Technical Report

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MCPTX for PS-LTE

Benefits of a Standards-based Implementation

Contents

Executive Summary

For first responders in the line of duty, effective communication is a foundational component of successful outcomes. Land Mobile Radio (or LMR) has evolved considerably over the past century to support a range of use cases and users. However, the standards and technologies that today's LMR systems are based on have reached an impasse in terms of their capability to meet growing needs for access to data and video. Nonetheless, the stringent requirements of first responders and public safety organizations with respect to security and reliability have led many to remain suspicious of the potential for modern LTE-based solutions to replace tried-and-true LMR systems.

This paper outlines how these suspicions can be readily dispelled through consideration of how the current MCPTX standards, in conjunction with the robustness of existing LTE network architectures, such as the IP Multimedia Subsystem – commonly used to provide Voice over LTE, or VoLTE, service – deliver a Mission Critical PTT experience that parallels or even surpasses LMR service while at the same time introducing flexible and powerful access to Mission Critical Video and Data functionalities (collectively, push-to-talk, voice and video in the Public Safety LTE context, are referred to as MCPTX or MCX).

In fact,the 3GPP standards for MC communications were developed by a diverse body of telecommunications industry stakeholders with an eye specifically to the user experience, technical requirements and particular challenges present in the LMR and public safety ecosystems. Many of the common pillars of mission critical LMR solutions are also a key focus in the development of PS-LTE standards and solutions, including Quality of Service management; prioritized access; device, application and network security; as well as robustness, redundancy and reliability.

At the same time, the MCX specifications are designed to cover a wide variety of potential deployment scenarios that efficiently integrate into LTE service providers' existing network systems and leverage the particular benefits that are today a staple of commercial service. This unlocks new opportunities for interoperability between devices, services and networks; greater potential for service growth, iteration and evolution; and vastly more efficient use of available network resources. In aggregate, this ensures that standards-based MCPTX and PS-LTE solutions can deliver superior ownership, service and user experiences as compared to proprietary or hybrid solutions as well as the various closed-box, over-the-top applications that have appeared on the market in recent years.

Introduction

Effective communication represents one of the most critical components of a successful emergency response. Better communication typically results in better outcomes. Public Safety agencies, including police, fire and emergency medical response are intimately aware of this – radio has played an increasingly integral role in coordinating safety operations for more than half a century.

Yet due to stringent requirements for reliability and security, the technologies that drive public safety communications have often fallen behind in terms of capabilities and feature sets when compared with consumer networks. Today's Land Mobile Radio (LMR) networks used by first responders are still predominantly focused on basic voice services, and only fairly recently has limited data transmission been supported. Even when smartphones and similar advanced devices are integrated into the process, services that involve video or data must typically be provided over-the-top, using commercial networks and with none of the guarantees of access, quality or reliability.

On the other hand, the needs of today's first responders, both on a day-to-day basis, as well as during emergency or crisis situations, have grown well beyond what LMR networks are capable of supporting. Operations are more complex, involving larger numbers of agents across more organizations, relying on volumes of data that are both larger and more interconnected. Real time communications in the field need to be robust enough to keep up and flexible enough to grow along the way.

There exists a false dichotomy between resiliency & redundancy on one hand, and innovation & flexibility on the other. Samsung's experience in the deployment of next-generation Public Safety LTE networks (PS-LTE) and Mission Critical Push-to-X (MCPTX) services demonstrates that it is entirely possible to serve both sides of the equation, delivering on the core pillars of public safety communications while making available cutting-edge services and features that help to redefine today's standard operating procedures.

In 2019, two high-profile markets are set to launch modern PS-LTE networks into commercial service, including MCPTX services that will serve to transition public safety agencies into the same communications renaissance that has propelled LTE to explosive growth. In both of these markets – the United States and Korea – Samsung has been uniquely selected to deploy its MCPTX solution, client and devices. This paper is intended to serve as an examination of the key underlying benefits of Samsung's approach to implementing MCPTX into the LTE network.

In particular, Samsung has occasionally received questions regarding the benefits of a 3GPP-compliant solution and the suitability of an IMS-based deployment architecture – perhaps due to the prevalence of closed-box systems that have traditionally dominated the PTT industry. The goal of this paper is to briefly highlight the various advantages of a standards-compliant, IMS-based, open solution, and why this approach was selected for deployment in pioneering PS-LTE markets.

