Executive Summary

3GPP Release 11: Understanding the Standards for HSPA+ and LTE-Advanced Enhancements

August 2013

4G americas

EXECUTIVE SUMMARY

3GPP Release 11: Understanding the Standards for HSPA+ and LTE-Advanced Enhancements

Third Generation Partnership Project (3GPP) standards have successfully driven the mobile marketplace to more than 6 billion connections worldwide. That number continues to grow as the number of devices and the expanse of connectivity into Machine to Machine (M2M) and many vertical industries magnifies. This is further exemplified by the growth in data traffic as smartphones, tablets and rich services like video have reached peaks never imagined in past years. There is a continuing story for 3GPP evolution in the coming years with further enhancements to High Speed Packet Access (HSPA/HSPA+) and to Long Term Evolution (LTE/LTE-Advanced) to enable advanced services and support the growing exabytes of mobile data traffic.

Progress on 3GPP standards is measured by the milestones achieved in particular Releases. New features are 'functionality frozen' and are ready for implementation when a Release is completed. 3GPP works on a number of Releases in parallel, starting future work well in advance of the completion of the current Release (Rel). Although this adds some complexity to the work of the groups, progress is continuous and stable. 3GPP standards development falls into three principal areas: radio interfaces, core networks and services. 3GPP Rel-11 standards for HSPA+ and LTE-Advanced were frozen in December 2012 with the core network protocols stable in December 2012 and radio access network (RAN) protocols stable in March 2013.

For HSPA, Rel-11 introduces new capabilities such as 8-carrier downlink operation (HSDPA), Downlink (DL) 4-branch Multiple Input Multiple Output (MIMO) antennas (either one will double maximum theoretical Downlink (DL) throughput rates to 336 Mbps), DL Multi-Flow Transmission, Uplink (UL) dual antenna beamforming (both closed and open loop transmit diversity), UL MIMO with 64 Quadrature Amplitude Modulation (64-QAM), several CELL_FACH (Forward Access Channel) state enhancements (for smart phone-type traffic) and non-contiguous HSDPA carrier aggregation.

For LTE, Rel-11 provides enhancements to the LTE-Advanced technologies introduced in Rel-10, such as: Carrier Aggregation (CA), Multimedia Broadcast Multicast Services (MBMS) and Self Organizing Networks (SON). Rel-11 also introduces the Co-ordinated Multi-Point (CoMP) feature for enabling coordinated scheduling and/or beamforming, Enhanced Physical Control Channel (EPDCCH) and Further enhanced Inter-Cell Interference Coordination (FeICIC) for devices with interference cancellation.

Finally, Rel-11 introduces several network and service related enhancements to Machine Type Communications (MTC), IP Multimedia Systems (IMS), Wi-Fi integration related enhancements, Home NodeB (HNB) and Home e-NodeB (HeNB) enhancements, etc. most of which apply to both HSPA and LTE.

This Executive Summary is intended to provide a brief review of some of the key specifications in 3GPP Release 11. More details will be provided in a future white paper by 4G Americas.

REL-11 LTE-ADVANCED ENHANCEMENTS

LTE is one of the most promising wireless technology platforms for the future. Today's version is only the beginning of a series of innovations in Rel-10 and Rel-11 that will increase performance, efficiency and capabilities as depicted in Figure 1. The enhancements shown in the 2013 to 2016 period are the ones expected from 3GPP Releases 10 and 11 and are commonly referred to as LTE-Advanced. However, subsequent releases such as Release 12 and 13 will continue this innovation through the end of this decade.

