IoT Device Connection Efficiency Guidelines

Version 2.0

01 July 2015

This is a Non-binding Permanent Reference Document of the GSMA

Security Classification: Non-confidential

Access to and distribution of this document is restricted to the persons permitted by the security classification. This document is confidential to the Association and is subject to copyright protection. This document is to be used only for the purposes for which it has been supplied and information contained in it must not be disclosed or in any other way made available, in whole or in part, to persons other than those permitted under the security classification without the prior written approval of the Association.

Copyright Notice

Disclaimer

The GSM Association ("Association") makes no representation, warranty or undertaking (express or implied) with respect to and does not accept any responsibility for, and hereby disclaims liability for the accuracy or completeness or timeliness of the information contained in this document. The information contained in this document may be subject to change without prior notice.

Antitrust Notice

The information contain herein is in full compliance with the GSM Association's antitrust compliance policy.

Table of Contents

1 Introduction

1.1 Problem Statement

The predicted large scale growth of IoT Devices and their associated IoT Device Applications will create major challenges for Mobile Network Operators. One major challenge that Mobile Network Operators must overcome is the risk caused by the mass deployment of inefficient, insecure or defective IoT Devices on the Mobile Network Operators' networks. When deployed on a mass scale such devices can cause network signalling traffic to increase to a level which impacts network services for all users of the mobile network. In the worst cases the mass deployment of such IoT Devices can disable a mobile network completely.

Mobile Network Operators have faced similar issues in the past, most recently with the massive growth of smartphones. In this case many smartphone application developers inadvertently created many inefficient applications. Over the past decade Mobile Network Operators, smartphone device makers and smartphone application developers have worked together to resolve these difficulties through a mix of increasing network capacity (e.g. 3.5G and 4G network deployment), 3GPP standardisation, improvements to smartphone operating systems and development of smartphone application developer guidelines. With the forecasted high growth in IoT Devices the industry is in a similar situation to the start of the smartphone boom, but with a different group of device makers and application developers. With the IoT however the potential number of devices is higher and, due to the different commercial models for IoT Devices, it is far more challenging for the Mobile Network Operator to influence the behaviour of IoT Device manufacturers and IoT Device Application developers.

An IoT Device overusing the network may lead to problems such as:

- Reducing the lifetime of the (U)SIM card by increasing dramatically the read/write cycles.
- Increased power consumption of the device due to continuous restarts which may also affect the device lifetime.
- Local issues within the Mobile Network Operator's network such as cell congestion.
- Capacity and performance problems within the Mobile Network Operator's core network, such as signalling storms, which result in wide area network disruption.
- Negatively impacting the IoT Service's performance, potentially resulting in delayed communications, degradation of the service quality and even service outages.

IoT Devices overusing the mobile network can affect not only the devices causing the incident but also other devices on the same IoT Service Platform or those devices of other End Customers.

Network signalling resources are dimensioned assuming an overall device usage profile with a sensible balance between traffic and signalling needs. It is therefore important that IoT Devices using mobile networks adhere to some basic principles before they can be safely connected to mobile networks.

Good design is essential to ensure that IoT Device performance is optimized and to prevent failure mechanisms creating runaway situations which may result in network overload. In situations where many IoT Devices of the same type may be deployed on a single mobile network the cumulative effect may have a detrimental impact on overall network performance. Poor design of IoT Device Application to IoT Service Platform communications which disregard the mobile network and IoT Device status may result in inefficient use of network and device resources, affecting the IoT Service experience end-to-end.

See annex A for example cases where problematic IoT Device behaviour has impacted network and device performance.

1.2 Document Scope

In IoT scenarios IoT Device firmware and software play a significant part in determining the overall performance and behaviour of the IoT Service on the mobile network. With no human intervention to fall back upon, the mechanisms that manage recovery from IoT Service failure need to be built into IoT Devices.

This document will serve as a key deliverable from the GSMA Connected Living programme for 2014/15. The objective of this document is to specify requirements for efficient use of mobile network connectivity.

