



# **Understanding 3GPP Release 12: Standards for HSPA+ and LTE Enhancements**



A GLOBAL INITIATIVE

**Executive Summary  
February 2015**

## FOREWORD

For more than a decade, 4G Americas has published white papers that condense and explain the standards work by 3GPP on the GSM-UMTS-LTE family of technologies. In February 2014, a working group of member company experts prepared a detailed report, *4G Mobile Broadband Evolution: 3GPP Release 11 & Release 12 and Beyond*, and in March 2014 a condensed report *Executive Summary – Inside 3GPP Release 12: Understanding the Standards for HSPA+ and LTE-Advanced Enhancements* was published. With the completion of Release 12 standards in December 2014, the Executive Summary on Release 12 is being updated to reflect any changes since March 2014 in this current publication.

## EXECUTIVE SUMMARY

### ***Understanding 3GPP Release 12 Standards for HSPA+ and LTE-Advanced Enhancements***

The 3rd Generation Partnership Project (3GPP) standards are a major reason why the technology supports 6.6 billion mobile connections worldwide. 3GPP Release 12 (Rel-12) arrives just as the mobile industry faces an unprecedented challenge: accommodating skyrocketing traffic growth amid a spectrum shortage that will not be alleviated until the next decade or further.

As Release 11 (Rel-11) standards were being finalized in early 2013, work began on 3GPP Rel-12. The primary goal of Rel-12 is to provide mobile operators with new options for increasing capacity, extending battery life, reducing energy consumption at the network level, maximizing cost efficiency, supporting diverse applications and traffic types, enhancing backhaul and providing customers with a richer, faster and more reliable experience.

In a kickoff workshop followed by subsequent 3GPP Radio Access Network (RAN) working group meetings, leading operators and equipment vendors discussed new LTE proposals for interference coordination/management, dynamic Time Division Duplexing (TDD), frequency separation between macro and small cells, inter-site Carrier Aggregation (CA), wireless backhaul for small cells and more. The additional analyzed proposals for LTE multi-antenna and multi-site technologies were 3D Multiple Input Multiple Output (MIMO) and beamforming, as well as further work on existing Coordinated Multi-Point Transmission and Reception (CoMP) and MIMO specifications. Other items included support for Proximity Services (ProSe), MBMS enhancements, Machine-to-Machine (M2M) applications, Self-Organizing Networks (SON) and interworking between HSPA, Wi-Fi and LTE.

Overall, Rel-12 provides LTE enhancements and new enablers that can be classified in four broad categories:

- LTE small cell and heterogeneous networks
- LTE multi-antennas (e.g., MIMO and beam forming)
- LTE proximity services
- LTE procedures for supporting diverse traffic types

Rel-12 has also enhanced UMTS/HSPA+, e.g. in the following areas: UMTS Heterogeneous Networks, SIB/Broadcast optimization, EUL enhancements, HNB optimization, DCH enhancements, MTC and WLAN offload.

Rel-12 is now complete with a functional freeze date of March 2015.

This document provides a final update of the Rel-12 Executive Summary and section of the white paper, *4G Mobile Broadband Evolution: 3GPP Release 11 & Release 12 and Beyond*, published in March 2014, which is available on the 4G Americas' website, including Rel-12's major features and how they benefit mobile operators and their customers.

## REL-12 LTE-ADVANCED ENHANCEMENTS

Figure 1 summarizes how Rel-12 builds on the innovations in Rel-10 and Rel-11 to further increase performance, efficiency and capabilities. All three releases are called LTE-Advanced.