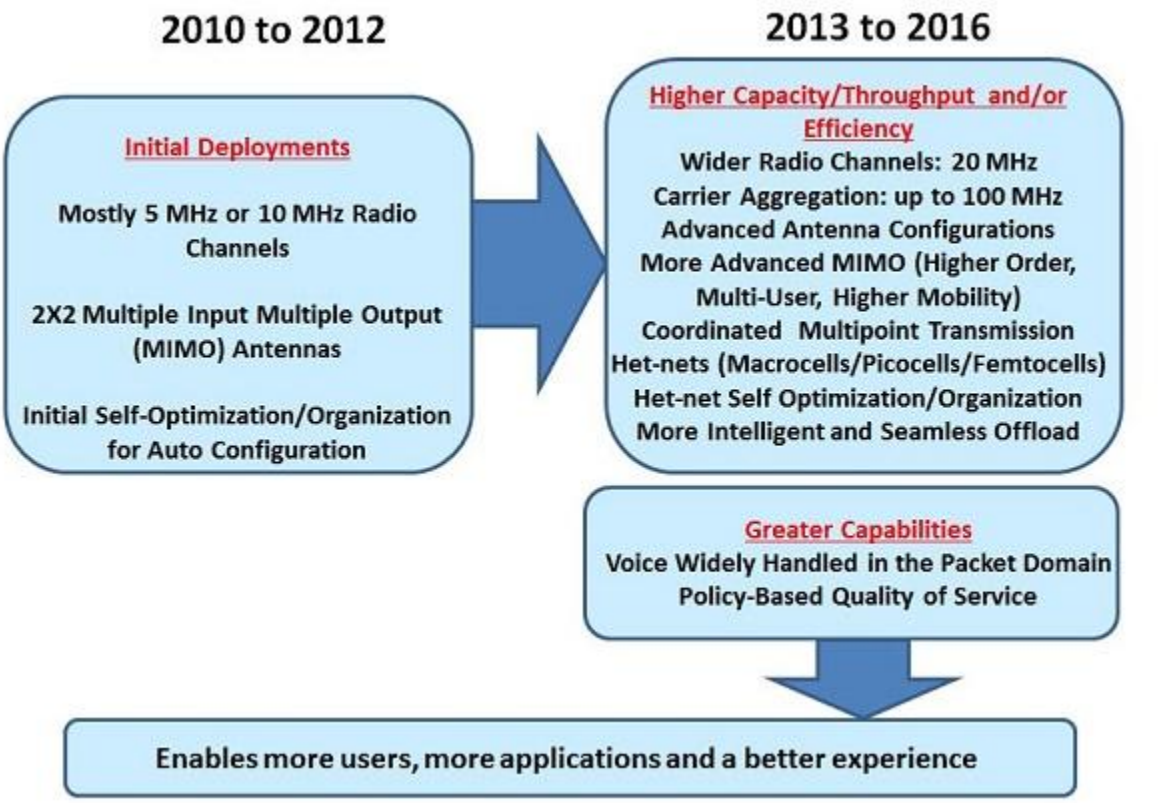

Figure 1: LTE as a Wireless Technology Platform for the Future.

The following are descriptions of some of the key elements and enhancements of Rel-11 LTE-Advanced:

Coordinated Multi-Point (CoMP) transmission/reception is considered by 3GPP as a tool to improve coverage, cell-edge throughput and/or spectral efficiency. A study item was initiated in 3GPP to evaluate this technology for Rel-11, followed by a work item for Rel-11 which was completed in December 2012. The main idea of CoMP is as follows: depending on a User Equipment's (UE) location, it may be able to receive signals from multiple cell sites and the UE's transmissions may be received at multiple cell sites regardless of the system load. If the transmissions from the multiple cell sites are coordinated for the DL, the performance can be increased significantly. This coordination can be simple, as in the techniques that focus on interference avoidance, or more complex, as in the case where the same data is transmitted from multiple cell sites. For the UL, the system can take advantage of reception at multiple cell sites to significantly improve the link performance (e.g. through techniques such as interference cancellation).

In terms of downlink CoMP, three different approaches were studied: Coordinated scheduling, or Coordinated Beamforming (CS/CB), Dynamic Point Selection (DPS) and Joint Processing/Joint Transmission (JP/JT). The main enhancement in LTE-Advanced Rel-11 for supporting DL CoMP is the provision of a new Physical Downlink Shared Channel (PDSCH) Transmission Mode 10 (TM10), which includes a common feedback and signaling framework that can support CS/CB and DPS. Uplink CoMP implies reception of the transmitted signal at multiple geographically separated points. Scheduling decisions can be coordinated among cells to control interference. Since UL CoMP mainly impacts the scheduler/receiver, it is mainly an implementation issue.