With the exception of section 9, the requirements and solutions captured in this document for efficient use of 3GPP mobile networks are for use within the current (short-term) timeframe, i.e. for the current generation of IoT Devices which do not necessarily support comparable 3GPP network efficiency features or are connecting to networks that do not support the necessary 3GPP network efficiency features.

In the mid to long term IoT Devices may make use of available features from 3GPP or other standards organisations to address the issues highlighted in this document. In section 9 we list the 3GPP feature that may be deployed within mobile networks and IoT Devices in the mid to long term.

1.3 Intended Audience

The target audiences for this document are Mobile Network Operators, IoT Service Providers, IoT Device makers, IoT Device Application developers, Communication Module Vendors and Radio Baseband Chipset Vendors.

1.3.1 Intended Use of the Document

1.3.1.1 Mobile Network Operators

The Mobile Network Operator shall promote the use of the requirements contained within this document. The Mobile Network Operator should make commercially reasonable efforts to reference this document in the connectivity contracts they agree with their IoT Service Providers.

1.3.1.2 IoT Service Providers

The IoT Service Provider shall ensure that their IoT Services and their IoT Device makers conform to the requirements stated within this document. The IoT Service Provider should reference this document in the supply contracts they place with their IoT Device makers.

1.3.1.3 IoT Device Maker

IoT Device makers are expected to implement the requirements contained within this document in the IoT Devices that they manufacture. The IoT Device maker will work with their IoT Application developer, Communication Module Vendor and Radio Baseband Chipset Vendor partners to implement the requirements contained within this document. The IoT Device maker should reference this document in the supply contracts they place with their IoT Application developer, Communication Module Vendor and Radio Baseband Chipset Vendor partners.

1.3.1.4 IoT Device Application Developer

The IoT Device Application developer shall ensure that their IoT Device Application conforms to the requirements stated within this document.

1.3.1.5 Communication Module Vendor

The Communication Module Vendor shall ensure that their Communication Modules conform to the requirements stated within this document.

1.3.1.6 Radio Baseband Chipset Vendor

The Radio Baseband Chipset Vendor shall ensure that their Radio Baseband Chipsets conform to the requirements stated within this document.

1.4 Key Words Used to Indicate Requirement Levels

The use of “shall”, “shall not”, “should”, “should not” and “may” in this document is as per the definitions found in RFC 2119 [2].

- "shall" means that the definition is an absolute requirement of the specification.
- "shall not" means that the definition is an absolute prohibition of the specification.
- “should” means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- “should not” means that there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.

1.5 Definition of Terms

Term	Description
ADM	Access condition to an Elementary File (EF) which is under the control of the authority which creates this file
Back-off Timer	The Back-off Timer is a dynamic timer which value is based on a unique value for the device (desirably the IMSI) and the number of consecutive failures (which points to different Back-off Base Intervals).
Communications Module	The communications component which provides wide area (2G, 3G, 4G) radio connectivity. Comprising of Communications Module Firmware, Radio Baseband Chipset and UICC
Communications Module Firmware	The functionality within the Communications Module that provides an API to the IoT Device Application and controls the Radio Baseband Chipset.
End Customer	Means the consumer of IoT Services provided by the IoT Service Provider. It is feasible that the End Customer and IoT Service Provider could be the same actor, for example a utility company.
Fast Dormancy	Device power saving mechanism. See GSMA TS.18 [14].
Global Certification Forum	An independent worldwide certification scheme for mobile phones and wireless devices that are based on 3GPP standards. The GCF provides the framework within which cellular GSM, UMTS and LTE mobile devices and Communication Modules obtain certification for use on GCF Mobile Network Operators’ networks. Obtaining GCF Certification on a mobile device ensures compliance with 3GPP network standards within the GCF Mobile Network Operators' networks. Consequently, GCF Mobile Network Operators may block devices from their network if they are not GCF certified. For more information, see http://www.globalcertificationforum.org
Internet of Things	The Internet of Things describes the coordination of multiple machines, devices and appliances connected to the Internet through multiple networks. These devices include everyday objects such as tablets and consumer electronics, and other machines such as vehicles, monitors and sensors equipped with machine-to-machine (M2M) communications that allow them to send and receive data.
IoT Device	The combination of both the IoT Device Application and the Communications Module.