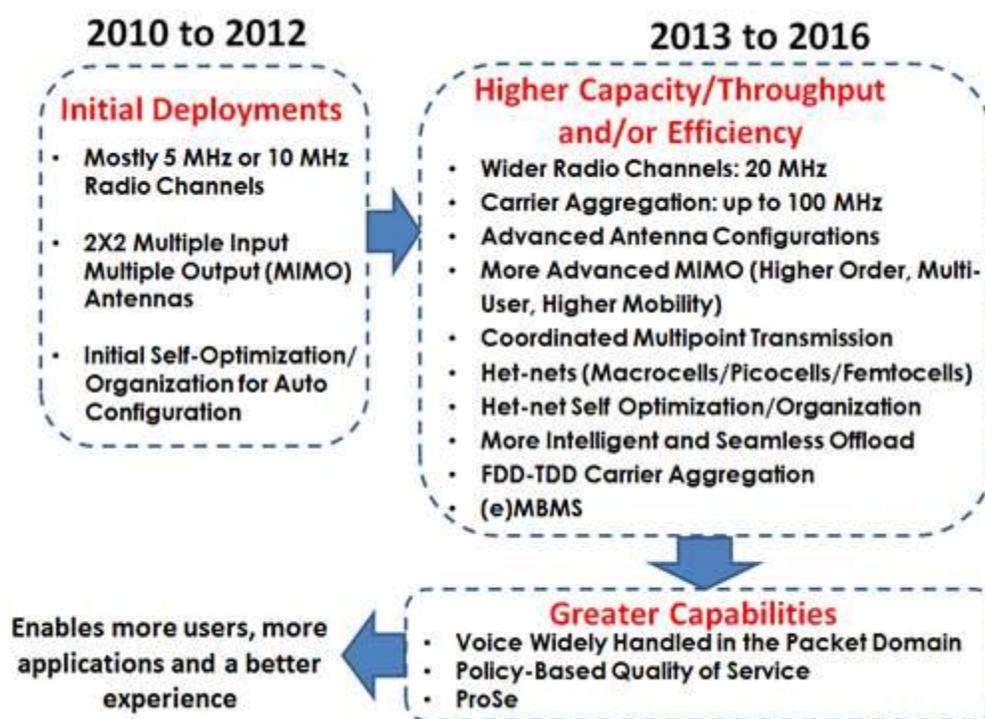


Figure 1. LTE as a Wireless Technology Platform for the Future.

Rel-12 defines new features and improvements to downlink enhancements for MIMO, as well as small cells, femtocells, M2M, Proximity Services (ProSe), User Equipment (UE) enhancements, SON, Heterogeneous Network (HetNet) mobility, Multimedia Broadcast/Multicast Services (MBMS), Local Internet Protocol Traffic Offload/Selected Internet Protocol Traffic Offload (LIPTO/SIPTO), Enhanced International Mobile Telecommunications Advanced (eIMTA) and Frequency Division Duplex-Time Division Duplex Carrier Aggregation (FDD-TDD CA).

### Downlink MIMO Enhancements

Rel-12 features two Channel State Information (CSI) enhancements: 4Tx (Transmit) Precoding Matrix Index (PMI) feedback codebook enhancement and aperiodic feedback Physical Uplink Shared Channel (PUSCH) mode 3-2. The CSI enhancements enable the Evolved NodeB (eNB) to complete delivery of data packets earlier than with legacy CSI feedback, thus improving spectral efficiency. The Rel-12 4Tx

codebook enhancement mainly targets cross-polarized antennas and thus, reuse of the 8Tx dual codebook structure. In addition to the enhanced codebook, a new aperiodic CSI feedback PUSCH mode 3-2 is introduced in Rel-12 with increased CSI accuracy since it provides both sub-band Channel Quality Indication (CQI) and sub-band PMI feedbacks.

## **Small Cells**

Various small cell enhancements were evaluated in Rel-12.

A *Physical Layer* study was developed to improve system spectrum efficiency by increasing the transmission efficiency and/or reducing overhead. Mechanisms for efficient operation of the small cell layer that were introduced in Rel-12 include interference mitigation through optimally powering On/Off small cells, cell discovery signals and procedures, and Radio Based Synchronization based on Network Listening. For spectral efficiency improvements in Rel-12, the highest supported modulation was increased from 64 QAM to 256 QAM for both PDSCH and PMCH.

Separately, a *Higher Layer* study focused on mobility robustness, reducing the signaling load toward the core network due to handover, and improved per-user throughput and system capacity using dual connectivity. Dual connectivity became the main objective of the subsequent work item in Rel-12. This referred to situations where a UE is capable of using radio resources provided by at least two different network points: a Master eNodeB and one Secondary eNodeB connected with non-ideal backhaul. Mobility robustness can be improved by keeping the control plane termination in a macro node, while allowing offloading of user plane traffic to pico nodes within the macro coverage. This solution also could reduce signaling overhead toward the core network by keeping the mobility anchor in the macro cell.

