Executive Summary

Inside 3GPP Release 13: Understanding the Standards for HSPA+ and LTE-Advanced Enhancements

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EXECUTIVE SUMMARY

The 3rd Generation Partnership Project (3GPP) standards are a major reason why the technology supports more than 7.2 billion mobile connections worldwide. The latest version, 3GPP Release 13 (Rel-13), arrives just as the mobile industry begins discussion and development of another generation, the fifth generation (5G), of mobile technology to face unprecedented challenges: accommodating skyrocketing traffic growth amid a spectrum shortage, escalation of the Internet of Things (IoT) and a vision for network transformation that will create an all-IP environment. All of that will not be alleviated until the next decade or further as IMT-2020 or 5G technology begins to take shape.

However, the 3GPP standards have many innovations remaining for both LTE and HSPA+ to create a foundation for 5G. Rel-12, which was finalized in December 2014, contains a vast array of features for both LTE and HSPA+ that brings greater efficiency for networks and devices, as well as enables newer services. Rel-13 continues to build on these while adding many rich new features of its own, for example, studies for Indoor Positioning System (IPS) enhancements and Licensed Assisted Access (LAA) were initiated in June 2014 for Rel-13. As in previous releases, and given the large number of features first introduced in Rel-12, many were extended into Rel-13. Study is currently ongoing in Rel-13, with an expected functional freeze in December 2015, and completion in March 2016.

In this executive summary, a concise overview of the main Rel-13 features is provided. More detailed explanations of 3GPP Rel-13 are provided in the 4G Americas white paper, ***Mobile Broadband Evolution Towards 5G: Rel-12 & Rel-13 and Beyond***.

For LTE-Advanced, Rel-13 supports Active Antenna Systems (AAS), including beamforming, Multi-Input Multi-Output (MIMO) and Self-Organizing Network (SON) aspects, enhanced signaling to support inter-site Coordinated Multi-Point Transmission and Reception (CoMP), Carrier Aggregation (CA) enhancements to support up to 32 component carriers and Dual Connectivity (DC) enhancements to better support multi-vendor deployments with improved traffic steering. Improvements in Radio Access Network (RAN) sharing are also being worked on as part of Rel-13. Work on enhancements to Machine Type Communication (MTC) and Proximity Services (ProSe) is continued from Rel-12.

Further features being considered in Rel-13 are: Licensed Assisted Access for LTE (LAA-LTE), in which LTE can be deployed in unlicensed spectrum, LTE Wireless Local Area Network (WLAN) Aggregation (LWA) where Wi-Fi can now be supported by a radio bearer and aggregated with an LTE radio bearer and Downlink (DL) Multi-User Superposition Transmission (MUST) which is a new concept for transmitting more than one data layer to multiple users without time, frequency or spatial separation.

For HSPA+, the main Rel-13 items being considered are enhancements for reducing control channel overhead and support for dual band Uplink (UL) Carrier Aggregation.

With respect to network-related services, Rel-13 introduces Wi-Fi integration enhancements to support Network-Based IP Flow Mobility (NBIFOM) enhancements to harmonize the support of voice and video services over Wi-Fi and enhancements to support Mission Critical Push-to-Talk (MCPTT) over LTE for public safety. Rel-13 continues work from Rel-12 in optimizing performance for MTC services by defining a Dedicated Core (DECOR) and Monitoring Enhancement (MONTE) for MTC services, as well as enhancements to MBMS, ProSe and group communications.

Additional features in network-related services include the User Plane Congestion Management (UPCON) feature which enables the identification of cells and users in congested situations so that policy decisions can be used to mitigate congestion, and the Application Specific Congestion Control for Data Communication (ACDC) can manage access attempts on a per application basis. Architecture

Enhancements for Service Capability Exposure (AESE) was added in Rel-13 to expose valuable information to third party application providers.

