LTE-M Deployment Guide to Basic Feature Set Requirements

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1 Executive Summary

LTE-M (LTE-MTC low power wide area (LPWA)) is a new cellular radio access technology specified by 3GPP in Release 13 to address the fast-expanding market for low power wide area connectivity. To achieve global coverage and wide adoption of LTE-M services, MNOs (mobile network operator) must ensure that devices and end-to-end services from various providers will connect to the LTE-M systems that have been deployed, and that the data transport capability and connection modes are well understood.

This document contains non-binding guidelines designed to help MNOs deploying LTE-M networks and devices globally to ensure interoperability and smooth roaming. It identifies a minimum set of key features, details key configurations and considerations for deployments in 2017 and 2018. The recommendations have been developed by the members of the GSMA LTE-M Task Force, based on the survey inputs provided to the GSMA by ten MNOs who are deploying LTE-M networks in North America, Canada, Latin America, Europe and parts of Asia.

The following guidelines have been set out in the first release of this guide:

- According to the survey, a minimum of eleven bands: **1**, **2, 3, 4, 5, 12, 13, 20, 25, 26 and 28** are required for coverage in all the countries for which the LTE-M members have provided input
- The deployment of the following features is included in the key minimum requirements to achieve a balance of roaming service continuity and power optimisation:
    - PSM (Power Save Mode)
    - eDRX (Extended Discontinuous Reception)
    - High Latency Communication
    - Support for extended coverage
    - LTE-M Half Duplex Mode/Full Duplex
    - Support of Category M1 device
    - VoLTE support
    - SMS
    - Connected Mode Mobility
- VoLTE, SMS, SCEF (Service Capabilities Exposure Function) and GTP-IDLE Timer on IPX Firewall have not been included among the key minimum features in this edition, although considerations for both features have been provided.

Finally, the GSMA plans to update this Deployment Guide six months' after publication, to provide more specific recommendations once mobile network operators have gained more LTE-M deployment experience.

2 Introduction

2.1 Overview

LTE-M is a new cellular radio access technology specified by 3GPP in Rel-13. The next step is to further establish LTE-M as a global coverage solution that enables customers, such as

enterprise application service providers, to deliver their services globally with the confidence that deployment and operation will be consistent, smooth and predictable. This white paper is a Deployment Guide for the setup and configuration of LTE-M networks and devices, detailing key timer settings and considerations for the deployments in 2017-2018.

The recommendations provided in this document are based on the input and deployment plans received from operator members of LTE-M Task Force, who plan to launch LTE-M on a global basis.

2.2 Scope

This document provides an overview of the existing deployment plans of the LTE-M key features, and sets out guidelines for mobile MNOs and application service providers on the set up and configurations of key LTE-M features and spectrum bands. These are recommendations to mobile operators deploying the networks globally. They are intended as an aid in the deployment of LTE-M networks and devices globally, to ensure smooth interoperability and roaming.

This guide includes the features standardised in 3GPP Rel10-13, focussing on the key features that will be deployed over the next 12 months. The features specified in 3GPP Release 14, published in the summer of 2017, are not included in this edition; these will be added in the third publication of the guide.

Out of scope are non-3GPP LPWA technologies, such as SigFox or LoRa, as well as NB-IoT (Narrow-Band IoT), which is addressed in the separate NB-IoT Deployment Guide.

2.3 Definitions

Term	Description
IoT	Internet of Things, a generic term for the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment. IoT offers functions and services which go beyond the pure M2M scope. MIoT is a subset of the far bigger IoT concept, for example a bunch of sensors connected together via Wi-Fi or Bluetooth are a part of IoT but not MIoT.
M2M	Machine-to-Machine, a general term referring to any network technology allowing devices to communicate with each other. For example two industrial robots connected to each other via Ethernet in a factory is a part of M2M but not MIoT.
MIoT	Mobile Internet of Things, a GSMA term which refers to the 3GPP standardised LPWA technologies using the licenced band (aka LTE-M, NB-IoT and EC-GSM-IoT). From 3GPP Release 13 and the following Releases, the Category of UEs that support power consumption optimisations, extended coverage and lower complexity are part of MIoT (CAT M1, CAT NB1 from Release 13 and CAT M2, CAT NB2 from Release 14). As this particular term is widely used throughout GSMA, it is utilized also in this document. Not to be confused with the term “mIoT” which means 5G massive IoT in 3GPP terminology.
LTE-M	LTE-M is the simplified industry term for the LTE-MTC low power wide area (LPWA) technology standard published by 3GPP in the Release 13 specification. It specifically refers to LTE CatM1, suitable for the IoT. LTE-M is a low power wide area

Term	Description
	technology which supports IoT through lower device complexity and provides extended coverage, while allowing the reuse of the LTE installed base.

2.4 Abbreviations

Term	Description
3GPP	3rd Generation Partnership Project
API	Application Programming Interface
AS	Application Server
BS	Base Station
BTS	Base Transceiver Station
Cat M1	Category Machine 1
CDF	Charging Data Function
CGF	Charging Gateway Function
CIoT	Cellular Internet of Things
CMM	Connected Mode Mobility
dB	Decibel
DRX	Discontinuous Reception
DL	Downlink
eDRX	Extended Discontinuous Reception
eNB	Evolved Node B
EPS	Evolved Packet System
GSM	Global System for Mobile Communications
GSMA	GSM Association
GTP	GPRS Tunnelling Protocol
HLCom	High Latency Communication
HPLMN	Home Public Land Mobile Network
HSS	Home Subscriber Server
IoT	Internet of Things
IP	Internet Protocol
IP-SM-GW	Internet Protocol Short Message Gateway
IPX	Internetwork Packet Exchange
IWF	InterWorking Function
IWK-SCEF	InterWorking Service Capabilities Exposure Function
LPWA	Low Power Wide Area
LTE	Long-Term Evolution
LTE-M	Long-Term Evolution Machine Type Communications
LTE MTC	Long-Term Evolution Machine Type Communications
M2M	Machine-to-Machine.