Related to small enhancements, Rel-12 also has several femtocell enhancements, including mobility to shared Home eNodeB (HeNB), and LTE X2 (Interface between eNBs). The mobility to a target HeNB that is shared by multiple operators relies on the principle that the Public Land Mobile Network (PLMN) which is going to be used at the target side is selected by the source HeNB. The challenge is that the target PLMN selected must be compatible with the UE in terms of membership when that HeNB is hybrid/closed. Rel-12 enhances UE mobility procedures by adding the capability to read and report to the source eNB (prior to the handover decision) a list of acceptable PLMNs of the target cell. When receiving this new list and deciding to trigger the handover, the source eNB is also enhanced with the capability of verifying that it actually is an equivalent PLMN or the serving PLMN.

Increased data traffic leads to network densification which can include deploying multiple small cells, particularly numerous HeNBs, under each macro sector. This architecture creates a number of challenges for the scalability of X2 connections. Rel-12 enables scalability by letting an eNB connect to its neighbor HeNBs through one or more LTE X2 Gateways (X2GW). The feature remains backward-compatible in the sense that the peering connections can be either direct X2 or via the X2GW.

## **MTC/M2M**

Rel-12 enhances LTE-Advanced ability to support MTC/M2M applications.

One work item focused on low cost and extended coverage. On low cost enhancements, a new UE category with reduced data rate, half duplex support and single receive antenna was introduced.

Another work item evaluated RAN solutions involving UE Power Consumptions Optimizations (MTCe-UEPCOP) and Small Data and Device Triggering Enhancements (MTCe-SDDTE). A new power saving

(or dormant) state was introduced as part of the UEPCOP work, while CN assistance information for eNB parameters tuning was introduced as part of SDDTE.

### **Proximity Services (ProSe)**

In ProSe communications, UEs that are near each other communicate directly rather than via the cellular network. The ProSe work in 3GPP is split into direct discovery and direct communication. Rel-12 focuses on enabling direct broadcast communication between public safety personnel when a network is unavailable, such as following a disaster.

The ProSe discovery process identifies UEs that are near each other and enables operators to provide a highly power-efficient, privacy-sensitive, spectrally efficient and scalable proximate-discovery platform. It can either be direct, or at the Evolved Packet Core (EPC)-level and is authorized by the operator. The network controls the use of resources used for discovery. Signal timing, discovery signal design, payload definition, resource allocation and resource selection were all studied as part of discovery design.

### **UE Receiver Enhancements**

Cell densification, HetNets and the various MIMO types, all make UE receiver enhancements an ideal way to mitigate the increased inter-cell interference that comes as a natural consequence. Rel-10 was the first to define advanced UE receivers with interference cancellation and/or suppression. Rel-12 now includes a new category of UE receivers called Network Assisted Interference Cancellation and Suppression (NAICS) receivers. The basic principle behind the NAICS receiver is the exchange of semi-static cell configuration information between the neighboring eNBs through X2 backhaul interface and higher layer signaling from serving eNB to UE of the neighboring cell configuration parameters.

### **Self-Optimizing Networks (SON)**

Rel-12 SONs focused on the interoperability aspects of existing features while introducing additional features. This work includes evaluating different opportunities with more UE-specific handling, in light of release dependent requirements linked to the UE's capability to be served by a cell that is not the strongest cell (cell range extension). One example is the ping-pong handovers in the case of different treatment of various UE types and capabilities in two eNBs involved in load balancing. Another aspect concerns network deployments based on active antennas and the new needs for SON to manage the deployment, as well as the impact on existing SON features.

### **HetNet Mobility**

Heterogeneous Networks (HetNets) can be deployed in single carrier or multicarrier environments (including non-CA and CA cases). Seamless and robust mobility of users from LTE macro to small BTS-layer, and vice versa, is needed to enable offload benefits. UE mobility-state estimation is based on the number of experienced cell changes in a given time period, but without explicitly taking the cell-size into account, and hence the mobility-state estimation may not be as accurate as in the macro-only environment.