As work on 3GPP Rel-13 continues to develop the standards for HSPA+ and LTE/LTE-Advanced, simultaneous discussion on future network requirements and recommendations for the next generation of 5G technologies has begun. Groups such as 4G Americas are contributing to the discussion and are liaising with other organizations such as NGMN Alliance, 5G PPP, ATIS, ITU, Small Cell Forum and others. 4G Americas has published several white papers on 5G topics including spectrum and technology recommendations. It is expected that discussions in the 3GPP working groups will turn to 5G standardization in Rel-14.

Following is an overview of some of the key features for LTE enhancements in Rel-13.

ANTENNA PROCESSING ENHANCEMENTS

Active Antenna Systems (AAS) use flexible cell split (vertical or horizontal) and/or beamforming to provide increased system flexibility and performance. The AAS Base Station (BS) uses multiple transceivers on an antenna array to produce a radiation pattern that can be dynamically adjusted. Spatial selectivity in both transmit and receive directions is important. For example, compared to fixed beam antennas, the AAS may experience different spatial selectivity because it does not achieve full spatial selectivity until after digital baseband processing of the multiple elements in the array. Therefore, new radio requirements are needed for AAS compared to legacy radio requirements that exclude the antennas. Another aspect is the requirement reference points at which core Radio Frequency (RF) requirements are specified. For the downlink, the minimum requirement for radiated transmit power will be on the accuracy with which declared Equivalent Isotropic Radiated Power (EIRP) level is met. For the uplink, the Over-the-Air (OTA) sensitivity requirement applies to the AAS BS operating as a system (i.e., including combining of received signals from all active receivers). The received signal level is given by the Equivalent Isotropic Sensitivity (EIS) power level.

With the added beamforming, cell shaping and cell splitting benefits of AAS, Rel-13 has studied the impact of such techniques to performance SON. The Rel-13 work item focused on ensuring the connection continuity and adapting the existing SON/Mobility Robustness Optimization (MRO) principles during the dynamic deployment changes due to AAS-based deployments and without impacting the Radio Resource Management (RRM) mechanism.

In addition to specifications of the radio requirements, layer one enhancements for AAS have been initiated in a new work item on **Elevation Beamforming (EBF) and Full Dimension (FD) Multi-Input Multi-Output (MIMO).** Similar to AAS, the antenna considered is a two-dimensional antenna array operation with eight or more Transceiver Units (TXRU) per transmission point, where a TXRU has its own independent amplitude and phase control. To support elevation beamforming or full-dimension MIMO, the enhanced NodeB (eNB) needs to know the latest Channel State Information (CSI) with sufficient accuracy of channel quantization. Several CSI feedback mechanisms for both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) have been evaluated, including beam-formed CSI-Reference Signal (RS) ports and non-precoded CSI-RS resources whose configuration is related to specific codebook design for a 2D antenna array and CSI feedback methodology. Other aspects considered are the need for more orthogonal or quasi-orthogonal Demodulation Reference Signal (DMRS) ports for estimating the demodulation channel as higher order UE pairing becomes more frequent.

COORDINATED MULTI-POINT (COMP)

Another area of focus for Rel-13 was enhanced signaling for inter-eNB CoMP. The goal of inter-eNB CoMP is to introduce a coordination mechanism to reduce interference between two eNBs. It is believed that Inter-eNB CoMP can provide better performance by improving the coverage of high data rates, cell-edge throughput and overall system throughput coordinated scheduling. In Rel-12, two options were considered. The 'Relative Narrowband Tx Power (RNTP)' Information Element (IE) is exchanged among eNBs over X2 in X2AP: LOAD INFORMATION message. The purpose of this IE is to signal, on a per Physical Resource Block (PRB) basis, that the downlink transmission power is lower than the threshold value indicated by the RNTP Threshold IE.

The receiving eNB may take such information into account when setting its scheduling policy and will consider the received RNTP IE value valid until reception of a new LOAD INFORMATION message carrying an update. A possible enhancement of the Rel-13 work item is to extend RNTP signaling in the time domain. Other enhancements include User Equipment (UE) CSI information, Rank Indicator (RI), and Channel Quality Indicator (CQI)).