Term	Description
MIoT	Mobile Internet of Things
MME	Mobile Management Entity
MNO	Mobile Network Operator
MSC	Mobile Switching Centre
MTC	Machine Type Communications
NB-IoT	Narrowband IoT
PGW	Packet Gateway
PRB	Physical Resource Block
PSM	Power Saving Mode
RAN	Radio Access Network
SCEF	Service Capabilities Exposure Function
SCS	Services Capabilities Server
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
SIM	Subscriber Identity Module
SMS	Short Message Service
SMS SC	Short Message Service Centre
TAU	Tracking Area Updating
UDP	User Datagram Protocol
UE	User Equipment (User Device)
UICC	Universal Integrated Circuit Card (sometimes known as the SIM card)
UL	Uplink
VPLMN	Visited Public Land Mobile Network

2.5 References

Ref	Doc Number	Title
[1]	IOTTF07_DOC004	MIoT Roaming Whitepaper Draft. GSMA NG working group
[2]	3GPP TS 23.682	TS 23.682 (clause 4.5.4): Architecture enhancements to facilitate communications with packet data networks and applications
[3]	3GPP TS 24.008	Mobile radio interface Layer 3 specification; Core network protocols; Stage 3
[4]	3GPP TS 24.301	Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3
[5]	3GPP TS 23.401	General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access
[6]	3GPP TS 36.201	Evolved Universal Terrestrial Radio Access (E-UTRA); LTE physical layer; General description

Ref	Doc Number	Title
[7]	GSMA IR.92	IMS Profile for Voice and SMS; Section 3.2.1
[8]	GSMA CLP.28	NB-IoT Deployment Guide to Basic Feature Set Requirements
[9]	3GPP TS 36.101	Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception

3 GSMA Minimum Baseline for LTE-M Interoperability - Problem Statement

3.1 Problem Statement

3GPP Rel 13 introduced several new features and functions within the new LTE-M technology, which defines Cat M1. Many of these enhanced features and functions are commonly referred to as Power Saving Mode (PSM), eDRX, Coverage Enhancement Mode A and B, etc.

There are several existing LTE timers that continue to be utilized, and there are some new timers defined in support of several of these features. It is the intent of the members of the LTE-M Task Force to deploy a common set of timer configurations so that enterprise application developers have a consistent experience globally. In addition to consistent timer setting configurations, this document will also address common mechanisms for which to handle conditions not previously experienced on legacy cellular networks, such as how to handle Mobile terminated data when a device is in PSM.

3.2 Minimum Baseline for LTE-M Interoperability: Risks and Benefits

The benefits of a consistent LTE-M deployment configuration settings is to achieve a common deployment experience for enterprise developers globally. Consistent experience is very important to enterprise developers independent of the MNO network being accessed.

In addition, several MNO's and network providers have gained early insights and experience with these new advanced features, and this document is intended to share that experience and learning with any MNO, network providers and chipset providers who plan to deploy and support LTE-M.

4 LTE-M Data Architecture

Figure 1 below provides an overview of the architecture for LTE-M (and NB-IoT) in a roaming scenario as described by 3GPP:

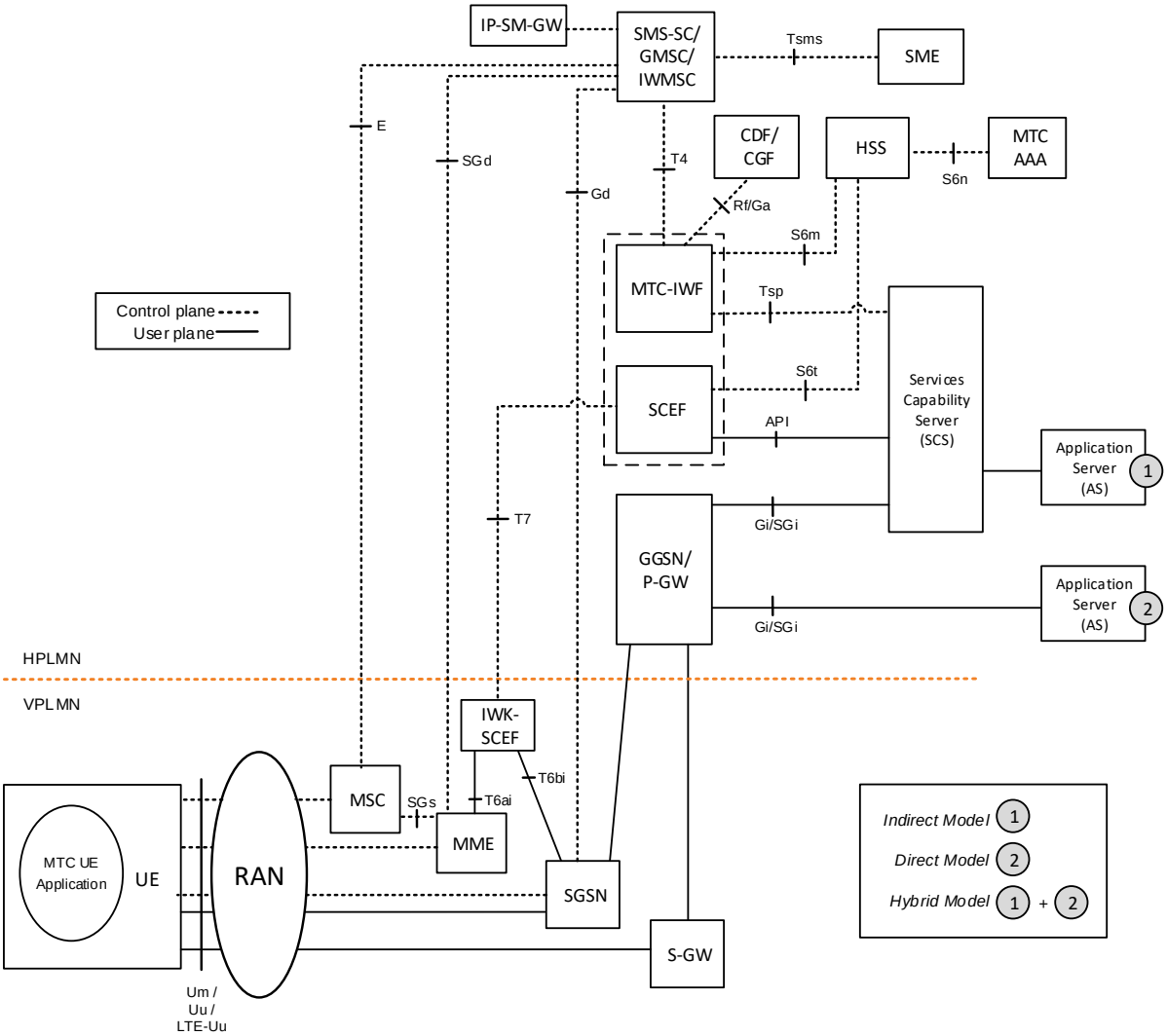

Figure 1: 3GPP Architecture for Machine Type Communication (NB-IoT and LTE-M Roaming)

This chapter provides an overview of the 3GPP options for data. There are two main Network Attach options to support connectivity:

1. Attach with PDN (Packet Data Network) connection: the UE (User Equipment) is required to establish the PDN connection as part of the attach procedure. This has been the case for all 3GPP EPS (Evolved Packet System) releases up to Rel-13.
2. Attach without PDN connection: this is a new capability that has been introduced in Rel-13 to allow UEs supporting CIoT (Cellular Internet of Things) optimisations to remain attached without PDN connection, which may be useful for cases where huge numbers of devices would keep a connection inactive for very long period of time and seldom transmit data over it.