The *Mobility Enhancements Work Item* provides means to improve overall handover performance with regard to HO failure rate and ping-pong in HetNet environments. Optimal configuration of parameters and better speed estimation are seen as potential solutions. It is also possible to configure different Time-to-trigger values for macro and small cell target cells. Faster re-establishments after a HO failure in HetNet

environments, where another suitable cell is available, are introduced to reduce interruption time for the user and improve the user experience.

### **Multimedia Broadcast/Multicast Services**

Operators must have tools and processes for maintaining service when a node or interface fails. In Rel-12, MBMS enhancements extend these recovery schemes to cover all MBMS nodes and interfaces.

The first cornerstone of MBMS recovery mechanisms consists of re-establishing the MBMS sessions over the M3 interface following a Multi-Cell/Multicast Coordination Entity (MCE) failure or an M3 path failure. The feature can also re-establish MBMS sessions over the M2 interface following an eNB failure or an M2 path failure. The second cornerstone consists of the Mobility Management Entity (MME) takeover following a Spatial Multiplexing (SM) path failure. For example, when there is a permanent SM path failure, this feature enables the MBMS gateway to select an alternate MME from the pool.

Furthermore, although support of MBMS services has been introduced in Rel-9, there have been no UE measurements defined that could be reported to the network in order to help monitor the signal quality at the UE. In order to provide better tools for the network to monitor and adjust the MBMS operational parameters, new measurements targeting MBMS Single Frequency Network (SFN) signals are introduced in Rel-12. Examples of radio layer Multicast Broadcast Single Frequency Networks (MBSFN) metric can include measurements related to signal strength, signal-to-noise ratio and error rate.

It has been decided that the handling of group communications service enablement for public safety would rely on MBMS services offered by LTE in Rel-12. Typically MBMS bearers would be established in advance and would experience low activity most of time until a public safety incident occurs in a cell (car accident, fire, etc.) in which case several tens of public safety groups could suddenly need to communicate in that cell concurrently over those MBMS resources. One issue is that MBMS radio resources are allocated semi-statically in a cell and would typically be set according to the large low activity period in order to not overprovision them uselessly. But then when an incident occurs, the allocated MBMS resources would experience severe overload. The Rel-12 work item on Group Calls MBMS Congestion provides mechanisms to cope with this overload situation.

### **Local Internet Protocol Access and Selected Internet Protocol Traffic Offload**

*LIPA/SIPTO enhancements* include the feature “Collocated SIPTO at local network.” This feature enables offloading of Internet traffic from the RAN node through an embedded Public Data Network Gateway (P-GW) function and into the private network. It also extends to a variety of RAN nodes, ranging from eNB to HeNB and NodeB+ to HNB. By directly offloading the Internet traffic into the private network, this feature significantly alleviates the core network’s workload, particularly for stationary or nomadic UEs.

The “SIPTO at Local Network with Stand-alone GTW” feature leverages the Rel-10 feature “SIPTO above RAN.” However, the Rel-12 feature has two main differences regarding location of the PGW enabling the offloading (in the private network) and the collocation of the Stand-alone (S-) and PGW. The set of RAN nodes served by a same gateway thus make up what is called a “Local Home Network” (LHN). This feature allows operators to offer a seamless offloading function for UEs moving within an LHN, while avoiding the single point of failure connectivity issue.

## Enhanced Interference Management and Traffic Adaptation

LTE supports two different duplex modes: FDD and TDD. To better utilize spectrum in a TDD system, a TDD configuration that matches the traffic could be selected. This is the scope of the eIMTA work.