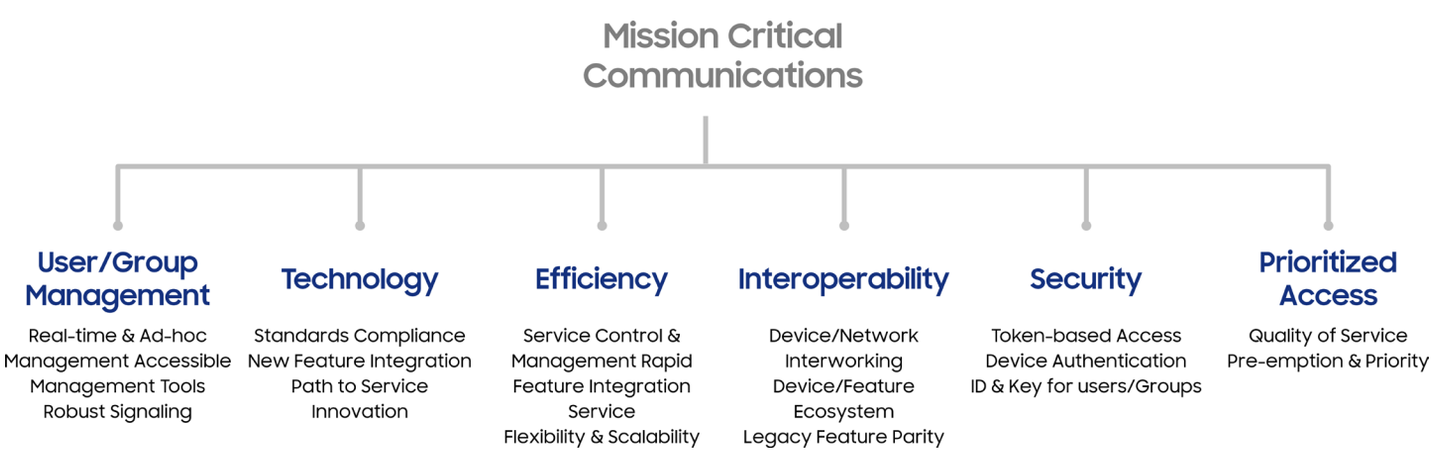

Figure 1. Selected key pillars for MCX Communications.
3GPP specifications for MCPTX and IMS provide support across several of these areas.

MCPTX Standards

At its most basic, an MCPTX implementation involves the deployment of an Application Server (AS), which interfaces with the operator's Evolved Packet Core (EPC) and is responsible for providing MCPTX functionality in conjunction with an MCPTX client application installed on end-user equipment.

The primary specification for MCPTX architecture is 3GPP TS 23.280 "Common functional architecture to support mission critical services". Relevant interfaces are defined by 3GPP between the MCPTX AS and the operator's LTE core (EPC) as well as the UE clients; and any MCPTX solution will accordingly need to implement these in order to integrate into an operator's core network. Taking this a step further, 3GPP has also defined a standard internal architecture for MCX services to provide for user/group management, signaling control, policy and charging enforcement and cross-network interworking. In contrast to 3GPP specifications for VoLTE, IMS for MCPTX remains optional, although this paper argues that the combination of a fully 3GPP-compliant and IMS-based implementation provides considerable advantages in terms of network integration, interworking, solution scaling, feature extensibility and overall flexibility.

From an application plane perspective, three key components are defined. In the core network domain exist the MCPTX AS and a Common Services Core (CSC) which provides management and storage of MCx-specific data, including groups, service configurations, users and authentication keys. The third component - the MCx client – sits in the user domain. Functional reference points are defined between each of these components, and additional interfaces are provided for interworking between multiple MCx systems. Finally, a reference point is defined between the MCx system and a subscriber database.

In terms of the signaling control plane specifications, the 3GPP specification makes reference to a SIP core as a foundational component for managing signaling between the various network elements of the MCx service, but as stated, does not explicitly require an IMS-SIP implementation. One key here, however, is that the Rx interface between the SIP core and EPS (PCRF) is referenced in the standard and represents an area in which IMS lends itself to a more robust implementation.

Finally, a set of Key Performance Indicators (KPIs) are defined for MCPTX communications. In the case of PTT voice, 3GPP TS 22.179 defines 4 KPIs as illustrated in the Table 1 and Figure 2 below. These KPI values are intended to ensure that LTE- or 5G-based MCPTX provides performance that is (at minimum) on-par with existing LMR standards and solutions. The KPIs involve end-to-end signaling delays between a user device and the MCPTX AS in the cases of KPI-1 and KPI-4, signaling delays between multiple user devices and the MCPTX AS in KPI-2, as well as media stream delays in KPI-3 and KPI-4. While KPI-1, 2 and 3 can apply to both private or group calls, KPI-4 involves a specific case in which a user joins an ongoing group call.