There are different data connectivity options for PDN connections available to IoT devices using the EPS:

- IP over Control Plane (both UDP (User Datagram Protocol) and TCP (Transmission Control Protocol)), from 3GPP Rel-13 using the Control Plane CIoT EPS optimisation with IP PDN types
- IP over User Plane (both UDP and TCP) (including User Plane Optimisation and user Plane Original), available since Rel-8 with IP PDN types
- Non-IP over Control Plane, from 3GPP Rel-13 using the Control Plane CIoT EPS optimisation with Non-IP PDN type
- Non-IP over User Plane (including User Plane Optimisation and User Plane Original), from 3GPP Rel-13 using the User Plane CIoT EPS optimisation with Non-IP PDN type

For Mobile Originating (MO) services, data coud be transmitted at any time if needed. For Mobile Terminating (MT) service, data can only be transmitted in accordance with PSM and eDRX timers, which is the only time that the device is reachable by the network. However, for MT services there is also the option to request the device to set up ad-hoc connections (not scheduled by PSM, eDRX) by means of triggering the device either via the interface Tsms or Tsp.

Each of these options has advantages and disadvantages. The traditional mechanism for transporting information over LTE is by means of IP over User Plane (most commonly TCP) and/or SMS.

Control Plane CIoT EPS Optimisation transports user data or SMS messages via MME by encapsulating them in NAS (Non-Access-Stratum), and reduces the total number of control plane messages when handling a short data transaction.

For services that occasionally transmit reasonably small amounts of data, the utilisation of the Control Plane will optimise the power consumption due to the fact that the amount of signalling required and the “air time” is reduced. Power consumption can be optimised using non-IP, UDP and TCP. Non-IP allows for the use of protocols that have been optimised for a specific use. UDP is asynchronous, which reduces the time of the connection, while TCP will keep the connection open until an acknowledgment is received. However, supporting a network-originated UDP connection might require the use of either a virtual private network (VPN) or IPv6 due to the need to specifically address the device from the server network.

The services that need to send more information could benefit from User Plane connection, which can be used to send multiple packages. Overall, this approach might consume less power than sending multiple messages over the Control Plane. On the other hand, using non-IP over the User Plane might be unrealistic simply because the benefits of using efficient protocols are nullified by using a user plane connection.

In the case of non-IP communication over the Control Plane, the MNO has two options, either through the PGW (Packet Gateway) (requiring support for the SGi interface to the application server) or by utilising SCEF. For the latter case, the visited network will direct the message to the IWF (InterWorking Function) -SCEF which will connect to the SCEF of the home network (via the new T7 interface in Figure 1).

Recommendations

It is recommended that MNO's support IP traffic over User Plane as a minimum requirement to start supporting roaming.

All other features an optimisation described above are currently not supported, future releases of this document might provide more details.

5 LTE-M Deployment Bands

According to 3GPP, including Release 14, there is a defined set of frequency bands for which LTE-M can be used. 3GPP specification [9] from Release 13 provides the list of the supported bands: 1, 2, 3, 4, 5, 7, 8, 11, 12, 13, 18, 19, 20, 26, 27, 28, 31, 39, 41 and Release 14 added the bands: 25 and 40.

From the input received by the LTE-M Task Force members so far there are a variety of bands that have been indicated to be used. In order to achieve global roaming support, the following bands will need to be covered in order to produce global modules that cover North America, Latin America, Europe and parts of Asia:

- **Bands 1, 2, 3, 4, 5, 12, 13, 20, 25, 26, 28**

As indicated above only a subset of the bands supported by 3GPP Release 13 are envisioned to be used, currently 11 frequency bands for a global coverage in all the countries for which the LTE-M members have provided input. As indicated there has been input from 11 MNO groups covering North America, Latin America, Europe and parts of Asia.

6 LTE-M Configuration Guide

This section outlines the following features will affect roaming and/or configurations and are recommended as part of the configuration guide:

- PSM Timers
- eDRX
- GTP-IDLE Timer on IPX Firewall
- Long Periodic TAU
- Support of CATM1
- Extension of coverage features
- SCEF
- VoLTE
- SMS Support
- HLcom
- CMM

6.1 PSM Standalone Timers

Power Saving Mode is a feature designed for IoT devices to assist them to conserve battery power and potentially achieve a 10 year battery life.

Whilst it has always been possible for a device's application to turn its radio module off to conserve battery power, the device would subsequently have to reattach to the network

when the radio module was turned back on. The reattach procedure consumes a small but finite amount of energy. The cumulative energy consumption of reattaches can become significant over the lifetime of a device and battery life could be extended if this procedure could be avoided.

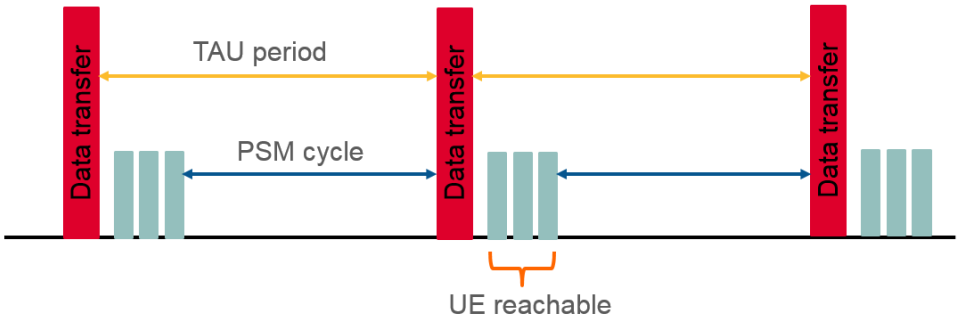

Figure 2: PSM Timers

Recommendations

As a minimum, PSM should be supported for LTE-M deployments.

PSM effectively turns off monitoring of Paging Instances on the device (that occur every 2.56 seconds), and increases time periods of devices sending Periodic Tracking Area Updates (pTAUs) to extended intervals to inform the network of its current registration (otherwise known as 'pTAU Extended Timer'). As a result, the device is able to save battery current drain by decreasing device-to-network signalling. With the introduction of PSM, radio modules can go into a HIBERNATE state (a state of low battery consumption) when not sending data to make the most efficient use of battery life.

PSM has 2 timers, configurable through AT Commands embedded within an enterprise Customer device software, which enables the device to request to the network when it would like to be put into the following PSM states:

1. **T3324 Active Timer** – Time the User Entity (UE) (otherwise known as "IOT Module") stays in ACTIVE / IDLE mode following a wake-up to Periodic Tracking Area Update or initiate a Mobile Origination event (Mobile Origination means the User Entity sends data or SMS up to the network destined to a back-end Application Server). This timer has a trade-off between lower values and maximum values: Lower values save more battery life by allowing the UE to go into HIBERNATE state quicker, which is the remaining duration of T3412 Extended timer. Higher values of T3324 will allow a longer time for the application server (AS) to respond to UE/MO data (e.g. Acknowledgements, network initiated data). Customers are advised to test out this parameter to come to a value that best fits their Use Case.