Term	Description
IoT Device Application	The application software component of the IoT Device that controls the Communications Module and interacts with an IoT Service Platform via the Communications Module.
IoT Device Host	The application specific environment containing the IoT Device e.g. vehicle, utility meter, security alarm etc.
IoT Server Application	An application software component that runs on a server and can exchange data and interact with the IoT Devices and the IoT Device Applications over the IoT Service Platform.
IoT Service	The IoT service provided by the IoT Service Provider.
IoT Service Platform	The service platform, hosted by the IoT Service Provider which communicates to an IoT Device to provide an IoT Service. The IoT Service Platform can exchange data with the IoT Device Application over the Mobile Network and through the Communication Module, using (among others) IP-based protocols over a packet-switched data channel. Also, the IoT Service Platform typically offers Device Management capabilities, acting as a so-called Device Management Server. Finally, the IoT Service Platform typically offers APIs for IoT Server Applications to exchange data and interact with the IoT Device Applications over the IoT Service Platform.
IoT Service Provider	The provider of IoT services working in partnership with a Mobile Network Operator to provide an IoT Service to an End Customer. The provider could also be a Mobile Network Operator.
Machine to Machine	Machine-to-Machine (M2M) is an integral part of the Internet of Things (IoT) and describes the use of applications that are enabled by the communication between two or more machines. M2M technology connects machines, devices and appliances together wirelessly via a variety of communications channels, including IP and SMS, to deliver services with limited direct human intervention turning these devices into intelligent assets that open up a range of possibilities for improving how businesses are run.
Mobile Network Operator	The mobile network operator(s) connecting the IoT Device Application to the IoT Service Platform.

Term	Description
PTCRB	The independent body established as the wireless device certification forum by North American Mobile Network Operators. The PTCRB provides the framework within which cellular GSM, UMTS and LTE mobile devices and Communication Modules obtain certification for use on PTCRB Mobile Network Operator networks. Obtaining PTCRB Certification on a mobile device ensures compliance with 3GPP network standards within the PTCRB Mobile Network Operators' networks. Consequently, PTCRB Mobile Network Operators may block devices from their network if they are not PTCRB certified. For more information, see http://ptcrb.com
Radio Baseband Chipset	The functionality within the Communications Module that provides connectivity to the mobile network.
Subscriber Identity Module	Module provided by the Mobile Network Operator containing the International Mobile Subscriber Identity (IMSI) and the security parameters used to authenticate the (U)SIM with the Network. Seen as an authentication application contained in the Universal Integrated Circuit Card (UICC).
UICC	The smart card used by a mobile network to authenticate devices for connection to the mobile network and access to network services.

1.6 Abbreviations

Abbreviation	Description
3GPP	3rd Generation Project Partnership
API	Application Programming Interface
APN	Access Point Name
GCF	Global Certification Forum
GSM	Global System Mobile
GSMA	GSM Association
IMEI	International Mobile station Equipment Identity
IMSI	International Mobile Subscriber Identity
IoT	Internet of Things
IP	Internet Protocol
LTE	Long Term Evolution
M2M	Machine to Machine

Abbreviation	Description
NAT	Network Address Translation
NFM	Network Friendly Mode – see section 7.1
OTA	Over The Air
PDP	Packet Data Protocol
PTCRB	A pseudo-acronym, originally meaning PCS Type Certification Review Board, but no longer applicable.
RFC	Request for Comments – a document of the Internet Engineering Task Force
RPM	Radio Policy Manager – see section **Error! Reference source not found.**
RRC	Radio Resource Control
SMS	Short Message Service
UMTS	Universal Mobile Telecommunications Service
(U)SIM	(Universal) Subscriber Identity Module
USB	Universal Serial Bus