KPI/Name	Definition	Value
KPI-1 MCPTT Access Time	The time between when an MCPTT User requests to speak and when this user gets a signal to start speaking	<300ms
KPI-2 End-to-End Access Time	Typical case is an MCPTT private call (w/ floor control) request where Rx user accepts the call automatically	<1000ms
KPI-3 Mouth-to-ear Latency	The time between an utterance by the Tx user, and the playback of the utterance at the Rx user's speaker	<300ms
KPI-4 Max Late Call Entry Time	The time to enter an ongoing MCPTT Group Call measured from the time that a user decides to monitor such a Group Call to the time when the user's speaker starts to play the audio	<150ms (encrypted calls: <350ms)

Table 1. Audio MCPTT call performance (3GPP TS 22.179 [6.15])

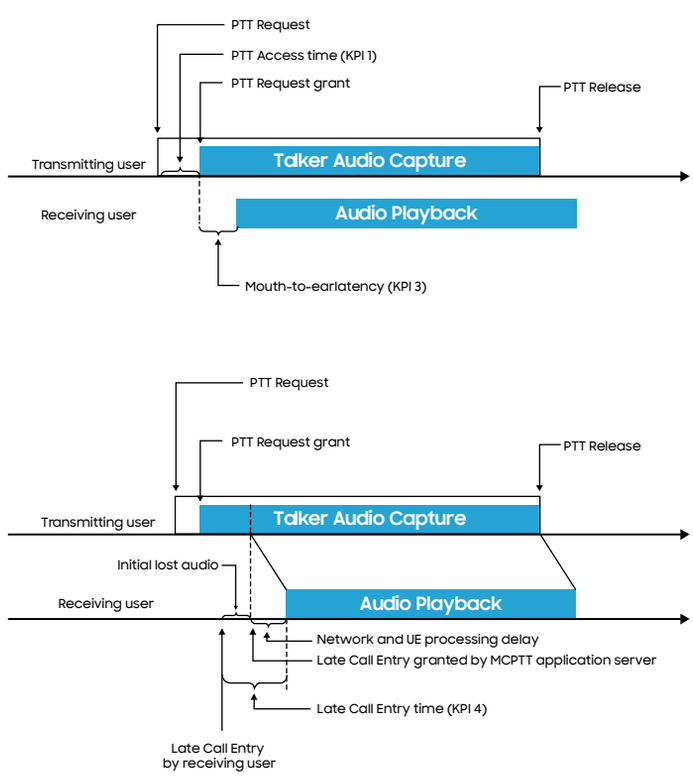

Figure 2. MCPTT access time and mouth-to-ear latency (3GPP TS 22.179 [6.15.3.1.1]) and Late call entry time (Ibid. [6.15.4.1.1])