It is recommended a Ratio of T3324 Active Timer to T3412 Extended Timer:

(T3412 Extended Timer -T3324 Active Timer)/T3412 Ratio should be > 90% in order to achieve optimum battery savings by use of the PSM feature.

There is no network recommended value but the value cannot be below:

Minimum: 16 Seconds Minimum Allowed Value, calculated from: (2*DRX cycles (MNO LTE DRX cycle value (e.g. 2.56sec)) + 10 seconds (buffer time)) = 2*2.56sec + 10 seconds = 16 seconds.

2. **T3412 Timer** – Extended T3412 Timer is the value the device informs the network with Periodic Tracking Area Update (pTAU) that it is still registered. The duration after T3324 Timer expiry and the next pTAU instance is the HIBERNATE period.

Note: The UE/Device is not reachable by a Mobile Terminated message/SMS during the PSM/Hibernate state.

It is recommended the following value of 4 Hours for this setting: Minimum: 4 Hours.

Note: Max T3412 Extended = 413 days – as defined by 3GPP (TS 24.008)

Regarding attempts to deliver mobile terminated SMS / Data, it is recommended that the enterprise application implement a “pull” model for MT Data, such that the device initiates MO data transmission to the application server, and the application server responds to the device with the downlink payload.

Note: On Mobile Originations: An Application Processor running on a UE, that controls the UE Module / the Radio, can initiate a Mobile Origination at any time, even if the device is within a PSM state. Therefore, Mobile Originations are not governed by the use of PSM. Furthermore, T3412 resets after MO events.

General APN Recommendations

There is also specific recommendations to the use of PSM in combination with custom APNs to ensure the APN Idle Timer are set such that they are in-sync with what the Customers PSM timers are set to. APN Idle Timer is a value that upon reaching, IMPLICITLY DETACHES the Context/UE from the network. This timer is typically set to a value of 4 hours. Therefore, if a Customer wants to use the PSM, their T3412 Extended Timer value should not be greater than their APN Idle Timer.

In cases where a customer has an existing APN that now wants to add PSM capable devices which require different (e.g. most likely longer) APN Idle times, it is recommended to use a separate APN for the PSM capable devices if the original APN Idle Time cannot be changed.

In Summary: It is recommended that the following timer T3412 should be supported for a LTE-M deployment:

- Minimum: 240 minutes (4 hours)
- Maximum: 3GPP Release 13 Maximum 413 days

Additionally, if the UE requested value is lower than the minimum recommended value the network may override to the minimum value. If the UE requested value is higher than the

maximum recommended value, the network will override to the maximum value as set in Release 13.

MT SMS

It is recommended that MT SMS are not be stored by the MNO beyond the existing SMS expiration timer.

MT Data Packets

Currently there is no general store and forward mechanism supported by MNOs, futher release of this document might provide more information. With this in mind, it is recommended to not store MT data while a device is in PSM mode and utilize the method defined above by the enterprise application developers to wait until the UE performs a MO data session, then deliver MT data.

6.2 eDRX Standalone

Extended Discontinuous Reception is an extension of an existing LTE feature which can be used by IoT devices to reduce power consumption. eDRX can be used without PSM or in conjunction with PSM to obtain additional power savings.

Currently, many smartphones use discontinuous reception (DRX) to extend battery life between recharges. By momentarily switching off the receive section of the radio module for a fraction of a second, the smartphone is able to save power. The smartphone cannot be contacted by the network whilst it is not listening but if the period of time is kept to a brief moment, the smartphone user will not experience degradation of service. For example, if called, the smartphone might ring a fraction of a second later than if DRX was not enabled.

eDRX allows the time interval during which a device is not listening to the network to be greatly extended. For an IoT application it might be quite acceptable for the device not to be reachable for a few seconds or longer.

For some applications eDRX may provide a good compromise between device reachability and power consumption.

Every eDRX cycle can be configured with a paging transmission window (PTW) containing a number of paging opportunities. The eDRX cycle determines the fundamental downlink reachability and the PTW determines with what reliability the reachability can be guaranteed under, such as, varying load conditions.

MO events can trigger uplink transmissions at any time, regardless of DRX/eDRX settings. MT traffic can be delivered after reaching the UE which is following eDRX.

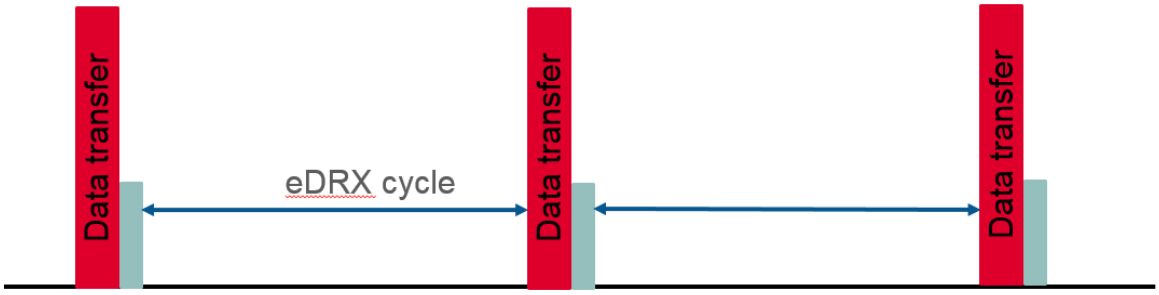

Figure 3: eDRX Cycle

Recommendations

It is recommended that LTE-M deployments support eDRX and to consider accepting the 3GPP Rel13 defined UE requested values of a minimum of 5.12 seconds, and maximum: 43.69 minutes.

6.3 PSM and e-DRX Combined Implementation

It is recommended that LTE-M deployments support both PSM and e-DRX as these are complementary and a customer's application might need both. A customer needs to be informed regarding the impact on the battery.

In case of combined use of PSM and e-DRX, a careful alignment is needed between the different configuration parameters (PSM timers and e-DRX paging cycle length) in order to ensure paging success by the network.

Further recommendations will become available which is for further study.

6.4 High Latency Communication

The High Latency Communications (HLCom) can be used to handle mobile terminated (MT) communication, when the UE is unreachable while using PSM or eDRX. "High latency" refers to the initial response time before normal exchange of packets is established. The feature is described in 3GPP TS 23.682.

Currently, high latency communications may be handled by two main mechanisms:

- an extended buffering to hold downlink data;
- Explicit notification towards the SCS/AS indicating the time a device become reachable again

Extended buffering is done at the Serving-GW (S-GW) and it is controlled by the MME/SGSN, which explicitly inform the S-GW to buffer downlink packets related to a specific UE until it is reconnected.

By using explicit notifications, the S-GW simply discards the downlink packets when the device is not reachable and the MME/SGSN issues a notification towards the SCS/AS once the device becomes available.

Recommendations

Currently there is no support for HLCom feature for LTE-M Deployments. Thus, it means that in case when a LTE-M device is in either PSM or eDRX, mobile terminating messages, depending on MNO choice the messages will either be buffered or discarded.