1.7 References

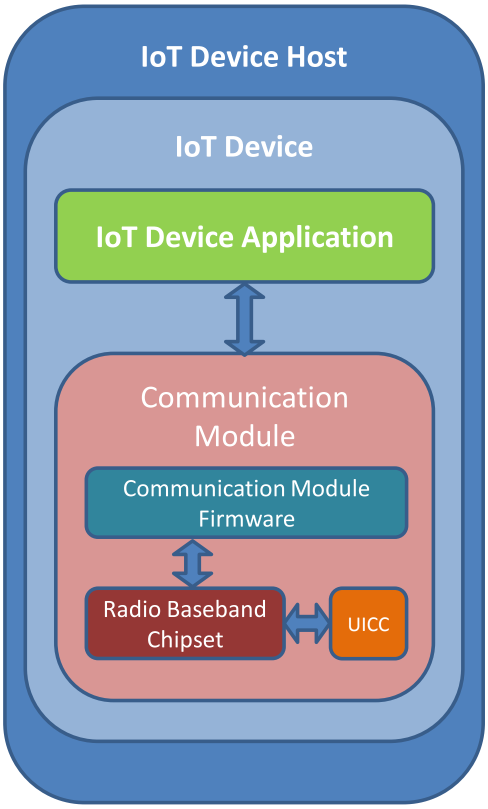
Ref	Document Number	Title
1	3GPP Specifications	www.3gpp.org
2	RFC 2119	Key words for use in RFCs to Indicate Requirement Levels http://www.ietf.org/rfc/rfc2119.txt
3	3GPP TS 36.331	Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification www.3gpp.org
4	3GPP TS 31.102	Characteristics of the Universal Subscriber Identity Module (USIM) application www.3gpp.org
5	GSMA SGP.02	Remote Provisioning Architecture for Embedded UICC Technical Specification www.gsma.com
6	3GPP TS 22.016	International Mobile station Equipment Identities (IMEI) www.3gpp.org
7	OMA DiagMon	OMA DiagMon Management Object Version 1.2 www.openmobilealliance.org

8	OMA DM	OMA Device Management Version 1.2 or 1.3 www.openmobilealliance.org
9	OMA FUMO	OMTA Firmware Update Management Object Version X.X www.openmobilealliance.org
10	GSMA TS.06	IMEI Allocation and Approval Process www.gsma.com
11	OMA ERELDDM_1.2	Enabler Release Definition for OMA Device Management www.openmobilealliance.org
12	3GPP TS 24.008	Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 www.3gpp.org
13	3GPP TS 23.122	Non-Access-Stratus functions related to Mobile Station in idle mode www.3gpp.org
14	GSMA TS.18	Fast Dormancy Best Practices www.gsma.com
15	OMA LightweightM2M	OMA LightweightM2M www.openmobilealliance.org
16	GSMA IR.92	IMS Profile for Voice and SMS

2 IoT Architecture Assumptions (Informative Section)

2.1 Generalised IoT Device Architecture

In order to ensure a common vocabulary is used within this document an illustration of a generalised IoT Device architecture is shown in Figure 1 below.



IoT Device Host – The application specific environment containing the IoT Device e.g. vehicle, utility meter, security alarm etc.

IoT Device – The combination of both the IoT Device Application and the Communication Module.

IoT Device Application – The application software component of the IoT Device that controls the Communications Module and interacts with an IoT Service Platform via the communications module.

Communication Module – The communications component which provides wide area (2G, 3G, 4G) radio connectivity. Comprising of Communications Module Firmware, Radio Baseband Chipset and UICC

Communications Module Firmware – The functionality within the Communications Module that provides an API to the IoT Device Application and controls the Radio Baseband Chipset.

Radio Baseband Chipset – The functionality within the communications module that provides connectivity to the mobile network.

UICC – The smart card used by a mobile network to authenticate devices for connection to the mobile network and access to network services.

Figure 1: Generalised IoT Device Architecture

- IoT Device requirements can be found in section 3 of this document.
- IoT Device Application requirements can be found in section 4 of this document.
- Communication Module (and Radio Baseband Chipset) requirements can be found in sections 5, 7, 8 and 9 of this document.