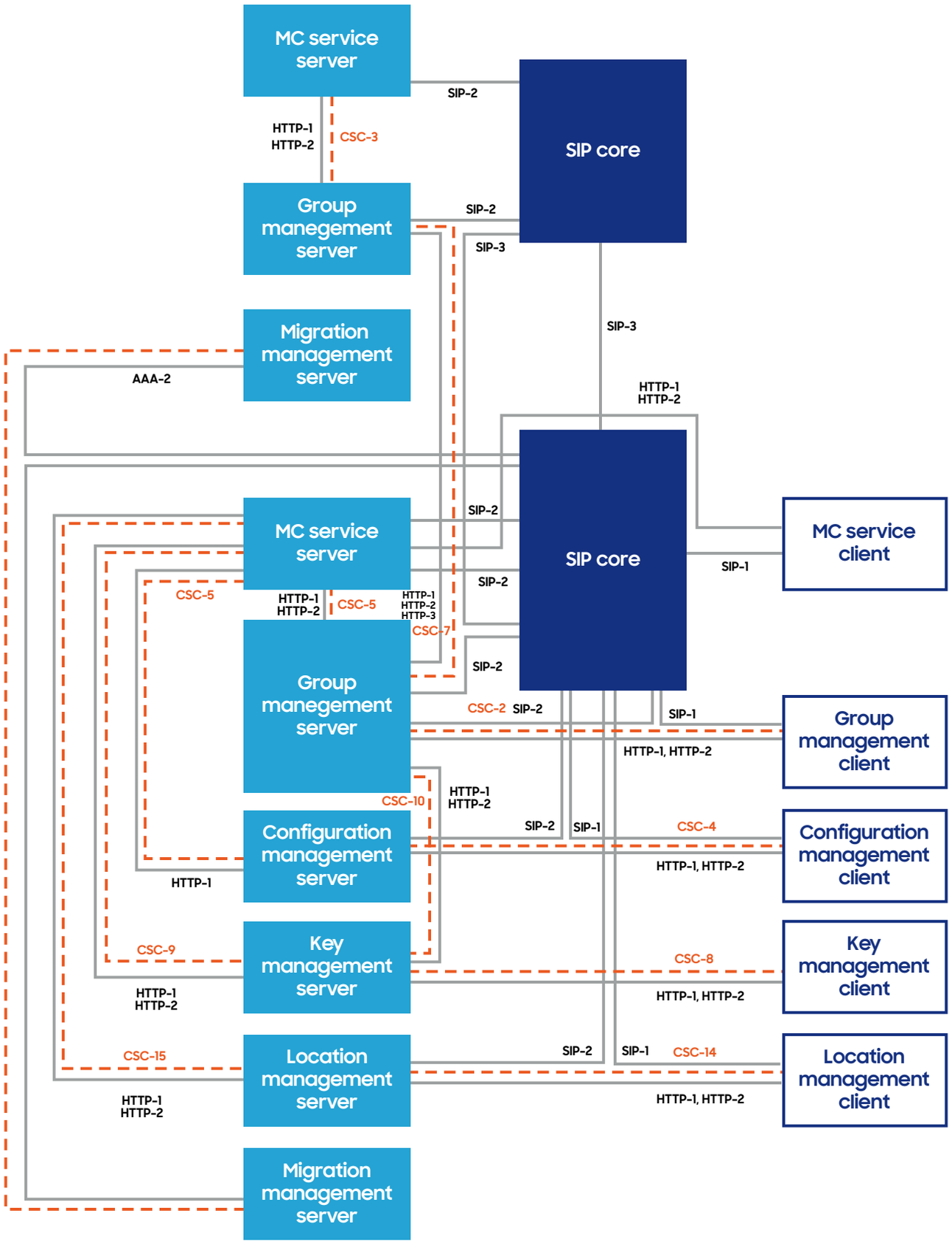

Figure 3. Relationships between reference points of MC service application plane and signaling control planes (3GPP TS 23.280 [7.3.1-3]). While 3GPP does not require the SIP core denoted in the specification to follow IMS architecture specifications, there are considerable benefits and synergies for operators who choose to implement an IMS-based MCPTX solution.

Delivering on MCPTX Pillars

For any service provider seeking to implement MCPTX service into their LTE network, special consideration must be paid to the core foundational pillars that separate MCx communications from typical network traffic. It would be easy to argue that each of these pillars is relevant to virtually any type of network service, however the bar is set considerably higher for mission critical uses, with far more stringent requirements. It is important that consideration be given into how a MCx solution delivers across these criteria both at the time of deployment and as service usage expands and evolves in the future. This section will aim to highlight why a standards-based solution built on top of IMS architecture provides for a streamlined, robust and flexible deployment.

Quality of Service

Quality of Service (QoS) can be identified as the most tangible component of MCx services – the standout feature that defines MCx requirements and is most visible to the users themselves.

In an LTE core network, QoS is implemented through the assignment of different service guarantees – or QoS Class Identifiers(QCIS) – to each traffic bearer individually. The assignment of a QCI, by the Policy and Charging Rules Function (PCRF), establishes a priority level which determines the order of precedence of traffic, sets budgets for packet delay and packet error loss rates, and defines whether a given traffic bearer has a guaranteed minimum bitrate or not. Collectively, these criteria are used by the SAE-GW to manage traffic, meet service level requirements and decide which traffic to deprioritize as the network becomes congested.

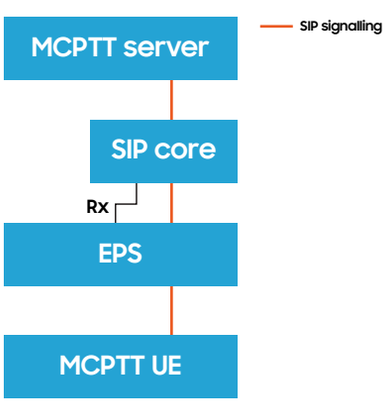

Figure 4. Bearer control by SIP core (3GPP TS 23.280 [9.2.2.3.2-1]).

3GPP has defined a new set of QCIs specifically for MCx service traffic with stricter latency and loss budgets as well as higher priority assignments – ensuring that even if the network becomes congested, MCx traffic takes priority over virtually all else. While an MCPTX AS can provide PTX service even without these QCIs, mission critical QoS requires the network and devices to support the new QCIs.

The PCRF needs to determine which QCI to assign for each traffic bearer, and so must receive information regarding the user's access level for a given service. The 3GPP defines the Rx interface for this purpose.

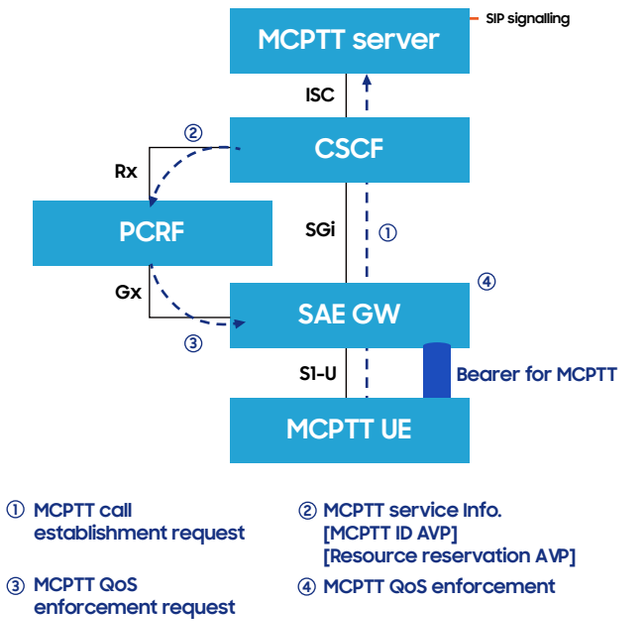

Figure 5. Samsung implementation of MCPTX QoS control.