6.5 GTP-IDLE Timer on IPX Firewall

Some MNOs employ a firewall on the 3GPP S8 interface towards IPX (Internetwork Packet Exchange) network in order to protect their network. These firewalls are not part of the 3GPP standards, but some of the settings could have an impact on the performance of the service. These firewalls usually supervise the GPRS Tunneling Protocol (GTP) tunnel (session) of each SIM that is roaming on the network. To clean up the firewall from unused GTP sessions, an idle timer is used, meaning that, if no traffic is transferred by a SIM, this GTP Tunnel is deleted.

Recommendations

There are no recommendations at this time with regards to the GTP-IDLE Timer on IPX Firewall until more experience obtained.

6.6 Long Periodic TAU

Recommendations

It is recommended that the 3GPP Release 13-defined TAU Requests from the UE are used to support Long Periodic TAU.

6.7 Support of Category M1

The [9] provides the set of features and capabilities that are defined for the UE category M1 which includes:

- Maximum output power: the supported classes are Class 3 (23dBm) and Class 5 (20dBm)
- Half duplex and full duplex for FDD and TDD, however currently supported frequency bands are only operating in FDD.
- Coverage extension.

6.7.1 Support of Half Duplex Mode in LTE-M

The LTE-M standard supports FDD and TDD operation for LTE-M deployment in paired and unpaired bands, respectively. An LTE-M device in FDD operation can either employ full-

duplex operation, which means that the device supports simultaneous transmission and reception, or half-duplex operation, which means that the device alternates between transmission and reception. Devices that only support half-duplex operation are associated with a lower peak rate compared to devices that support full-duplex operation, but devices that only support half-duplex operation are less complex and less costly since they may be implemented with fewer and/or less expensive components.

Recommendations

It is recommended that Half Duplex Mode is supported.

6.7.2 Extension of coverage features (CE Mode A / B)

The LTE-M standard supports two Coverage Enhancement (CE) Modes: CE Mode A and CE Mode B. Both CE Modes enable coverage enhancement using repetition techniques for both data channels and control channels. For data channels, CE Mode A supports up to 32 times repetition and CE Mode B supports up to 2048 times repetition. CE Mode A is the default mode of operation for LTE-M devices and LTE-M networks, providing efficient operation in coverage scenarios where moderate coverage enhancement is needed. It is designed to maintain the LTE-M advantages of higher data rates, voice call possibility, and connected mode mobility.

CE Mode B is an optional extension providing even further coverage enhancement at the expense of throughout and latency. It was mainly designed to provide coverage deep within buildings. For this reason, Mode B is intended more for stationary or pedestrian speeds applications that require limited data rates and limited volumes of data per month. The maximum coverage Mode B provides is highly configurable by the MNO (from 192 to 2048 repeats).

Recommendations

It is recommended that Coverage Enhancement Mode A is included in the basic LTE-M feature set. CE Mode A is the mandatory coverage extension mode, to be supported by all LTE-M devices. LTE-M advantages of higher data rates, voice call possibility, and connected mode mobility may continue to be supported.

For MNOs considering to add CE Mode B in the future, which provides additional coverage enhancement via increased message repetition, additional testing by MNO is required to understand its effects on data throughput, and other features deployed within the network. It is recommended that MNO’s that have deployed mode B, provide this information to its roaming partners to allow them to inform their customers of the availability of the feature. If CE Mode B is not enabled on a visited network, the roaming device will revert to CE Mode A and revert to the coverage benefits offered by CE Mode A.

6.8 SCEF

The Service Capability Exposure Function (SCEF) provides a means to securely expose and discover the services and capabilities provided by 3GPP network interfaces. The SCEF provides access to network capabilities through homogenous network APIs (see 3GPP TS 23.682 [2]).

Recommendations

Currently there is no support for SCEF. Some MNOs surveyed by the GSMA plan to support SCEF from 2018, others have not yet decided. Some will be implementing it in phases, others going directly to full SCEF deployment. Those who will be deploying both NB-IoT and LTE-M networks might benefit from deploying SCEF, but it is an optional feature for LTE-M. Therefore, SCEF is not part of the minimum feature set required for the short-term deployment and this edition of the guide does not make recommendations for the SCEF functions to be exposed through network APIs.

The following points will be considered for the next edition of the LTE-M Deployment Guide:

- Messaging and Wake-Up notifications features
- APIs monitoring the UE
- Device Triggers: Device states, etc.,
- Location/ Presence
- QoS

6.9 VoLTE

Recommendations

VoLTE is not a mandatory recommendation for global LTE-M deployments, however if operator does deploy VoLTE the following recommendations should apply:

- The device and then network must support GSMA PRD NG.108 “IMS Profile for Voice and SMS for UE category M1” to support voice and SMS for UE category M1.

6.10 Connected Mode Mobility

There are two main mobility modes: Idle Mode Mobility and Connected Mode Mobility. In Idle Mode the UE has the decision to perform cell reselection. While In the Connected Mode, the network controls UE mobility, the network decides when the UE shall move, to which cell and triggers the handover procedure.

Connected Mode Mobility (CMM) is important especially for VoLTE in combination with mobility. Stationary VoLTE use cases will not require CMM. However, VoLTE use cases requiring mobility (i.e.: Wearables) will want to combine VoLTE with CMM to retain the session during movement between eNB’s.

Recommendations

There is clear support for the Connected Mode Mobility for VoLTE. It is also recommended that Connected Mode Mobility also be supported for all data traffic at this stage. More details will be provided in future releases of this document.

6.11 SMS Support

Recommendations

At this stage there is clear consensus that SMS will be deployed for global LTE-M deployments. Currently the majority of deployments support the MME SGs interface. The following 3GPP features are available however are not yet widely deployed:

- Support of Rel 12 Feature SMS without Combined attach relies on implementation of SMS over MME. It has some limitation in term of support of services offered on current M2M such as “No Wake ON”.
- Support of Rel 11 Feature SMS over MME relies on a new interface “SGd”.

However, if the MNO does deploy SMS the following recommendations apply:

- For deployments supporting also VoLTE, consider to support SMS over IMS
- Devices supporting 2G, 3G and/or 4G, as well as LTE-M, the MNO should deploy and support LTE-M SMS in the manner consistent with the MNO’s existing implementation of SMS over legacy LTE networks
- If a service is deployed which utilises SMS and international roaming is required, the MNO will need to advise the customer where this will be and where this is not available.