PUBLIC SAFETY

Several Public Safety functionalities initiated in Rel-12 were continued in Rel-13, such as enhancements to **LTE device-to-device** communications and discovery, meeting public safety requirements for in-network coverage (intra-cell and inter-cell), partial network coverage and outside network coverage scenarios. For non-public discovery, the work item covers in-network coverage only. Some of the enhancements prioritized are for Device to Device (D2D) discovery to enable Type 1 discovery, the partial and outside network coverage scenarios targeting public safety use and enhancements to D2D communication to enable the extension of network coverage using L3-based UE-to-Network Relays, including service continuity (if needed). These Public Safety functionalities are based on Rel-12 D2D communication, considering applicability to voice and video.

Mission critical push-to-talk over LTE (MCPTT) capabilities include group calls, person-to-person calls, prioritization of calls and of individuals, group management, user management, configuration management, security, operation in relay-to-network mode, operation in off-network mode and a number of other related features. MCPTT also uses the 3GPP Proximity Services (ProSe) to allow two public safety devices to communicate directly with each other, both in and out of regular LTE network coverage.

Current standardization activities also involve studying and developing the application level architecture for MCPTT. The discussions are around proposed solutions such as basic architecture functionalities across application, IP Multimedia Subsystem (IMS), Evolved Packet System (EPS) layers and the deployment models supported, identifying reusable components in existing TETRA and Critical Communications Evolution (TCCE) and Open Mobile Alliance (OMA) Push-to-Communicate for Public Safety (PCPS) specifications, roaming models, etc.

Multimedia Broadcast Multicast Services (MBMS) access was made available to applications in Rel-12 by the creation of the MB2 interface (between the Group Communication Service Application Server and the Broadcast Multicast Service Center). This work was primarily done to support MCPTT as well as any applications implementing the MB2 interface. In **MBMS enhancements**, two areas needing improvement in Rel-13 are service continuity and greater independence of the application from knowing the service areas defined in the network.

To support pre-emption of MBMS bearers and support service continuity for the devices is to alert the devices that a particular MBMS bearer is about to be suspended. This gives the devices some time to be able to request a unicast bearer from the application, and this is precisely the method of service continuity already present in Rel-12. The additional warning provides the ability to have a smaller content gap at the application level when the switch from broadcast to unicast occurs. The other MBMS improvement in Rel-13 involves the ability of the application Group Communication System Application Server (GCS AS) to request an MBMS bearer using a list of cells, rather than a list of MBMS service areas.

MACHINE TYPE COMMUNICATIONS (MTC)

In Rel-12, a new UE category with reduced data rate, half duplex support and single receive antenna was introduced. Further enhancements in Rel-13 aim at specifying a new UE for MTC operation in LTE that also allows for enhanced coverage compared to existing LTE networks and low power consumption. Coverage improvement corresponds to 15 dB for FDD UEs operating delay tolerant MTC applications, relative improvement with respect to their respective nominal coverage as well as power consumption reduction targeting ultra-long battery life for UEs both in normal coverage and enhanced coverage.

Other enhancements are: Dedicated Core Networks (DECOR), Architecture Enhancements for Services capability exposure (AESE), optimizations to support High Latency Communication (HLCom), Group Based Enhancements (GROUPE), Extended Discontinuous Reception (DRX) Cycle optimization and Monitoring Enhancements (MONTE). These are described in the following paragraphs.

In **DECOR**, architectural enhancements such as routing, to support dedicated core networks for specific type(s) of subscribers and maintain UEs in their respective Dedicated Core Network (DCN) are defined. The use of Dedicated Core Network can be to provide specific characteristics and/or functions or isolate specific UEs or subscribers (e.g., MTC subscribers, subscribers belonging to a specific enterprise or separate administrative domain, etc.). The main architecture enhancements are to route and maintain UEs in their respective dedicated core network (for UEs with assigned DCN).