2.2 Generalised IoT Service Architecture

Beyond the scope of the IoT Device itself, and considering the architecture of the end-to-end IoT Service, a generalised IoT Service Architecture can be described as follows:

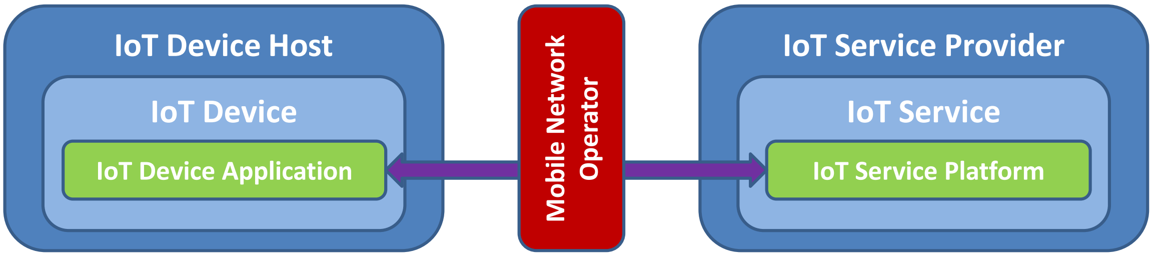


Figure 2: Generalised IoT Service Architecture

- **IoT Service Provider –** The provider of IoT services working in partnership with a network operator to provide an IoT Service to an End Customer. The provider could also be an MNO.
- **IoT Service –** The IoT service provided by the IoT Service Provider
- **IoT Service Platform –** The service platform, hosted by the IoT Service Provider which communicates to an IoT Device to provide an IoT Service.
- **Mobile Network Operator –** The mobile network operator(s) connecting the IoT Device Application to the IoT Service Platform

The IoT Service Platform very often exposes the deployed IoT devices and their data to applications located on the server side, e.g. in an enterprise system. These applications are the IoT Server Applications.

On the IoT Device, there is an evolution where the IoT Device Applications tend not to be monolithic, but are developed on top of a component providing several generic IoT functionalities (e.g. device management, security, location, application framework…) so as to focus on business-specific logic. This component is called the IoT Embedded Service Layer.

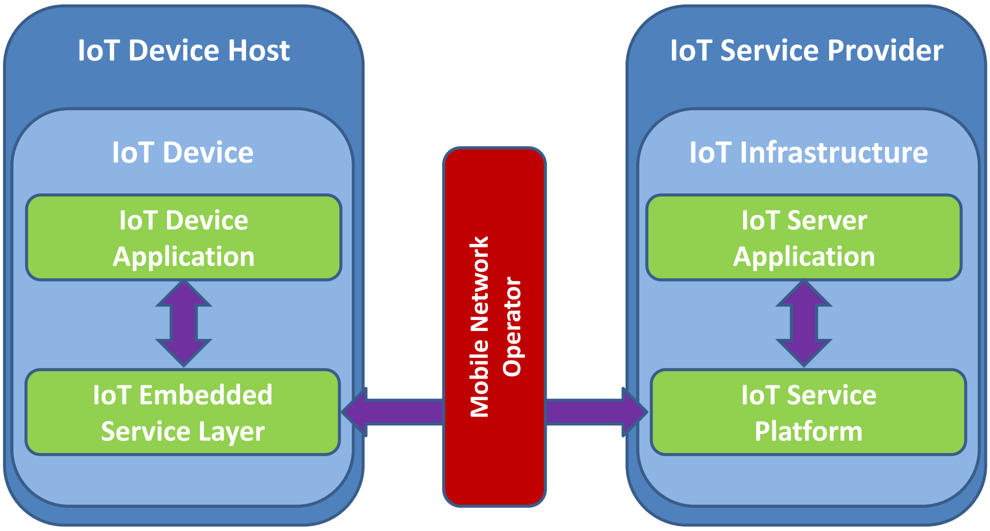


Figure 3: Generalised "Layered" IoT Service Architecture

- **IoT Server Application** – An application software component that runs on a server and exchanges data and can interact with the IoT Devices and the IoT Device Applications over the IoT Service Platform.
- **IoT Service Platform** – The service platform, hosted by the IoT Service Provider which communicates to an IoT Device to provide an IoT Service.
- **IoT Device Application** – The application software component of the IoT Device that controls the Communications Module and interacts with an IoT Service Platform via the IoT Embedded Service Layer and the Communications Module
- **IoT Embedded Service Layer** – The component offering generic IoT functionalities to IoT Device Application.