Note: Timers for SMS in the case of EPS CioT optimisation need to be evaluated in the next revision of this Deployment Guide for CE Mode A as described in section 10 of 3GPP TS 24.011

7 Conclusions

The recommendations provided in this guide aim to achieve the following:

- An accelerated realisation of the wider benefits of common standards and predictable interconnect, while ensuring that forthcoming decisions about deployment architectures are well informed, making it more straightforward to enable device interconnect and roaming;

The guide also advises that MNOs support the following key minimum features to achieve a balance of roaming service continuity and power optimisation:

- PSM (Power Save Mode)
- eDRX (Extended Discontinuous Reception)
- Support for extended coverage mode A
- LTE-M Half Duplex Mode
- CMM
- SMS
- Cat M1

For other features, such as VoLTE and HLCom MNOs don’t yet have consistent deployment plans. Therefore, VoLTE and HLCom are not key features for the short term deployment, and no related recommendations can be provided in this first edition of the Deployment Guide.

SCEF is also not included in the key minimum requirements of this edition of the Deployment Guide as some MNOs surveyed by the GSMA plan to support SCEF from Q2’2018, others have not yet decided. Some implementing it in phases, others going directly to full SCEF deployment. Those who will be deploying both NB-IoT and LTE-M networks might benefit from deploying SCEF, but it is an optional feature for LTE-M. Therefore, SCEF is not part of

the minimum feature set required for the short-term deployment and this edition of the guide does not make recommendations for the SCEF functions to be exposed through network APIs.

Finally, the GSMA plans to update this Deployment Guide regularly to provide more specific recommendations once network operators have more LTE-M deployment experience.

Annex A 3GPP Standardized MIoT Features

The list of 3GPP features related to the Low Power Wide area is taken from the MIoT Roaming Whitepaper currently developed by the GSMA NG working group [1].

A.1 3GPP Release 10 Features

Ref no.	MIoT Feature	Benefits
1	UE low access priority indicator (LAPI)	A UE can be configured to be low access priority, meaning that it accepts to be considered with lower priority by the network (access and core parts). This information is sent within UE requests to the network. The latter uses it in case of congestion, to first drop/reject requests with low priority
2	AS-level congestion control	In congestion situations, the access node can bar some UEs belonging to a certain class and configured for EAB (Extended Access Barring) TS 22.011 § 4.3.1
3	MME/SGSN control of overload	SGSN and MME may request the access nodes to reduce the load they are generating on it. Congestion control can be applied per APN for Session management or Mobility management.
4	Congestion control at the PGW / GGSN	The PDN GW detects APN congestion based on criteria (manufacturer dependent) such as: Maximum number of active bearers per APN; and/or Maximum rate of bearer activation requests per APN.
5	Optimizing the periodic LAU/RAU/TAU Signalling	Network load could be generated by signalling traffic of M2M devices caused by periodic mobility management procedures or RAT/PLMN change due to network problems. A solution to limit that load is to extend the value of the periodic LAU/RAU/TAU timer and the Mobile Reachable timer
6	Protection in case of PLMN reselection	Various feature to limit Attach procedure impact in case of PLMN reselection (Attach with IMSI at PLMN change, long minimum periodic PLMN search time limit, invalid SIM/USIM states or forbidden PLMN lists, …)

A.2 3GPP Release 11 Features

Ref no.	MIoT Feature	Benefits
7	External Identifier	The growth of number of MTC devices in the next years will induce a shortage of phone numbers (i.e. MSISDN). The 3GPP solution is to define a new identifier as part of the subscription data and allow for operations

Ref no.	MIoT Feature	Benefits
		whereby a MSISDN is not allocated but a new identifier is used instead. This new identifier is named External Identifier (<Local Identifier>@<Domain Identifier) TS 23.682 § 4.6, TS 23.003 § 19.7.2
8	Operations without MSISDN	The growth of number of MTC devices in the next years will induce a shortage of phone numbers (i.e. MSISDN). Operations without MSISDN in 2/3G PS core networks will be allowed. Some services are not supported at operation without MSISDN, like the CAMEL ones. Moreover, there may be additional problems with the following services: I-WLAN, IMS, Location services, Mobile Number Portability, Presence Services, MBMS, Generic User Profile, Charging, Remote Device Management and Over-the-Air configuration. This evolution does not concern EPC because MSISDN is already optional in EPC since Rel-8 TS 23.060 [5] § 5.3.17, TS 23.008 § 2.1.2, 5.1, 5.2
9	Device Triggering	The solution is based on the MTC InterWorking Function (MTC-IWF). The SMS message presents an indicator allowing the UE and the network to distinguish an MT message carrying device triggering information from any other type of message. In addition, useful Device trigger information named Trigger payload may be inserted in the SMS message.
10	SMS in MME	SMS in MME enables support of MO and MT SMS over LTE without requiring deployment of MSCs. Instead of delivering MT-SMS via the MSC (which would require the UE to be registered in the CS domain), the Short Messages pass directly between the MME and the SMSC using a new Diameter-based interface SGd.
11	PS Only Service Provision	For M2M applications/devices that only require PS data, avoiding to attach to the CS domain is trivial. However, for other applications/devices, attachment to the CS domain can be avoided only when the following conditions are satisfied: (a) The UE only needs PS domain services and SMS. (b) The SGSN supports SMS. (c) The HLR/HSS supports SMS via SGSN. (d) For roaming cases, the roaming agreement allows SMS via SGSN
12	Extension of Release 10 features on congestion control	Includes - Permission to override “low access priority”

Ref no.	MIoT Feature	Benefits
		and “extended access barring” - Additional Load/Overload Control

A.3 3GPP Release 12 Features

Ref no.	MIoT Feature	Benefits
13	Power Saving Mode	Some particular MTC Devices infrequently send/receive mobile originating/terminating small data. In order to lower the power consumption of MTC Devices, Power Saving Mode (PSM) mechanism has been introduced. It refers to a particular UE state applicable in the PS domain where the UE is considered as powered-off, but remains registered with the network and there is no need to re-attach or re-establish PDN connections when exiting this state. TS 22.368 § 7.1.1 TS 23.682 § 4.5.4

A.4 3GPP Release 13 Features

Ref no.	MIoT Feature	Benefits
	LTE Category M1 UE (LTE-M)	This is an evolution of 4G M2M modules “Category 0 “. Called "Category M1" (previously "Category -1"), they have up to 15 dB coverage extension and work in a narrower bandwidth of 1.4 MHz TS 36.300 § 23.7a
14	Extended DRX Cycles	Extended discontinuous reception (eDRX) is a mechanism used by the UE and network to reduce UE power consumption by extending its sleeping cycle in idle mode. It may be used instead of, or in addition to, PSM (Power Saving Mode) defined in Release 12 TS 23.682 § 4.5.13.1
15	LTE Coverage Enhancement (CE)	UE uses enhanced coverage functionality to access the cell. This is a RAN feature based on the repetition of messages between the UE and the eNB. A single transport block is transmitted over multiple sub frames, thereby providing higher transmit energy per information bit for a given transmit power TS 36.300 § 23.7b
16	High Latency Communication	High latency communication is a feature used for devices using PSM and/or eDRX. It allows an extended buffering of downlink data packets based on network awareness of UE power saving cycle until UE becomes reachable again