Thus when an MCx session is initiated, the MCx SIP core provides session information through the Rx interface to the PCRF, which then requests the establishment of a new traffic bearer with the relevant resources to meet the required service level.

Where an IMS-based implementation excels in this case is that the Rx interface between the IMS core – the Call Session Control Function (CSCF) – and the PCRF is well-defined in the 3GPP standards and fairly mature. In fact, a special set of IMS extensions has been developed for the SIP protocol specifically for the purpose of ensuring the IMS core (CSCF) has all the information needed by the PCRF for effective policy enforcement and charging.

A non-IMS-based implementation on the other hand faces several key challenges in this respect. A non-IMS SIP core will lack some of the features necessary for handling policy and charging control, and thus a propriety implementation would likely be required – a costly and inflexible proposition. However, there is currently no evidence in the market today of a non-IMS-based PTX solution that can leverage the Rx interface to establish bearer-level QoS. This implies that such solutions rely on the same default QoS level as any typical LTE data connection.

Performance and KPIs

One of the concerns that is occasionally raised with respect to IMS is the potential addition of overhead or latency for services hosted there. Some of this concern seems to stem from early VoLTE deployments and the need to maintain performance parity versus circut switched voice services that were common at the time. During the past decade, IMS and VoLTE have both improved considerably to the point where they are now standard in virtually any LTE network with little concern paid to IMS overhead. In most cases, VoLTE today performs better than legacy CS systems.

It is understandable that similar questions arise regarding performance of MCPTX systems as compared to the legacy LMR services they are designed to replace. Fortunately, the steady evolution of IMS ensures that any overhead introduced by its use is minimized.

As part of our performance testing within our customer's lab, KPIs were comfortably achieved as highlighted in the chart below. It is worth noting that the bulk of the measured delay resulted from network delay itself and the impact of the IMS was relatively minor. This is to be expected as the IMS core is fairly compact.

KPI/Name	KPI Requirement	Result
KPI-1 MCPTT Access Time	<300ms	200ms
KPI-2 End-to-End Access Time	<1000ms	450ms
KPI-3 Mouth-to-ear Latency	<300ms	200ms

Table 2. KPI measurements in customer lab (conditions: 1:1 private call, no SRTP, LTE connected mode, manual calculation)

Security

Mission Critical implies a notion of strong security, and for good reason. Many of the typical scenarios in which MCx services are employed involve sensitive data and zero margin for failure. At both the application and signaling levels, an MCx service must provide robust defence against any efforts to attack, dismantle or abuse the network, its users or the MCx service itself.

Accordingly, strong authentication must be a core component of the MCx solution. Perhaps paradoxically, it is also ideal that the authentication mechanism be transparent to the service provider. The methods implemented for security need to be testable and guardable, with potential avenues of attack easily identifiable.

At the functional level, the 3GPP specifications of MCPTX provide for a centralized network element, called the Common Services Core (CSC), that provides for user and group management and sits as a separate component from the MCPTX Application Service (AS) itself. Interfaces are defined between these, as well as between the CSC and the MC Subscriber Repository (MCSR) which provides a front-end for the MC user information database. In a typical operator-administered IMS implementation, these components sit within the same trusted network, typically protected and hidden from public networks by a Session Border Controller (SBC).

From a device perspective, too, there are clear security advantages for an IMS-based implementation, particularly from a device interoperability perspective. 3GPP standards provide for authentication of user devices between the IMS Home Subscriber Server (IMS-HSS) and a user device's SIM card. This mechanism is well-understood and is a ubiquitous standard in LTE networks today.

On the other hand, a non-standard MCPTX solution would need to rely on a different, likely proprietary, mechanism for user or device authentication, potentially requiring the use of customized devices, or providing only application-level user authentication in an over-the-top application. This may shift security concerns behind a curtain that does not easily satisfy regulatory requirements for mission critical security.

Interoperability

Building on the topic of interoperability, it is important to understand that there is no one-size-fits all MCx solution. In the realm of mission critical communications, what works for one user, one public agency, one government or one market, may not meet the needs of another. As is the nature of the public sector, different solutions are often selected by different decision makers to meet the requirements of different operating procedures. Cross-compatibility between these various solutions and systems has been a concern within the industry for quite some time.