Carrier Aggregation was first introduced in LTE-Advanced Rel-10, allowing multiple Rel-8 component carriers to be aggregated together and offer a means to increase both the peak data rate and throughput. Essentially, Rel-11 enhances the carrier aggregation feature in the following aspects:

a) Provides better support for Time Division Duplex (TDD) configurations in which the TDD UL and DL can be configured differently on each of the component carriers and bands either in a full-duplex or in a half-duplex mode.

b) Allows multiple timing advances in User Equipment (UE) different for each component carriers to support the case where the transmission delays from the UE to the eNodeB (eNB) are significantly different for each of the component carriers.

c) Enhances Uplink signaling with the support of multi-cell periodic Channel State Information (CSI) multiplexing and multi-cell Hybrid Automatic Repeat Request Acknowledgement (HARQ-ACK) and periodic CSI. Also, transmit diversity is supported for Physical Uplink Control Channel (PUCCH) for the case of HARQ-ACK multiplexing with channel selection.

Rel-11 defines **Further enhancements to non-carrier aggregation based eICIC (FeICIC).** It includes further reduction in interference through cancellation of interference on common control channels of Almost Blank Subframes (ABS) caused by Common Reference Signals (CRS) of high power macro cells and better detection in the cell range extension region around a picocell of critical broadcast system information. The interference cancellation receiver fully handles colliding and non-colliding CRS scenarios and eases the need for cell planning of heterogeneous deployment. Without an IC-capable UE receiver, heterogeneous networks' eICIC can only work effectively for non-colliding CRS cases. In Rel-11, the network can signal assistance information to UE for CRS interference cancellation which involves signaling of interfering neighbor macro cells information.

Enhanced Physical Downlink Control Channel (EPDCCH) provides a downlink signaling enhancement that increases control channel capacity in support of other LTE enhancements such as CA, CoMP, Machine-Type Communication (MTC) and dense small cell deployments. The Enhanced Physical Downlink Control Channel (EPDCCH) will provide increased control channel capacity and flexible resource allocation through the use of legacy data resources for control information transmission. It improves spectral efficiency and control channel robustness through CSI feedback and use of beamforming. The EPDCCH will be able to coexist on the same carrier as legacy UE and it is frequency multiplexed with the existing Physical Downlink Shared Channel (PDSCH).

E-UTRAN MBMS (eMBMS) in Rel-11 provides support for MBMS service continuity in a multi-carrier deployment of MBMS service. Rel-11 enhancements allow the network to signal assistance information to MBMS capable devices that include information like carrier frequencies and service area identities where MBMS service is available. A MBMS capable device can also indicate information related to the MBMS services of interest to the network. The MBMS interest indication by the device also allows the device to

indicate the priority between MBMS service and unicast service. The network uses the MBMS interest indication provided by the device to ensure continuity of MBMS services. In idle mode, a MBMS capable device can prioritize a particular carrier frequency during cell reselections depending on the availability of MBMS service of interest in that carrier frequency.

SON in Rel-11 includes various enhancements to several of the SON use cases as described below:

a) *Automatic Neighbor Relations (ANR)*; Rel-11 ANR focuses on the management aspects of ANR for UTRAN and Inter-Radio Access Technology (IRAT) ANR.

b) *Load Balancing Optimization* aims to address unnecessary traffic load distribution beyond what is acceptable and to minimize the number of handovers and redirections needed to achieve load balancing. 3GPP Rel-11 has defined the following targets or the combination of the following targets to use for load balancing: Radio Resource Control (RRC) connection establishment failure rate related to load, Enhanced Radio Access Bearer (E-RAB) setup failure rate related to load, RRC Connection Abnormal Release Rate Related to Load, E-RAB Abnormal Release Rate Related to Load and Rate of failures related to handover.

c) *Handover Optimization (HO)* aims at optimizing parameters in such way to mitigate the problem scenarios, namely, too early handovers, too late handovers and inefficient use of network resources.

d) *Coverage and Capacity Optimization* in Rel-11 addresses symptoms such as coverage holes, weak coverage, pilot pollution, overshoot coverage and DL and UL channel coverage mismatch. Capacity and coverage-related performance measurements collected at the source and/or target eNodeB (eNB) can be useful in detecting capacity and coverage-related issues on the cell level. *Minimizing Drive Tests (MDT),* discussed more below*,* or Handover (HO) related performance measurements may also be used in detecting capacity and coverage related issues on the cell level.