Ref no.	MIoT Feature	Benefits
		TS 23.682 § 4.5.7
17	Control plane CIoT Optimizations	Control plane CIoT EPS optimization allows to transport user data (IP, Non-IP) within signalling on the access network until the MME (called also Data over NAS (DoNAS))
18	User plane CIoT Optimizations	User plane CIoT EPS optimization allows to transfer on the user plane data without the need for using the Service Request procedure to establish the Access Stratum (AS) when the user is in ECM-IDLE mode
19	Attach without PDN Connection	Attach without PDN connection establishment allows the UE to be attached without having a Default PDN connection established. SMS is available to UE that has attached without PDN connection
21	Non-IP Data Delivery (NIDD)	Non-IP PDN type allows an EPS UE to transfer data without operating an IP stack and obtaining an IP address. "Non-IP" transport is specifically requested by the UE in a PDN Connectivity Request (as part of an Attach Request or separately), by selecting "PDN-type = Non-IP" (possible values are IPv4, IPv4v6, IPv6 or Non-IP). Two mechanisms (provisioned in HSS) are currently defined for the delivery of Non-IP data to the Service Capability Server / Application Server (SCS/AS): • Delivery using SCEF; • Delivery using a Point-to-Point (PtP) SGi tunnel TS 23.401 § 4.3.17.8. TS 23.682 § 5.13.
22	Optimized EPS Architecture option for CIoT (C-SGN)	An EPS optimized for CIoT can be enabled by having sub-set of functionalities implemented in a single logical entity C-SGN (CIoT Serving Gateway Node) described below. C-SGN is a deployment option using the existing external interfaces of MME + S-GW + P-GW all together, and it does not create new system requirements. C-SGN supports for Mobility and Attach procedures the MME, S-GW and P-GW
23	Monitoring Enhancements	The network detects and reports events that M2M Application Servers / Services Capability Server have configured, related to their devices : association of the UE and UICC, UE reachability, Availability after DDN failure, Current Location, Loss of connectivity, Roaming status, ... The support of monitoring features in roaming scenarios implies a roaming agreement between the HPLMN and the VPLMN. TS 23.682 § 4.5.6

Ref no.	MIoT Feature	Benefits
24	Service Capability Exposure Function (SCEF)	The Service Capability Exposure Function (SCEF) provides a means to securely expose service and network capabilities like resource management, communication patterns, QoS to third parties through network application programming interfaces (API). For NIDD, the SCEF is enhanced with the capability to support Control Plane CIoT EPS Optimisation. In the roaming case, the Interworking SCEF (IWK-SCEF) serves for interconnection with the SCEF of the Home PLMN and is located in the Visited PLMN TS 23.682 § 4.4.8 (SCEF) TS 23.682 § 4.4.9 (IWK-SCEF)
25	Group Message Delivery Using MBMS	Group message delivery using MBMS is intended to efficiently distribute the same content to the members of a group that are located in the particular geographical area on request of the SCS/AS via SCEF. Multimedia Broadcast / Multicast Service (MBMS), is a point-to-multipoint service in which data is transmitted from a single source entity to multiple recipients. Transmitting the same data to multiple recipients allows network resources to be shared. TS 23.682 § 4.5.5 and § 5.5.1 TS 23.246
26	Dedicated Core Network	A Dedicated Core Network (DCN, aka DECOR) provides specific characteristics and/or functions dedicated for specific types of subscribers (such as IoT subscribers). The main architecture enhancements are to route and maintain UEs in their respective DCN. An operator may choose to deploy one or more DCNs within a PLMN with each DCN for specific types of subscribers. TS 23.401 [8] § 4.3.25 and § 5.19

Annex B Summary of recommendations per Revisions

Feature	Release 1	Release 2
LTE-M Deployment Bands	1, 2, 3, 4, 5, 12, 13, 20, 26 and 28	1, 2, 3, 4, 5, 12, 13, 20, 25, 26 and 28
PSM	T3324 minimum 16 second T3412 minimum 4 hours, maximum 413 days For UE requesting value lower than the minimum recommended, the network may override to the minimum value. For UE requesting value higher than the maximum recommended value, the network will override to the maximum value. No store and forward support for MT data Store and forward for MT SMS as per current SMSC expiration timer	No changes
eDRX	Recommended to support eDRX and to consider accepting the 3GPP Rel13 defined UE requested values of a minimum of 5.12 seconds, and maximum: 43.69 minutes.	No changes
GTP-IDLE Timer on IPX Firewal	No specific recommendation at this stage on the value of the timer.	No changes
Long Periodic TAU	3GPP Release 13-defined TAU Requests from the UE are used to support Long Periodic TAU	No changes
Support of CATM1	Support as per 3GPP Release 13, both power classes 23 dBm and 20dBm	No changes

Half-Duplex and Full-Duplex	It is recommended that Half Duplex Mode is supported.	No Changes
Extension of coverage features	CE Mode A is the mandatory coverage extension mode, to be supported by all LTE-M devices. Optionally MNOs can support also CE Mode B, if CE Mode B is not enabled on a visited network, the roaming device will revert to CE Mode A and revert to the coverage benefits offered by CE Mode A.	No Changes
SCEF	Currently not supported.	No changes
VoLTE	VoLTE is not a mandatory recommendation for global LTE-M deployments, however if operator does deploy VoLTE the following recommendations should apply: the device and then network must support GSMA PRD NG.108 “IMS Profile for Voice and SMS for UE category M1” to support voice and SMS for UE category M1.	No changes
SMS	No support of SMS	SMS support with following recommendations: • For deployments supporting also VoLTE, consider to support SMS over IMS • Devices supporting 2G, 3G and/or 4G, as well as LTE-M, the MNO should deploy and support LTE-M SMS in the manner consistent with the MNO’s existing

		implementation of SMS over legacy LTE networks • If a service is deployed which utilises SMS and international roaming is required, the MNO will need to advise the customer where this will be and where this is not available.
HLcom	Feature not present	No current support.
CMM	Feature not present	support for the Connected Mode Mobility for VoLTE and all data traffic

Annex C LTE-M Task Force Questionnaire – Release 1

The recommendations in this paper are based on the responses collected from the LTE-M Task Force mobile network operator members.

Below is the questionnaire that was used for gathering the deployment information. All responses to the questionnaire were anonymized and aggregated, to analyse operator plans for deploying LTE-M with PSM to ensure smooth interoperability and roaming treatment.

1. Deployment Bands: In which bands are you planning to deploy LTE-M in each of your markets?

2. What other cellular network (Type, Frequency band) may be used for back-up in area not covered by LTE-M (in order of priority)?