An ideal MCx deployment therefore needs to maximize its ability to work across several different dimensions: between different MCx networks, between the network and a wide assortment of UEs, between individual UEs and clients, between new features and existing MCPTX services, across regulatory or national boundaries, etc.

This can largely be facilitated by the introduction of standardized architectures and interfaces, as well as a logical decomposition of the basic components of the MCPTX application service itself. For example, interfaces are defined to handle both application and control plane interworking between one operator's MCx service and another's, greatly helping to minimize the work necessary to ensure interoperability, even if multiple vendors are involved.

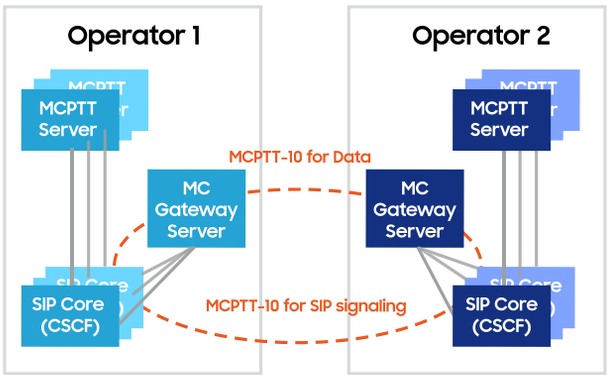

Figure 6. MCPTT-10 interface for cross-MNO interworking.

Building the MCPTX solution on top of an IMS core extends such cross-network interoperability due to the well-defined interworking mechanisms between different operators' IMS core networks.

From a device perspective, too: UEs today commonly support IMS connectivity (e.g. VoLTE). With some modification, the same IMS stack can be leveraged to support MCPTX access, meaning that the potential device ecosystem for MCx services is considerable. In contrast, a proprietary MCx solution will likely rely on a closed ecosystem of certified devices that support the non-standard interfaces involved. This has the potential to significantly hamper interoperability both within market, as well as across service provider boundaries.

User Identification and Management

Users and groups lay at the heart of any communications platform, and mission critical services arguably need to provide a higher degree of flexibility than most. This is in large part due to the fact that MCx services need to be dimensioned specifically for worst-case scenarios – multiple agencies responding in minutes to an unplanned and dynamic emergency or crisis situation, with ad hoc PTX groups accordingly created and managed; chaotic voice, video and data transmissions need to be streamlined, managed and accurately steered by a centralized dispatch authority in real-time even as the situation on the ground continues to evolve.

For this reason, user and group management needs to be robust and accessible. Each component feature of the MCx service, from PTX and location services to user profiles and administration, needs to be able to reliably identify users across a number of different data repositories and these databases need to be highly scalable.

Typically, a closed-box PTX solution will rely on a single PTT ID to identify users, using a single data point to authenticate users and handle traffic routing and service charging. As an MCx solution grows beyond basic PTT functionality, however, such an approach begins to show its limitations.

In a User Data Convergence (UDC) model on the other hand, a SIP database handles subscriber session information and a Mission Critical Subscriber Repository (MCSR) stores MCx application-level information.

The IMS-based approach leverages the IMS-HSS as the SIP database, which allows for access to a variety of new data points that are common across a user's presence in the operator's network (e.g. telephone number, SIP URI, etc.). This also means that subscriber records are consistent and linked between the EPC and IMS core networks for unified billing and service management.

Convergence of this data into a single repository also provides for a more robust model of identifying users (read: greater security and service assurance), and grants the potential for service evolution as new features require new IDs (e.g. IoT device IDs) that need to be dynamically linked to different users at different times. At the same time, mechanisms for accessing, sharing or hiding user data are well-defined in cases of roaming users or cross-network communications. On the other hand, reliance on a single PTT ID may not be usable or meaningful between different carrier networks or different MCx solutions and presents an all-or-nothing scenario in terms of exposing identifying user data.

Network Services

For mobile network operators, one of the biggest draws for deploying PS-LTE and MCPTX is the opportunity to build on and take advantage of existing LTE network investments to reduce deployment costs of the new service. It is also worth considering, however, the operational advantages that the existing network itself and the standards it is built upon can provide to the rollout of new services built around the same standards.

That is to say, an LTE network generates potential functional synergies with a 3GPP-compliant MCPTX solution.

One such area where this is readily demonstrated is broadcast and multicast: eMBMS. Network features such as this can be leveraged by old and new network services alike, and MCPTX in particular will benefit considerably from the presence of eMBMS in the network. In fact, the 3GPP specifications for MCPTX include optional interfaces to specifically take advantage of eMBMS. A non-standard solution however may or may not be able to make use of these types of network services.