e) *RACH Optimization Function* is to automatically set several parameters related to the performance of Random Access Channel (RACH). Specific target values are set by 3GPP to be configured by operators such as access probability and access delay probability.

f) *Energy Saving Features* in Rel-11 spell out the importance of Energy Savings Management (ESM) for Network Operators to look for means to reduce energy costs and protect the environment. The various Energy Savings Management (ESM) concepts can apply to different Radio Access Technologies (RAT), for example, UMTS and LTE. However, 3GPP has specified that some of these ESM concepts may be limited to specific RATs and network elements and specific solutions may be required for them. Rel-11 also addresses the impacts on signaling between the UE and core network when energy saving measures are applied to network entities. A primary energy saving mechanism is realized by a switch-off of radio equipment on the network side. As a consequence, a UE currently being served by the radio equipment subject to switch-off, will have to find an alternative either in the same RAT (if possible by coverage–this would naturally be preferred) or in another RAT. These cases are called ‘intra-RAT energy saving’ and ‘inter-RAT energy saving’ respectively. The fundamental assumption is that due to overlapping radio coverage in all practically relevant cases, an alternative radio access can indeed be found.

g) *Coordination between various SON Functions* addresses the conflict that may happen when two or more SON Functions try to change the same network configuration parameter. The mode of operation

between the SON Coordination Function and the SON Function, as well as the role of the SON Coordination Function in the detection and attempt to resolve the conflicts are specified in Rel-11.

Minimization of Drive Tests (MDT) in Rel-11 defines detailed mechanisms for Management-Based Activation, Trace Parameter Propagation and Trace Record Collection in the case of signalling-based activation. Rel-11 includes Quality of Service (QoS) verification use; the MDT data reported from UEs and the RAN may be used to verify QoS, assess user experience from the RAN perspective and to assist network capacity extension.

MTC enhancements are introduced in Rel-11 which target better control of signaling congestion and overloading of RAN due to MTC devices. *Extended Access Barring* (EAB), is an extension of the legacy Access Control Barring (ACB) mechanism, enabling the RAN (eNB) to bar the access of one or several classes of UEs configured for EAB via new system information (dedicated for 'EAB devices').

Further Home NodeB (HNB) and eNodeB Enhancements in Rel-11 UMTS extend the use of Iur via the HNB gateway to create a Iur link between the HNB gateway and a macro RNC. This enabled soft and hard handover using enhanced Serving Radio Network Subsystem (SRNS) relocation to the macro network. Also introduced for Rel-11, is an implementation-only solution for handling legacy UEs. In LTE Rel-11, mobility involving HeNBs for X2 handover from/to HeNB to/from macro eNB and Inter-Closed Subscriber Group (CSG) X2 handover towards hybrid HeNBs are introduced.

REL-11 HSPA+ ENHANCEMENTS

New HPSA features in Rel-11 include 8-Carrier HSDPA, Downlink Multiflow Transmission, Downlink 4-branch MIMO, Uplink dual antenna beamforming and MIMO together with 64QAM and a number of small enhancements to the Cell_FACH state.

Downlink Enhancements

8-carrier HSDPA (8C-HSDPA) extends the HSDPA carrier aggregation up to 40 MHz aggregate bandwidth by enabling transmission simultaneously on up to eight carriers towards a single UE. The carriers don't necessarily need to reside adjacent to each other on contiguous frequency blocks, as it is possible to aggregate carriers together from more than one frequency band.

Downlink Multiflow Transmission improves the achievable HSDPA cell edge data rates by both reducing the inter-cell interference and increasing the energy of the desired signal. By transmitting independent data streams to the UE, the achievable cell edge peak and average data rate can be increased. This gain stems from spatial multiplexing and exploits advanced interference suppression receivers that are able to suppress the cross-interference of the two data streams from each other. It can be configured together with Dual-Cell HSDPA for transmitting to the UE from up to four cells (two in each carrier) at the same time. Multiflow is also compatible with 2X2 MIMO allowing for each cell in the Multiflow set to transmit two data streams to the UE.