Most networks see more downlink than uplink traffic and hence utilize a somewhat downlink heavy configuration. This is typically configured to be the same over the whole network to make sure as to not introduce strong base station-to-base station interference. This implicitly means that the TDD configuration seldom matches the instantaneous need of a cell, only a long term average of the network. To enable better utilization of TDD resources, dynamic adaptation of uplink-downlink ratios is introduced in LTE Rel-12

To enable traffic adaptation, a UE is configured with two different TDD configurations from the network. The UE then follows one configuration for uplink communication and a second configuration for downlink configuration. The subframes with different directions in the two configurations are dynamically selected by the network for either uplink or downlink communication. To save UE power and enhance channel quality measurements in the UE, the base station provides an indication of what subframes will be used for uplink and downlink respectively using a new physical layer signaling. The indication is communicated in a broadcast manner.

### FDD-TDD Carrier Aggregation (CA)

Within Rel-12, 3GPP has specified support for allowing UEs to operate TDD and FDD spectrum jointly. The main solution to be specified is CA between a number of TDD and FDD carriers. CA between the FDD and TDD spectrum would allow user throughputs to be boosted (at least for DL CA) and it would allow a better way to divide the load in the network between TDD and FDD spectrum. In addition to CA support operation of dual connectivity between TDD and FDD is further specified. Dual connectivity<sup>1</sup> provides a tool to connect UEs to cells that are operating either TDD or FDD while the cells are connected with a backhaul of higher delay than that required for CA. The reason for operating in such a mode can, for example, be to enhance user throughputs, lower core network signaling or enhance the mobility performance.

## HSPA+ ENHANCEMENTS

Rel-12 defines multiple areas for enhancing HSPA which include UMTS Heterogeneous Networks, SIB/Broadcast optimizations, Enhanced Uplink (EUL) enhancements, emergency warning for Universal Terrestrial Radio Access Network (UTRAN), HNB mobility, HNB positioning for UTRA, MTC and Dedicated Channel (DCH) enhancements.

### UMTS HetNets

To optimize performance in 3G small cell deployments, 3GPP studied enhancements for UMTS HetNets, with a focus on improving their capacity. The conclusion was to include new features related to interference/imbalance mitigation and mobility enhancements. For example, interference/imbalance mitigation features provide improvements in the reception quality of the uplink control channels in the presence of strong uplink/downlink imbalance. Mobility enhancements include extending the size of the inter-frequency neighbor cell list for both Idle and RRC connected states, so that the network could configure UEs to monitor and detect (in dense small cell deployments) more inter-frequency neighbor

<sup>1</sup> TR36.842, "Study on Small cell enhancements for E-UTRA and E-UTRAN – Higher layer aspects"

cells (than 32). Also, a new RRC inter-frequency measurement event is introduced, to trigger/report a change of best cell on a configured secondary downlink frequency. Finally, there were enhancements added to extend the enhanced Serving Cell Change procedure to facilitate faster replacement of the serving cell in certain HetNet RF conditions.

### **System Information Broadcast (SIB) Enhancements**

In order to increase system information capacity, a new second system information broadcast channel can be configured. In REL-12 and later, SIBs are introduced on both the system information broadcast channel as well as the second system information broadcast channel. Prior to REL-12, SIBs may be broadcasted on the second system information broadcast channel in addition to the system information broadcast channel. Any SIB type may be scheduled simultaneously on the system information broadcast channel and the second system information broadcast channel provided that the content is the same.

Most of the existing principles and procedures for system information reading are retained for the second system information broadcast channel. To reduce the latency to acquire the system information on both the system information broadcast channel and the second system information broadcast channel, the UE acquires the system information on both channels simultaneously.

### **Further Enhanced Uplink (F-EUL)**

As each LTE and UMTS user drives more and more traffic, 3GPP has standardized several features to improve HSPA uplink and downlink performance. Rel-12 has identified eight additional Enhanced Uplink (EUL) enhancements to study: enabling high user bitrates in a mixed-traffic scenario; rate adaptation to support improved power and rate control for high rates; improvements to the handling of dynamic traffic on EUL; improvements to EUL coverage for both single and multi-Radio Access Bearer combinations; a more efficient approach for UTRAN in case of uplink overload; reducing UL control channel overhead for HSPA operation; mechanisms to perform UL data compression between the UE and the RAN; and low-complexity uplink load-balancing solutions.