Another example that is now being studied is Isolated E-UTRAN Operation for Public Safety (or IOPS) – the ability to provide end-to-end local network functionality from a base station even when it is cut off from the core network, or a so-called EPC-on-wheels. By definition, a standards-compliant, IMS-based MCx solution will be inherently compatible with an IOPS deployment, whereas a proprietary solution would likely need a customized implementation to ensure support in this scenario.

The same too can be said for core networks migrating to 5G. In this case, IMS compatibility is assured – it would certainly go against the interests of 3GPP and its members to allow 5G evolution to break existing network systems such as IMS. The same cannot necessarily be said for a non-standard solution.

Reference Case

Korea SafeNet

When Samsung began technical discussions with the core network operator for SafeNet in Korea – KT – the topic of architecture came up fairly early on. KT, having had experience with its own commercial PTT service deployment, initially assumed that an MCPTX solution would simply implement a SIP core based on the general IETF SIP standard.

The two companies fairly quickly identified several challenges that would arise with this approach. While the IETF specification for SIP can handle the basic signaling aspects of the MCPTX service, there would be no mechanism for QoS control nor for interworking between devices, application servers or across networks. By itself, an MCPTX deployment would thus require a proprietary solution to bridge these gaps.

QoS is one of the defining features of mission critical communications, and while a proprietary standard could have conceivably worked to meet the KPIs required, a closed implementation isn't desirable when it can be avoided. A bigger concern, however, would be the challenges for interworking. Any proprietary implementation of server-device, cross-server or cross-network interfaces creates considerable risk for the operator and makes implementation of future 3rd party features a potential cost generator for the vendor.

Fortunately, an obvious solution to these concerns is suggested by the 3GPP's MCPTX specification itself and was thus proposed by Samsung in discussion with KT. Together, the two companies have nearly a decade of experience with the deployment and evolution of one of the first VoLTE-capable networks in the world. The IMS core technology that drives KT's commercial VoLTE solution provided a perfect fit for 3GPP's SIP core requirements for MCPTX. The Rx interface provided everything needed to control QoS on the network side, while a variety of interfaces have been defined to handle all the interworking required (Gm, ISC and Mw interfaces).

A simplified IMS core dedicated to MCPTX was thus selected and deployed for the SafeNet network in 2018. The Korean PS-LTE project is now undergoing the final steps of its phase 2 deployment which extends coverage to include the central and southern two-thirds of the country and approximately 50% of the population. On schedule for initial commercial deployment within the next few months, Samsung's 3GPP-compliant IMS-based MCPTX solution has met all readiness and KPI requirements in ongoing deployment testing.

Samsung's Commitment to Standards-based Solutions

Samsung has been an innovative pioneer in the mobile telecommunications market for more than two decades, with a series of world first accomplishments in the LTE and now 5G eras. The company's experience with technologies such as VoLTE and eMBMS, as well as its unique position as an end-to-end LTE solution vendor establishes Samsung as a strong partner for PS-LTE and MCPTX deployments. With a presence as sole MCPTX solution provider to both of the major PS-LTE deployments in 2019 – the US and Korea – there is clear evidence that the approaches being taken in the implementation of MCPTX are solid.

As an active challenger in the LTE infrastructure market, innovation, open standards and flexibility form the core philosophy of Samsung's business approach. Wherever possible, solutions aim to minimize monolithic design, the need for dedicated hardware or proprietary implementations. This enables Samsung to flexibly meet the needs of its customers based on their individual market characteristics, customer demands and business strategies.

By building an MCPTX solution that reliably mirrors the 3GPP specifications, as well as building on top of the tried and true IMS architectural model for operator managed multimedia applications, Samsung can ensure that its customers understand what they are deploying, and precisely how such a solution can be integrated into their existing network infrastructure. It also generates confidence in the ability to augment the solution in the future, whether that involves new features from Samsung's roadmap or integrating new 3rd party solutions.

It also generates confidence in the ability to augment the solution in the future, whether that involves new features from Samsung's roadmap or integrating new 3rd party solutions. This is a particularly salient point as commercial networks today begin to adopt and deploy 5G technologies. While Public Safety for 5G (PS-5G) isn't expected to be defined until 3GPP Release 17 (targeting a 2022 release) it is important that service providers are able to identify and plan for a clear and smooth path of evolution from PS-LTE to PS-5G that builds on the same principles, standards and lessons learned from the current ongoing introduction of 5G infrastructure.