For **AESE**, architecture enhancements are considered for a service capability exposure framework, wherein the 3GPP system provided service capabilities are exposed via one or more standardized Application Programming Interfaces (API). 3GPP Mobile Network Operators (MNO) can offer value added services by exposing these 3GPP service capabilities to external application providers, businesses and partners using web based APIs. In addition, 3GPP MNOs can combine other internal or external services with their network capabilities to provide richer, composite API services to their partners. This Rel-13 project studies and evaluates architecture enhancements for a service capability exposure framework wherein the 3GPP system provided service capabilities are exposed via one or more standardized APIs, (e.g., the OMA-API(s)).

HLCom enhancements consider: the scenario where applications communicate with temporarily unreachable devices (potentially for a long period) over the 3GPP IP connectivity and the ability to support large numbers of such devices in the system without negatively affecting the system performance. The specific scenario is the downlink access for devices that are not reachable for a long period, for example, due to the UE being in Power Saving Mode (PSM) and the problems associated with such devices such as packet discard when the UE sleeps, frequent retransmissions, load on the CN network, waste of radio resources and UE power when the network unnecessarily conveys retransmit packets, among others.

With **GROUPE**, handling of groups of MTC devices in the network includes Group based features such as Message Delivery to a Group of Devices, Group Based Non Access Stratum (NAS) Level Congestion Control and Group Based Addressing and Identifiers. Group message delivery using MBMS is more

suitable to deliver a group message to a large group membership in a particular geographical area. Devices that belong to a predefined group may overload the Mobility Management Entity by generating a large amount of NAS signalling. For example, a particular group of devices may continuously try to connect to a non-responding server and do so by repeatedly (and successfully) reattaching to the network during the recovery phase of this particular server. Lastly, group based addressing and identifiers are essential to support group based features such as delivery of group messaging and group policing, to determine if a subscription is a member of a specific group or to address the individual devices within a group.

Extended DRX Cycle studied long DRX cycles beyond 10.24 seconds for both Idle and Connected Mode DRX for power consumption optimization for cases where mobile terminated data has a delay tolerance in the order of minutes to an hour. The study intends to complete the work that was initiated as part of Rel-12 work on MTC Power Consumption Optimization.

In **MONTE,** mechanisms to monitor various aspects of device operation via different 3GPP interfaces/nodes were defined. A primary mechanism was defined that allows an application (e.g., a Service Capability Server/Application Server (SCS/AS), as defined by oneM2M, to be able to access the set of capabilities required for monitoring via different 3GPP interfaces/nodes (e.g., Home Subscriber Server (HSS) via Sh (interface between AS and Home Subscriber Server), with enhancements), or Policy Charging and Rules Function (PCRF) via Receive (Rx) with enhancements or MME/Serving GPRS Support Node (SGSN) via the new interface T6a/T6b to Service Creation Environment Function (SCEF). The mechanism for monitoring is generic, in the sense that additional events and data requests can be supported using this same mechanism.

LICENSED ASSISTED ACCESS (LAA) AND CARRIER AGGREGATION (CA) ENHANCEMENTS

Licensed Assisted Access features carrier aggregation operation with one or more low power Secondary Cells (SCells) operating in unlicensed spectrum and is either downlink-only or contains both uplink and downlink. To ensure good end user experience, LAA and the usage of the unlicensed spectrum is tightly coupled with LTE in licensed spectrum.

Ensuring fair sharing of the unlicensed spectrum with other operators and other systems such as Wi-Fi is central to LAA. Several mechanisms that enable fair coexistence have been evaluated. The LAA node searches and finds a part of the unlicensed spectrum with low load, thereby avoiding other systems if possible. If no free channel is found, LAA will specify the algorithm and share the channel with other technologies or other LAA deployments. Rel-13 will also include a Listen-Before-Talk (LBT) mechanism, where the transmitter ensures there are no ongoing transmissions on the carrier frequency prior to transmitting.

A separate but related Rel-13 feature is the enhancements to the carrier aggregation framework which will be extended to handle up to 32 carriers. The enhancements include specifying control signaling for up to 32 component carriers for both uplink and downlink. In the 5 GHz bands considered for LAA, there is already room for even larger bandwidths. More licensed spectrum is also expected to become available, for example in the 3.5 GHz band, which can be used to increase network capacity and meet traffic growth.