As an enhancement for DC-HSUPA, it was agreed that the DTX cycle 1, DTX cycle 2 and the inactivity threshold for cycle 2 can be configured differently for the secondary and primary uplink carriers. The downlink DRX was also enhanced. In order to improve the power control after a DTX gap, an averaging filter that retrieves information from the primary carrier was introduced in Rel-12. The post-verification period of the synchronization procedure was enhanced for dealing with bursty traffic, The TDM operation was enhanced by a scheduling algorithm named "Grant Detection". A multi-user scheduling solution was also introduced, which has to do with always using "all HARQ processes" for performing a TDM operation. This way the absolute grant scope bit will be used for switching in between the Rel-12 grant detection rules and the legacy rules.

In a broad sense, when the above set of enhanced features are properly configured, the secondary uplink frequency can be used for serving UEs who have the need of transmitting at medium to very high data rates (i.e., users having medium to large amounts of data waiting in their buffers). Another optimization area regards UL overhead reduction. One standardized enhancements allows the RNC to configure the UE to scale down the DL control channel power or use a (second) longer CQI reporting period.

In order to improve UL coverage extension, a more efficient and faster TTI switching (e.g. from 2 to 10 ms at cell edge) was introduced, which includes the incorporation of a new filtering for UPH measurement reporting (it can also be used for other scopes) and a new method for informing the UE to perform TTI switching. An additional enhancement targets access control in connected mode and is referred to as

Access Groups-based access control. In summary, this feature allows the network, e.g. in case of Uplink congestion, to differentiate and control accesses of specific classes/groups of UEs.

### **Enhancements for HNB Mobility**

Additional HNB Mobility enhancements include: Cell Forward Access Channel (CELL\_FACH) and Cell Paging Channel (CELL\_PCH) and UTRAN Registration Area Paging Channel (URA\_PCH) support for HNBs. This is achieved by introducing a method for managing the User Radio Network Temporary Identifiers (URNTIs) where the HNB-GW allocates blocks of URNTIs by specifying a URNTI prefix to each HNB under its control, enabling these modes to be supported for Rel-12 HNBs.

### **HNB Positioning for UTRA**

While HNBs generally have a small cell radius and therefore positioning based on cell-ID may be adequate, in circumstances of dense urban or rural deployments, enhanced positioning of the UEs may be necessary using a Standalone Serving Mobile Location Center (SAS). To support this, the Packet Capture (PCAP) protocol can be used, as it is for macro network; however this is not supported across the HNB-HNB-GW interface. Introducing a User Adaption Layer will allow PCAP to be used and hence enable enhanced positioning to be used for HNBs, enabling the same UE positioning facilities as are available in the macro network.

### **Machine Type Communications (MTC)**

Rel-12 standardized a new UE Power Saving Mode for MTC. A few changes have been made to the specifications, aligning the Idle mode procedure description with the new Non Access Stratum functionality.

### **DCH Enhancements for UMTS**

There are two main types of transport channels to carry traffic over the UTRAN radio interface: DCH, used for transporting CS (and R'99 PS) traffic and the shared HSPA channels, used to carry high speed data (radio signaling can use both options). The Rel-12 work on "DCH enhancements for UMTS" refers to a series of optimizations to enhance the link efficiency of DCH traffic (e.g. for CS AMR voice).

A Study Item was concluded on DCH enhancements, showing that optimizing DCH efficiency will provide benefits not only to CS traffic capacity, but also PS/data capacity. In fact, a few of the optimizations were shown to provide data throughput gains in scenarios involving a mix of voice and data transfer, when CS voice is carried over DCH. Furthermore, certain enhancements improve the UE battery life (or talk time) as well.

The standardized Rel-12 DCH enhancements include a few main sub-features: DL Frame Early Termination (DL FET), Uplink DPCCCH with DL FET ACK, DL overhead optimization, Enhanced rate matching and transport channel multiplexing, and Uplink DPDCH dynamic 10ms transmission.

## **NETWORK AND SERVICES ENHANCEMENTS**

Rel-12 includes features for network and services enhancements for MTC, public safety, Wi-Fi integration, system capacity and stability, Web Real-time Communication (WebRTC), further network energy savings, multimedia and the Policy Charging Control (PCC) framework.