Downlink 4-branch MIMO introduces a higher order MIMO mode to HSDPA. With four receive antennas in the UE, the downlink peak rate can be doubled. This is possible with 2X2 MIMO to 84 Mbps for a 5 MHz carrier. The capacity gain of 4-branch MIMO comes mostly from supporting 4-way Receive (Rx) diversity. The peak data rate gain on the other hand is enabled by extending the HSDPA MIMO layers from two in 2X2 MIMO to four in 4X4 MIMO.

In Rel-11, the 4-branch MIMO is supported with up to four carriers (20 MHz) leading to a peak downlink data rate of 336 Mbps. Future releases could weld the 4-branch MIMO and 8-carrier HSDPA together and reach 672 Mbps peak data rate for HSPA with 40 MHz bandwidth and four MIMO layers.

Uplink Enhancements

Uplink dual antenna beamforming and 2X2 MIMO with 64 QAM allows for the HSUPA transmissions to originate from two transmit antennas. Both rank 1 (single stream beamforming) and rank 2 (dual-stream MIMO) transmission modes are introduced. The rank 1 beamforming gains allow for better uplink data rate coverage and the rank 2 MIMO doubles the achievable peak data rate on the carrier. In addition, 2X4 antenna configurations with 4 Node B Rx antennas have been considered in the 3GPP evaluation work, even though additional receive antennas are more of a deployment option and do not impact the standards. Four-way Rx is expected to roughly double the capacity and significantly improve the probability for rank 2 transmission.

With uplink 2X2 (and 2X4) MIMO, the uplink peak rate reaches 23 Mbps per 5 MHz carrier with 16 QAM modulation. As an additional evolutionary step, 64QAM modulation is also introduced, bringing the uplink peak rate with MIMO to 35 Mbps per 5 MHz carrier.

UL beamforming is supported in two possible modes known as Open Loop and Closed Loop Transmit Diversity (OLTD and CLTD respectively).

The **Cell_FACH improvement features** of Rel-11 are building on top of the high-speed FACH and RACH concepts introduced in 3GPP Rel-7 and Rel-8 respectively. The set of small improvements can be split in categories: improvements in downlink, uplink, UE battery life and mobility.

MTC enhancements for Universal Terrestrial Radio Access (UTRA), similar to EAB, have been defined also for Rel-11. EAB enables the RAN (in this case UTRAN) to bar the access of one or several classes of UEs configured for EAB via new system information (dedicated for 'EAB devices'). This allows a better control of signalling congestion and/or overloading in RAN due to MTC devices. At a high level, the mechanism is similar to that defined for LTE.

REL-11 NETWORK AND SERVICES - RELATED ENHANCEMENTS

For **Machine-Type Communication (MTC)** the most important features and requirements such as device triggering, PS-only (Packet Switched) subscription and E.164 number shortage were addressed under the work item 'System Improvements for Machine Type Communication (SIMTC)' in 3GPP Rel-11.

Following are the main features introduced as part of this work and documented in TS 23.682[1]:

- Identifiers (Mobile Subscriber Integrated Services Digital Network Number-less (MSISDN-less)) – Usage of Internet-like identifiers at the external interface between Public Land Mobile Network (PLMN) and service provider domain to replace MSISDN

- Addressing – IPv6 was recommended for usage with MTC devices

[1] 3GPP TS 23.682, "Technical Specifications Group Services and System Aspects; Architecture Aspects to Facilitate Communications with Packet Data Networks and Applications (Release 11)", V11.1.0 (2012-06).

- Device Triggering – Mobile Terminated-Short Message Service (MT-SMS) with a standardized interface to the SMSC (SMS Service Center)

- Optimizations for devices with Packet Switched (PS)-only subscription

- Dual-priority devices – certain applications can override low access priority configuration

- EAB for E-UTRAN and UTRAN

- SMS in Mobility Management Entity (MME) configuration (architecture option for networks with no UTRAN or GSM EDGE Radio Access Network (GERAN) Circuit Switched (CS) domain where a direct interface from SMSC to MME for SMS delivery is deployed).