IoT Service Provider requirements can be found in section 6 of this document.

3 IoT Device Requirements (Normative Section)

IDR1	The IoT Device should conform to all IoT Device Application requirements defined in section 4
IDR2	The IoT Device shall conform to all Communication Module requirements defined in section 5.
IDR3	The IoT Device should conform to GSMA TS.24 “Operator Minimum Acceptance Values for Device Antenna Performance” [x].
IDR4	When required by the Mobile Network Operator, the IoT Device shall be certified by the GCF and/or the PTCRB.

4 IoT Device Application Requirements (Normative Section)

DAR1	In the case of an IoT Device Application which needs to send data very frequently the IoT Device Application should use an “always-on” connectivity mechanism instead of activating and deactivating network connections (a ‘network connection’ being the establishment of a radio connection between the Communications Module and the network) very frequently.
DAR2	The IoT Device Application should minimize the number of network connections between the IoT Device and the network. Data should be aggregated by the IoT Device Application into as big a chunk as possible before being compressed and sent over the communications network. If the IoT Device Application provides several IoT Services using the same Communications Module, the IoT Device Application should coordinate each of the IoT Services network communication to make efficient use of the network.
DAR3	If permissible for the IoT Service, the IoT Device Application should avoid synchronized behaviour with other IoT Devices and employ a randomized pattern (e.g. over a period of time of a few seconds to several hours or days) for network connection requests.
DAR4	The IoT Device Application should be implemented securely. For example by following industry guidelines such as those provided by: • IETF – www.ietf.org • Open Web Application Security Project (OWASP) - www.owasp.org • W3C – www.w3.org • OASIS – www.oasis-open.org • OMA – www.openmobilealliance.org • 3GPP – www.3gpp.org • OneM2M – www.onem2m.org
DAR5	The IoT Device Application should implement appropriate security measures to prevent unauthorized or insecure device management functionality (e.g. diagnostics, firmware updates) of the IoT Device software and firmware. Such security measures shall apply to all local and remote (over the air) device management functionality.
DAR6	If the IoT Service requires the use of ‘keep alive’ messages, the IoT Device Application should automatically detect the Mobile Network Operator’s TCP_IDLE value or UDP_IDLE value (NAT timers) when using push services. This can be achieved by increasing the IoT Device Application’s polling interval until a network timeout occurs and then operating just below the timeout value. The IoT Device Application should adapt to the new value as opposed to using a hard coding a polling interval set within the device.

DAR7	If the IoT Service requires the use of 'keep alive' messages, use of dynamic polling interval (ref. DAR6) is preferred. However, if a fixed polling interval is used, the IoT Device Application should use a time value specified by the Mobile Network Operator. If the preferred value of the Mobile Network Operator is unknown a default value of 29 minutes is recommended as the polling interval when devices use TCP protocol. If a fixed polling interval is used, the IoT Device Application should allow remote and/or local configuration of the interval. Note: The suggested value of 29 minutes for devices using TCP protocol is recommended because the routers used by many Mobile Network Operators' will clear the Network Address Translation (NAT) entry for the IoT Device's data session 30 minutes after the last communication is sent to/from the IoT Device. Note: If the device uses UDP protocol the device must use a timer value appropriate for the target network operator environment.
DAR8	The IoT Device Application should be designed to cope with variances in mobile network data speed and latency considering the variety in performance of mobile communications technologies such as 2G, 3G and LTE.
DAR9	The IoT Device Application should be capable of adapting to changes in mobile network type and data speed at any given time.
DAR10	If data speed and latency is critical to the IoT Service the IoT Device Application should constantly monitor mobile network speed and connection quality in order to request the appropriate quality of content from the IoT Service Platform.

