel-Lucent can provide full support for operations and maintenance through cost-effective outsourcing agreements. These contracts can cover some or all aspects of the network, including managed field operations, multivendor maintenance, managed network operations center and managed security. Through these arrangements, Alcatel-Lucent can take full responsiblity for mission-critical networks, while generating OPEX savings for the public safety agency. Alcatel-Lucent high-quality maintenance contracts cover multivendor networks, providing continuous coverage worldwide.

Unparalleled experience and expertise
Alcatel-Lucent delivers solutions and services to public safety organizations around the world — and has broad experience with large multi-force, multivendor programs. This includes in-depth experience with the integration and deployment of digital mobile radio networks in highly challenging environments. Worldwide, Alcatel-Lucent has managed over 2300 network migration projects across multivendor platforms.

THE CRITICAL ROLE OF INTEGRATION

Successful LTE for Public Safety deployments rely heavily on systems integration and configuration, because LTE and LMR networks are invariably linked to other vital systems. For example, the broadband mobile network may need to be seamlessly integrated with a video surveillance system to provide video interactivity or interact with 911 centers.

To take full advantage of LTE and LMR network capabilities, they must be fully interoperable with other systems in a complex, multi-technology, multi-service environment. As network integrator, Alcatel-Lucent is uniquely qualified to do the job.

Industry leadership and project management
Alcatel-Lucent has 25 years of experience in high-security wireless networks and proven methodologies for mobile radio planning and project management. For each project, Alcatel-Lucent can combine a solid understanding of public safety requirements with its accumulated expertise in the customization of mission-critical communications systems. As a result, first responders gain a predictable evolution for their project, a single point of contact and improved control of risks.

An end-to-end multivendor approach
Alcatel-Lucent is vendor-neutral, selecting best-of-breed products from leading manufacturers to ensure an optimal public safety solution. Alcatel-Lucent offers the full range of services needed to design, integrate and deploy end-to-end solutions — and to operate and maintain these multivendor systems. Its communications solutions feature full interoperability between different manufacturers' equipment, which means public safety communities can reduce the risk of transformation to LTE.

A global presence but a local player
Alcatel-Lucent — a global company — is a local player, active in 130 countries around the world. This rich experience has resulted in a detailed understanding of local and national public safety conditions, including prevailing technologies, regulatory constraints and radio spectrum considerations. As a result, Alcatel-Lucent solutions can be effectively tailored to meet each customer's needs.

6. Conclusion

Today's public safety networks need to provide interoperability across multiple locations and disciplines, along with secure, reliable support for mission-critical services. In addition, they must have the capacity to support emerging public safety applications, such as video, digital imaging, remote database access and messaging. These capabilities can accelerate response times when emergencies occur, improve situational awareness and play a vital role in planning and decision making.

Embraced by the public safety community, as well as global telecommunications carriers, LTE is the right technology to support public safety broadband applications. LTE at 700 MHz will provide high-capacity, high-data-rate coverage over wide areas — minimizing the number of base stations required and reducing costs for hardening and security. It is also uniquely suited to deliver high-data-rate services efficiently and with robust performance. Consequently, LTE can allow public safety field personnel to use bandwidth-intensive data applications such as real-time video, high-resolution still photographs, images and floor plans — giving them fast access to visual information that can be crucial for responding most effectively to a crisis.

Alcatel-Lucent has provided mission-critical solutions to the public safety industry for over 20 years — and has been a driving force in transforming the United States public safety 700 MHz band to support broadband applications. As a market leader in LTE, Alcatel-Lucent offers a comprehensive wireless broadband solution for public safety. It provides a complete end-to-end network from the RAN to the core, including operations support and a growing ecosystem of application developers, device manufacturers and content developers. This solution offers a unified communications infrastructure that can be shared across cooperating public safety agencies, while leveraging existing investment in public safety radio infrastructure to enhance communications and enable key broadband applications that accelerate response times and improve situational awareness.

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