3GPP mainly introduced a new **Machine-Type Interworking Function (MTC-IWF)** in the architecture for service providers to interconnect with the mobile operator's network to enable control plane device triggering, identifier translation and other features in the future. The end-to-end communication between the MTC application in the UE and the MTC application in the service domain may use services provided by the 3GPP system, and optionally services provided by a Services Capability Server (SCS). The MTC Application in the external network is typically hosted by an Application Server (AS). The SCS can be located in the service provider domain, or it can also be hosted by the Mobile Network Operator (MNO) as a kind of Service Delivery Platform. In the latter scenario the SCS can implement charging and security functions. The SCS can be located in the service provider domain or by the MNO as a kind of Service Delivery Platform. In the latter scenario the SCS can implement charging and security functions.

Network Provided Location Information for IMS Services (NetLoc) is a core network enhancement defined in Rel-9. Normally the Location Service (LCS) information is provided in the geographical information format, which is not suitable for charging purposes as it lacks access network information. Rel-11 updates were completed in September 2012 for charging architecture and principles with the addition of network-provided location information to Internet Protocol Multi-Media System (IMS) charging, Charging Data Record (CDR) definitions and corresponding diameter Attribute Value Pair (AVP) definitions.

Voice over LTE (or VoLTE) with **Single Radio Voice Call Continuity (SRVCC)** improves voice coverage by handing over the voice session from LTE to 2/3G CS domain and has been standardized since Rel-8. Rel-10 improved handover performance overall and in Rel-11 the SRVCC feature is further enhanced with the priority handover enhancements for Multimedia Priority Service (eMPS aspect of SRVCC), SRVCC from 2/3G CS to LTE/HSPA (rSRVCC) and video SRVCC from LTE to UMTS (vSRVCC).

Enhancements for Multimedia Priority Service (eMPS) is a feature in Rel-10 for IMS sessions and EPS bearer sessions. The SRVCC with priority treatment is deferred to Rel-11. Depending on regulatory requirements in a region, it is useful to forward priority indication of an IMS-based voice call over LTE with priority to Circuit Switch of GERAN/UTRAN so that the call can be handled in a prioritized way compared to other normal IMS-based voice calls when SRVCC is performed. In Rel-11, SRVCC has also been standardized for IMS voice+video sessions to UMTS CS video; hence, eMPS SRVCC can also apply to video SRVCC. The mechanism to handle SRVCC for an IMS-based priority voice or voice+video session,

established in LTE in GERAN/UTRAN, is to reuse the priority handling mechanisms that were already defined for GERAN/UTRAN in TS 25.413[2] for UMTS and defined in TS 48.008[3] for GSM/EDGE.

SRVCC from 2G/3G to LTE/HSPA has also been introduced in Rel-11, where 3GPP has developed a feature to allow a CS voice call to be handed over to LTE/HSPA as an IMS voice session. Specifically, CS call from 2/3G to LTE or from 2G to HSPA is supported (i.e. 3G to HSPA is not supported). This feature is sometimes called rSRVCC where 'r' stands for reverse. The solution is biased toward enhancing user experiences (for as much higher data throughput as possible) versus the traditional view for coverage scenario. Hence, the handover solution requires more network preparation before the UE can perform the RAT changes.

3GPP Rel-11 has also developed a feature to allow an IMS voice+video session over LTE to be handed over to 3G CS video with 64 kbit CS data bearer. The overall concept follows the voice SRVCC as defined earlier. The main difference is that the MME is aware that a video component is being involved (indicated by PCC) and it requests the MSC Server to initiate the video SRVCC handling.

Policy Control Framework is enhanced with the Traffic Detection Function (TDF) for application detection and control features which comprises the request to detect the specified application traffic, report to the Policy and Changing Rules Function (PCRF) on the start/stop of application traffic and to apply the specified enforcement actions. The supported enforcement actions are: bandwidth limitation, gating and redirection. Additionally, usage monitoring report to the PCRF is supported per session and per detected application. Policy and Charging Convergence (PCC) architecture is enhanced with a new interface between the TDF and the PCRF. Two models may be applied, depending on operator requirements: solicited and unsolicited application reporting.