## **MTC and Other Mobile Data Applications Communications Enhancements**

A third release of improvements is being developed for MTC devices and smartphone data applications under “Machine-Type and other mobile data applications Communications Enhancements (MTCe)”. The two main building blocks are device-triggering enhancements and Small Data Transmission (infrequent and frequent) (SDDTE) and UE power consumption optimizations (UEPCOP).

Device triggering enhancements in Rel-12 include: securing device triggers; preventing fake SMS from reaching devices; and increasing signaling. For small data transmission solutions, new CN assistance information for eNB parameters-tuning has been introduced. For optimizing UE power consumption, Rel-12 includes a new power saving mode (PSM) for devices.

## **Public Safety**

LTE enhancements for public safety are widely backed by governments around the world and were standardized by 3GPP with Proximity Services (ProSe) and Group Call System Enablers for LTE (GCSE\_LTE).

### **Proximity Services (ProSe)**

Proximity Services (ProSe) consist of discovering mobile devices in physical proximity and enabling optimized communications between them. Proximity Services are described as either “Direct Mode” or “off-network communications” and are critical services for firefighters, police officers and first responders. The 3GPP Proximity Services standardized in Rel-12 for support of public safety needs has the capability to discover users who are in close physical proximity and wish to have direct communications, and to facilitate direct communications between users with or without supervision from the LTE network.

The 3GPP system enablers for ProSe include: EPC-level ProSe Discovery; EPC support for WLAN direct discovery; and communication, direct discovery and direct communication.

### **Group Communication System**

Group Communication System is a frequent mode of operations for public safety when simultaneously communicating with multiple users is needed. An example of a public safety group would be firefighters that are battling a structure fire. Push-to-Talk (PTT) is an example of voice-based multiple-user communications. LTE supports the capability for users to communicate in parallel at the same time with several groups with different media types. The work on Group Communication System Enablers in 3GPP will optimize the LTE environment for multiple user environments.

### **Wi-Fi Interworking**

As mobile networks evolve to all-IP, and traffic continues to build and constrain network capacity, the importance of Wi-Fi cellular interworking remains essential. Rel-12 provides additional Work Items to improve Wi-Fi as an access point for mobile networks in the areas of Network Selection, SaMOG and Optimized Offloading.

Before Rel-12, Wi-Fi interworking with 3GPP technologies was already supported at the CN level, but the WLAN and PLMN selection mechanisms were not satisfying enough to be deployed, and the Traffic Steering mechanisms via ANDSF were not sufficient. Given that different operators have different deployment scenarios, two solutions have been specified in Rel-12: an enhanced ANDSF policy based

solution; and a RAN rules based solution. If the UE is provided with ANDSF policy, the UE shall use the ANDSF rule otherwise the UE may utilize the RAN specified rules.

Rel-12 introduced enhancements to SaMOG enabling UEs to: indicate the requested connectivity type (PDN connection to EPC or non-seamless WLAN offload); indicate the APN to establish PDN connectivity; request to hand over an existing PDN connection; establish multiple PDN connections in parallel over trusted WLAN; and establish an NSWO connection in parallel to PDN connection(s) over WLAN. Rel-12 also introduced features improving Intersystem routing policies and additional clarifications to UE behavior during inter-RAT mobility addressing bearer loss, QoS degradation and handover ping pong.

### **Core Network Overload**

The objectives of Core Network Overload were to define Load/Overload control-related information with enough precision to guarantee a common multi-vendor interpretation of this information allowing interoperability between various GTP-C nodes, and to define mechanism addressing various issues. Alternative solutions were investigated and it was concluded that changes be made to the specifications that define the GTPv2-C protocol and the DNS procedures.

### **WebRTC and VoIP/Multimedia Enhancements**

WebRTC enhances Web browsers with support for Real-Time Communications (RTC) capabilities via JavaScript Application Programming Interfaces (APIs), enabling smartphones to serve as video conferencing endpoints. Rel-12 includes specifications for clients to access the Internet Protocol (IP) Multimedia Subsystem (IMS) services using WebRTC. The architecture changes involve developing support for IMS media (including transcoding) and protocol interworking, which is necessary for a WebRTC client to access IMS services including charging, Quality of Service (QoS), authentication and security.