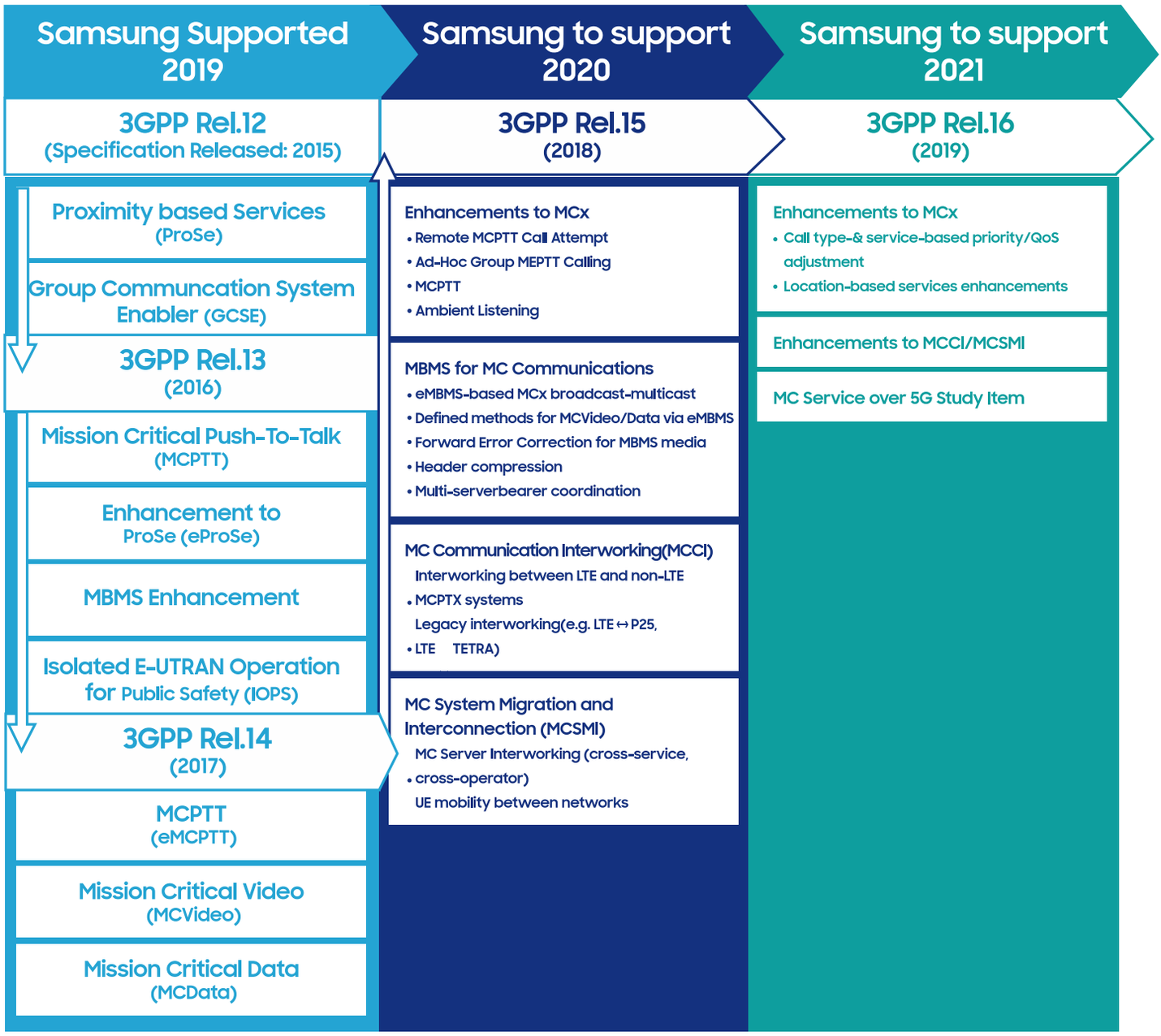

Figure 8. Evolution of MCPTX Features and Samsung Support Timeline.

Summary

Overall, the 3GPP specification considers a wide variety of implementation scenarios with regard to separation of individual functions between the MC service provider and the operator's network. Separate assumptions regarding ownership and security of the various network functions and user databases allows for a high degree of flexibility in deployment and is likely to help bridge the gap between the traditional PTT industry and modern LTE network operations.

Current trends indicate that most dedicated MCx deployments will need to be deployed within an operator's network in order to meet performance and QoS requirements as well as policies or laws in place regarding MCx service operations. This gives operators two main choices: a closed-box proprietary solution that externally mimics IMS reference points, or a fully 3GPP-compliant solution that implements IMS standard interfaces.

Samsung's experience deploying LTE-R and MCPTX solutions in the world's first pioneering PS-LTE markets has demonstrated significant benefits to the IMS approach. Interoperability, security, network integration, device and feature ecosystems all derive advantages from an underlying IMS framework and the use of open standards. Concerns regarding the added overhead of IMS are largely mitigated by the decade of steady improvement to IMS implementations and are overshadowed by the inherent benefits that IMS generates in terms of integration and cross-device/service/network interworking. Furthermore, it avoids a fairly worrisome alternative – proprietary solutions, proprietary interfaces, closed ecosystems and solution lock-in.

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