   Example
   - GSM 900 – E-GPRS
   - GSM 1800

3. LTE-M Features: Which features are you planning to deploy that will affect roaming and/or configurations and should be agreed as part of the PSM/eDRX/TAU timer configuration settings?

   a. PSM (**please select "yes" if you consider PSM a key feature, and provide the explanation to questions ii –v, or put "haven't decided yet" if this decision hasn't been made yet.**

i. yes/no
ii. If yes, which configurations (e.g. timer limits) should be agreed and what is the maximum limits to the e-T3412 and T3324 timers (if different from limits fixed by the protocols?)?

iii. If yes, which policy on packets is going to the device when it's in PSM (Ex: discard, store and forward all of them, store and forward last packet(s), store and forwards first packets(s))

iv. If yes, will you set a limit to the amount or type of downwards information?

v. Do you plan to offer customers visibility or management of PSM configuration in their devices?

vi. Do you plan to offer customers visibility or management of PSM configuration in their devices?
    1. If Yes to "v.", and yes to "ii." – will Carrier perform an Override function if UE requests a value not supported by network?
    2. If Yes, what are Override Value Maximum for T3412 and T3324?

b. eDRX (**please select "yes" if you consider e-IDRX and e-CDRX a key feature, and provide the explanation to questions ii –v, or put "haven't decided yet" if this decision hasn't been made yet.**)
   i. yes / no
   ii. If yes, which configurations (e.g. timer limits) should be agreed, and will you set limits for the e-IDRX & e-CDRX value (if different from limits fixed by the protocols?)?

   iii. If yes, which policy on packets is going to the device when it's in e-IDRX & e-CDRX (e.g. Ex: discard, store and forward all of them, store and forward last packet(s), store and forwards first packets(s))

   iv. If yes, will you set a limit to the amount or type of downwards information?

   v. Do you plan to offer customers visibility or management of e-IDRX & e-CDRX configuration in their devices?

c. GTP-IDLE Timer on IPX Firewall used:
   i. Yes/no
   ii. If yes which value:

   iii. If yes, which traffic separator do you support
      1. APN-Name
      2. PGw IP-Address
      3. IMSI Range

d. Long Periodic TAU supported
   i. Yes/no
   ii. If yes, which configurations (e.g. timer limits) should be agreed?

<u>Additional</u> <u>LTE-M Planned Feature Set Questionnaire</u>:

1. **Support of Cat M1**

   a. Half Duplex Mode
   a. Yes / No
   b. Full Duplex Mode
   a. Yes / No
   c. UE Class +23 dBm
   a. Yes / No
   d. UE Class +20 dBm
   a. Yes / No

2. **Extension of coverage features**
   a. Extension coverage Mode A
   a. yes/no
   b. Extension coverage Mode B
   a. yes/no
   c. Do you intend to limit the use of Mode A or Mode B to some range of device / use case
   a. yes/no
   b. if yes, what mechanism to limit the usage

3. **Do you plan to deploy SCEF?**
   a. Yes / No

   b. If Yes – please clarify when you plan to deploy it (3Q 2017? 4Q 2017, or later?) Please also clarify whether you plan to deploy it in phases, e.g. “traditional” PGW initially, followed by new SCEF based architecture, or SCEF from the start)

   c. If Yes – which features are you planning to expose via APIs?

4. **Do you plan to deploy VoLTE calls in the future?**
   a. yes/no
   b. VoLTE yes/no (only from 3GPP Rel 14)

5. **Do you plan to provide SMS on LTE-M?**
   a. Yes / No
   b. If yes: how?
   c. If Yes – do you plan to provide SMS transfer without combined attach?

Annex D LTE-M Task Force Questionnaire – Release 2

This questionnaire is part of the study conducted by the GSMA as part of the production of the LTE-M Deployment Guide. All responses will be anonymized and aggregated, to analyse operator plans for deploying LTE-M ensure smooth interoperability and roaming treatment.

1. **Deployment Bands: In which bands are you planning to deploy LTE-M in each of your markets?**

(Currently in the LTE-M Deployment Guide: 1, 2, 3, 4, 5, 12, 13, 20, 26 and 28)

LTE Deployment Band	Regions

2. **Are you planning to deploy eDRX? (please select "yes" if you consider e-IDRX and e-CDRX a key feature, and provide the explanation to questions ii –v, or put "haven't decided yet" if this decision hasn't been made yet.**)

   i. yes / no
      a) If yes, which configurations (e.g. timer limits) should be agreed, and will you set limits for the e-IDRX & e-CDRX value (if different from limits fixed by the protocols?)?

      b) If yes, which policy on packets is going to the device when it's in e-IDRX & e-CDRX (e.g. Ex: discard, store and forward all of them, store and forward last packet(s), store and forwards first packets(s))

   i. If yes, will you set a limit to the amount or type of downwards information?

   ii. Do you plan to offer customers visibility or management of e-IDRX & e-CDRX configuration in their devices?

   iii. Which policy, if any, are you recommending for e-IDRX and e-CDRX in combination with PSM?

3. **Do you plan to deploy VoLTE calls in the future?**
   i. yes/no
   ii. VoLTE yes/no (only from 3GPP Rel 14)
   iii. If yes, will you support VoLTE for Half-duplex, full-duplex or both?
   iv. If yes, will you support VoLTE for Mode A only or also Mode B?

4. **Do you plan to support the connected mode mobility**
   i. Yes for VoLTE calls only
   ii. Yes for VoLTE and other type of data traffic
   iii. No

5. **Do you plan to provide a continuity of service by complementing LTE-M to a backup 3GPP solutions**
   i. Yes with 2G GSM
   ii. Yes with 3G UMTS
   iii. Yes with NB-IoT
   iv. In case of backup to 2G / 3G, do you plan to support PSM, eDRX function to this Radio Network?

6. **Do you plan to provide SMS on LTE-M?**
   i. Yes / No
   ii. If yes: how?
   iii. If yes - do you plan to use SMS for SIM provisioning (Network originated)
   iv. If yes - do you plan to use SMS for SIM tools KIT application (SIM originated)
   v. If Yes – do you plan to provide SMS transfer without combined attach?
   vi. If yes, are you planning to support SMS over IMS? (Either long term or short term, if long term what would be the intermediate solution?)

7. **Do you plan to deploy SCEF?**
   i. Yes / No
   ii. If Yes – please clarify when you plan to deploy it (3Q 2017? 4Q 2017, or later?) Please also clarify whether you plan to deploy it in phases, e.g. “traditional” PGW initially, followed by new SCEF based architecture, or SCEF from the start)
   iii. If Yes – which features are you planning to expose via APIs?

Annex E Document Management

E.1 Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
1.0	5 July 2017	New White Paper CLP.29	LTEM TF	L Purnell/GSMA
2.0	12 April 2018	Release 2 of CLP.29 incorporating the information gathered from 8 new deployments of LTE-M	LTEM TF	L Purnell/GSMA

E.2 Other Information

Type	Description
Document Owner	Internet of Things Programme, LTE-M Task Force
Editor / Company	L Purnell/ GSMA

It is our intention to provide a quality product for your use. If you find any errors or omissions, please contact us with your comments. You may notify us at prd@gsma.com

Your comments or suggestions & questions are always welcome.