To allow mobile operators a much finer granularity of control of the subscribers' usage of the network resources by linking the subscribers' session QoS with a spending limit, 3GPP work groups completed the **QoS control based on Subscriber Spending Limits (QoS_SSL)** work as one of the PCC architecture enhancements. QoS_SSL gives the operator the ability to deny a subscriber access to particular services if the subscriber has reached his allocated spending limit within a certain time period. It is also possible that the QoS of a subscriber's session could be modified when this spending level is reached. This allows the operator to have additional means of shaping the subscriber's traffic in order to avoid monopolizing the network resource at any one time. Support for roaming subscribers without impact on the visited network is also provided. Also, using triggers based on the operator's charging models, the subscriber could be given the opportunity to purchase additional credit that increases the spending limit.

System Architecture (SA) group 5 and Core Network and Terminals (CT) specifications regarding the **Online Charging System (OCS)** architecture and logical function definition for spending limit control, diameter interface impact, Sy interface related procedures and message flows are updated in Rel-11.

Multimedia Emergency Services (MMES) are next generation emergency services utilizing real-time session-based text and other multimedia, in addition to voice, that are based on trusted applications in support of non-voice communications between citizens and emergency authorities. Support of IMS

---

[2] 3GPP TS 25.413, "Technical Specifications Group Radio Access Network; UTRAN Iu Interface Radio Access Network Application Part (RANAP) Signaling (Release 11)", V11.0.0 (2012-06).

[3] 3GPP TS 48.008, "Technical Specification Group GSM/EDGE Radio Access Network; Mobile Switching Centre – Base Station System (MSC-BSS) Interface; Layer 3 Specification (Release 11)", V11.2.0 (2012-05).

Emergency Sessions with other media on UTRAN and E-UTRAN is also called IMS MES (IMS Multimedia Emergency Session). The enhancement has been added to support session based IMS emergency sessions that allow the UE to use other media and communication types than voice and Global Text Telephony (GTT) during an IMS emergency session. This occurs when the network supports IMS voice emergency calls and UE also supports other media or communication types.

Enhancements to **Interworking with Wi-Fi** are introduced in Rel-11. The specifications support enhancements to Evolved Packet Core (EPC) for multi-access Public Data Network (PDN) connectivity, IP Flow Mobility and seamless Wideband Local Area Network (WLAN) offloading. WLAN Access to the EPC with IP address continuity was defined in Rel-8 and extended in Rel-10 with Internet Protocol Flow Mobility and seamless WLAN Offload (IFOM) and Multi-Access PDN Connectivity (MAPCON). However, routing from the UE to the PDN Gateway (GW) was not optimized prior to Rel-11 because it did not consider UE location. Rel-11 improves the enhanced Packet Data Gateway (ePDG) and PDN-GW selections based on the location of the UE for the WLAN Access to EPC through an enhancement called LOcation Based Selection of gaTEways foR WLAN (LOBSTER). Network Management specifications are also being added in Rel-11 to support Management Information Objects and Performance Management data for the new network elements and respective interfaces (for example: s2a, s2b, s2c).

Enhancements to **Universal Integrated Circuit Card (UICC)** are introduced in Rel-11. Specifically, there have been UICC enhancements inside femtocells (providing femtocell hosting party authentication), inside handsets (enabling femtocells), Public Warning Systems (enabling Over The Air (OTA) management) and to the Non-Access Stratum (NAS) configuration.

3GPP SA working group 3 was chartered with the goal of studying all relevant functions and services of Rel-11 to fulfil the national requirements on **lawful interception**. The following areas were considered:

- CAT (Customer Alerting Tones) & CRS (Customized Ringing Signal)
- VCC (Voice Call Continuity) & Service Continuity
- IMS Media security
- H(e)NB also with Local IP Access and Selected IP Traffic Offload
- eMBMS
- LCLS
- SIMTC
- IMS Enhancements
- EPS Enhancements
- Enhanced Location Reporting

RELEASE INDEPENDENT FEATURES

As the spectrum allocations in different countries evolve, 3GPP continuously updates and adds new frequency bands. While a new frequency band or carrier aggregation scheme or other enhancements may be introduced in a particular release, it may be used in UEs which otherwise implement an earlier release. This speeds the utilization of new spectrum and allows terminal manufacturers to support various frequency bands without having to otherwise upgrade all the terminal's features to the latest release level. Rel-11 introduced several new frequency bands, carrier aggregation band combinations and HSPA multi-carrier scenarios.