INDOOR POSITIONING

Enhancements to improve positioning both indoors and in other challenging environments were studied since September 2014 with the motivation for the study driven by the observation that mobile devices are used increasingly indoors. In the U.S., the FCC has recognized this, and in January 2015 issued the Fourth Report and Order on Wireless E911 Location Accuracy Requirements, in which the order requires that wireless providers provide either a dispatchable location or an x/y location within 50 meters for 80 percent of all wireless 911 calls within six years.

Various technologies are evaluated in Rel-13 to improve location performance including Wi-Fi, barometric pressure, collaborative positioning and terrestrial beacon systems.

CONGESTION CONTROL AND MANAGEMENT

Features in User-Plane Congestion (**UPCON**) aim at detecting and mitigating situations where the offered load exceeds the capacity of the RAN to transfer user data for a few seconds or longer. Congestion mitigation techniques include traffic prioritization (e.g., by adjusting Quality of Service (QoS) for specific services according to operator policies and subscriber profile), traffic reduction (e.g., by compressing images or by applying adaptations for streaming applications) and traffic limiting (e.g., by prohibiting or deferring certain services traffic such as unattended data traffic where unattended data traffic is defined as data traffic of which the user is unaware.

Application specific congestion control for data communication (**ACDC**) is intended to be an access control mechanism allowing the operator to prioritize/restrict access attempts from specific applications, so as to mitigate overload of the access network and/or the core network. The home network will configure the UE with at least four Application Specific Congestion Control for Data Communication (ACDC) categories, and the network will then broadcast access control information (e.g., barring rates) for each ACDC category and will also broadcast an indication of whether ACDC applies to roaming UEs. When an application at the UE triggers an access attempt, the UE will check the ACDC category to which this application belongs, and then apply access control per the information broadcast by the network for the corresponding ACDC category. This mechanism is optional at both the network side and the UE side, and is applicable to both Universal Terrestrial Radio Access Network (UTRAN) and Evolved (E)-UTRAN.

SERVICES

Prior to Rel-13, mechanisms have been defined for simultaneous connectivity of different Public Data Network (PDN) connections over Wi-Fi and 3GPP based technologies. In Rel-10, 3GPP defined the capability for Dual Stack Mobile IPv6 (DSMIPv6) capable UEs to dynamically and seamlessly be directed to move IP flows belonging to the same PDN between Wi-Fi and 3GPP technologies. DSMIP is a mobility protocol specified in the Internet Engineering Task Force (IETF) that provides IP address preservation for IPv4 and IPv6 sessions, allowing the user to roam independently in IPv4 and IPv6 accesses. However, many operators have deployed alternative network-based mobility protocols (e.g., GPRS Tunneling Protocol (GTP) and Proxy Mobile IP (PMIP)). Thus, Rel-13 is defining a feature called Network Based IP Flow Mobility (NBIFOM) using other network-based mobility protocols, in particular PMIP and GTP-based mobility protocols for both trusted (S2a based) and untrusted (S2b based) Wireless Local Area Network (WLAN) access.

In **Enhancements to WEBRTC Interoperability** (eWEBRTCi), continued from Rel-12 WebRTC work, this work item studied the use case that WebRTC clients' IMS subscription corresponds to the third party

managed users (e.g., corporate users or the users of a web service such as a game, where a range-IMPU corresponds to a set of IMPU (called "individual IP Multimedia Public Identity (IMPU)") that share the same IMS services). Some characteristics of the scenario are when the number of the third party managed users may scale from a small number to a huge number and when the assignment for Public User ID (Public Service Identity or PSI) for the third party managed users is left to a third party (Corporate/Web service). This supports flexibility for the third party to manage their services and users. Three proposed solutions have been evaluated.