In addition, the 3GPP SA4 working group has standardized other enhancements to multimedia services, codecs and protocols. In Rel-12, SA4 has introduced a new Voice over Internet Protocol (VoIP) codec that improves speech quality and enables operation at lower data rates; this codec is called EVS (which stands for Enhanced Voice Services). Other work and enhancements relate to High Efficiency Video Coding (HEVC), and enhancements for MBMS, such as multicast-on-demand.

### **Network Energy Savings**

Further studies were introduced in Rel-12 for the purpose of improving network power efficiency, and helping to reduce CO2 emission and the OPEX of operators. The studies were divided into three primary parts: Inter-eNB energy saving enhancement for overlaid scenario; energy saving scenarios for LTE coverage layer; and transmission power optimization scenario. For the overlaid scenario, enhancements for selective switch-on of small cells were studied in particular. Another part of the study aimed at evaluating whether and how far ES solutions could provide gains when taking QoS requirements of subscribers into account. One solution is to re-use existing QoS parameters and another solution is to specify a new indicator sent from CN to the eNB. The third part of the study assumed the TX power of LTE cells can be reduced. This approach to save energy is to optimize the transmission power of all or most cells, so that without switching off any cell, overall energy consumption is minimized.

## Policy and Charging Control

Rel-12 introduces system enhancements on top of the existing Policy and Charging Control (PCC) framework to fulfill application-based charging for the detected applications. In the case of the Traffic Detection Function (TDF), system enhancements are needed so that the applications can not only be detected and enforced but also be charged by the TDF. Time-Based Usage Monitoring is a further addition to the Rel-11 volume-based usage monitoring.

## RELEASE-INDEPENDENT FEATURES

As the spectrum allocations in different countries evolve, 3GPP continuously updates and adds new frequency bands. While a new frequency band, carrier aggregation scheme or other enhancements may be introduced in a particular release, it may be used in UEs that support an earlier release. This approach 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-12 added five new bands. Aggregated over all releases, Rel-12 brings the total up to 43 bands. (These bands are identified for UTRA/EUTRA, and are tabulated in Appendix A in the full white paper on the 4G Americas website). Typically, about three bands are added each year.

CA combinations are being added even more quickly. In 2012, there were only 21 CA schemes. By 2013, there were 13 intra-band and 50 inter-band configurations-- an indication of the explosive demand for spectrum and the demand for increasing the typical end user's peak throughputs. The additional presence of combinations of a single UL with three DL carriers reflects the overwhelming preponderance of DL traffic in today's typical wireless data network and the need for additional DL capacity to serve it. This ability to serve typical traffic patterns with appropriate combinations of UL and DL blocks of spectrum is a major appeal of CA and is driving the rapid adoption of this LTE-Advanced capability.

Rel-12 includes CA of FDD and TDD frequency bands, as well as support for aggregating two UL CCs and three DL CCs.

**Based on the latest updates, all work on Rel-12 is scheduled to be finalized by March 2015.**

More detailed explanations of 3GPP Release 12 are provided in the 4G Americas white paper, [\*4G Mobile Broadband Evolution: 3GPP Release 11 & Release 12 and Beyond\*](#).

## ACKNOWLEDGEMENTS

The mission of 4G Americas is to advocate for and foster the advancement and full capabilities of the 3GPP family of mobile broadband technologies, including LTE-Advanced, throughout the ecosystem's networks, services, applications and wirelessly connected devices in the Americas. 4G Americas' Board of Governors members include Alcatel-Lucent, América Móvil, AT&T, Cable & Wireless, Cisco, CommScope, Entel, Ericsson, HP, Intel, Mavenir Systems, Nokia, Openwave Mobility, Qualcomm, Rogers, Sprint, T-Mobile USA and Telefónica.

4G Americas would like to recognize the significant project leadership and important contributions of Jim Seymour of Cisco and Michael Peeters and Teck Hu of Alcatel-Lucent, as well as representatives from member companies on 4G Americas' Board of Governors who participated in the development of this white paper.

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