Following the introduction in Rel-12 of the new EVS codec for Multimedia Telephony (MMTel), 3GPP has started working on extending the support of **Enhanced Voice Services** (EVS) over UMTS Circuit Switched (CS) networks. This will improve user quality and capacity for CS users, also providing a seamless voice experience between and across CS and Voice over IP (VoIP) networks. Needed specifications that have been considered are the codec requirements, Radio Access Network (RAN) UTRAN updates) and Core Network and Terminals (CT for NAS/Core Network (CN) updates).

In **Enhanced Dynamic Adaptive Streaming over HTTP** (DASH), 3GPP started to work on Rel-13 enhancements for DASH-based services. Specifically, the Rel-13 work aims at covering the following aspects: additional tools to optimize efficiency and robustness for Live Services, alignment with common industry practices on Digital Rights Management (DRM) and Content Protection, the addition of metadata to support client-controlled streaming services, the support of methods to address optimized DASH Operation with network proxy caches as well as services for caching of DASH content at UE functions, and last but not least, the support for consistent playout behavior of specific content with metadata support and dedicated client behavior including authentication, authorization and session control.

This concludes the overview of enhancements to LTE in Rel-13; additional study items follow for enhancements to HSPA+.

HSPA+ ENHANCEMENTS

Various improvements for the downlink of HSPA+ in Downlink Enhancements and Machine Type Communications are being studied in Rel-13.

Complementing work introduced in Rel-12 and titled "Further Enhanced Uplink (EUL) enhancements" to improve the uplink performance, the Rel-13 Study Item, "Downlink **Enhancements for UMTS**" covers various downlink improvements. They can be broadly categorized into reduction of downlink control channel overhead in high load scenarios, improvements to L2/L3 signaling transmission and enhancing Serving Radio Bearer (SRB) over HSPA. For downlink control channel, the focus has been on evaluating investigating methods whereby the overhead associated with downlink power control can be reduced. For the case of SRB over HSPA, there is no downlink soft handover and the coverage is smaller than SRB over Dedicated Radio Channel (DCH) which can benefit from the soft handover gain.

For Machine Type Communications improvements, similar to LTE, a Study Item on **Small Data Transmission Enhancements for UMTS** aims to identify current system limitations and technical solutions for improved support of small data/delay tolerant applications and massive deployment of devices in UMTS/HSPA networks. In addition to studies on device power saving enhancements, signaling optimizations and coverage enhancements, improving access control for CELL_Paging Channel (Cell_PCH) and UTRAN Registration Area Paging Channel (URA_PCH) are considered as well.

FREQUENCY BANDS AND CARRIER AGGREGATION COMBINATIONS

In Rel-12, LTE CA allows a maximum of three component carriers in the downlink (DL) CA. Rel-13 already enhances it to a maximum of four component carriers in the downlink CA and further enhancements in this regard are possible. Rel-12 LTE CA also allows a maximum of two component carriers in the uplink CA to pair with two-carrier downlink CA. Rel-13 LTE CA includes work on an enhancement to allow two-carrier uplink CA to pair with three-carrier downlink CA. Finally, TDD-FDD CA for 3DL combinations is also currently being considered in 3GPP.

For HSPA+, the only release-independent band combinations being standardized as part of Rel-13 are Dual Band UL carrier aggregation. Leveraging from existing HSPA multi-carrier data aggregation features such as Dual Band Dual Cell ((DB)DC)/4C-HSDPA (DL) and DC-HSUPA (UL), Dual Band UL carrier aggregation is expected to enable better system and capacity performance (e.g., when used in combination with Dual Band DL multi-carrier, both UL carriers on the serving and non-serving band may be efficiently exploited, achieving a better UL load balancing).

CONCLUSION

3GPP, and its hundreds of participating industry subject matter experts, continue to build the foundation for the next generation of technology through global standards that will span the decades. LTE will continue as the leading mobile broadband technology well into the next decade beyond 2020, even as new standards are developed for 5G.

All work on Rel-13 is scheduled to be finalized by March 2016 and shortly thereafter, 4G Americas will publish an updated version of this executive summary on Release 13.

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