DAR11	The IoT Device Application should always be prepared to handle situations when communication requests fail. Communication retry mechanisms implemented within an IoT Device Application can vary and will depend on the importance and volume of downloaded data. Possible solutions can be: • Simple counting of failed attempts since the data connection was first established (often the easiest solution). • Monitoring the number of failed attempts within a certain period of time. For example, if the data connection is lost more than five times within an hour, then the request can be suspended. This can be a more reliable technique to avoid short but regular connection problems, such as when a device is moving away from one network cell to another. The data connection can be lost when the device switches between cells, but when the cell is providing good coverage; the request can be processed successfully. Depending upon the IoT Service, no communication request by the IoT Device Application should ever be retried indefinitely – the request should eventually timeout and be abandoned. Note: The requirements contained within section 5.2 of this document describe the functionality that, when implemented within the Communications Module to monitor IoT Device Application behaviour, ensures the retry mechanisms implemented within the IoT Device Application do not prevent the normal operation of the mobile network.
DAR12	The IoT Device Application should monitor the number of network connections it attempts over a set period of time. If the number of connection attempts exceeds a maximum value the IoT Device Application should stop requesting network connectivity until the time period has expired. The maximum value shall be set by the IoT Service Provider. In the case the IoT Device exceeds the maximum value a report should be sent to the IoT Service Platform.
DAR13	The IoT Device Application should monitor the volume of data it sends and receives over a set period of time. If the volume of data exceeds a maximum value the IoT Device Application should stop sending and receiving data until the time period has expired. The maximum value shall be set by the IoT Service Provider. In the case the IoT Device exceeds the maximum value a report should be sent to the IoT Service Platform.
DAR14	The IoT Device Application should send a notification to the IoT Service Platform with relevant information when there is an unexpected power outage or unexpected battery power problem. This notification should follow the application scaling advice contained in Annex C.
DAR15	The IoT Device Application should use data transcoding and compression techniques, as per the intended QoS of the IoT Service, to reduce network connection attempts and data volumes.

DAR16	The IoT Device Application should be designed to ensure the application's network communication activity is not concentrated during periods of high network utilisation (i.e. utilises "off-peak" hours as guided by the Mobile Network Operator).
DAR17	The IoT Device Application should minimise any geographical network loading problems and tolerate any geographical network loading problems that may still occur.
DAR18	Each time there is a need to send data over the mobile network the IoT Device Application should classify the priority of each communication. For example, the IoT Device Application should distinguish between data that requires instantaneous transmission and delay tolerant data that could be aggregated and/or sent during non-peak hours.
DAR19	The IoT Device Application should not frequently reset the Communications Modem.
DAR20	When an IoT Device Application does not need to perform regular data transmissions and it can tolerate some latency for its IoT Service, it should implement a 'low power' mode where the device and its Communication Module is effectively powered down between data transmissions. This will reduce the power consumption of the IoT Device and reduce network signalling.
DAR21	Data sent from the IoT Device Application and the IoT Service Platform should be end-to-end encrypted to a security strength appropriate to the IoT Service. Note: It is recognised that for some IoT Services no encryption may be required.
DAR22	The IoT Device Application should authenticate the IoT Service Platform prior to data communication. The strength of authentication used should be appropriate to the IoT Service. Note: It is recognised that for some IoT Services no encryption may be required.
DAR23	NULL.
DAR24	The IoT Device Application should support a "reset to factory settings" via remote and local connection.
DAR25	The IoT Device Application should support "time resynchronisation" via remote and local connection.
DAR26	If the IoT Device supports more than one family of communications access technology (for example 3GPP, TD-SCDMA, Wireless LAN) the IoT Device Application should implement a protection mechanism to prevent frequent 'Ping-Pong' between these different families of communications access technologies.

DAR27	For mass deployments of IoT Devices (e.g. >10,000 devices within the same mobile network), if the IoT Device supports more than one family of communications access technology (for example 3GPP, TD-SCDMA, Wireless LAN) the IoT Device Application should employ a randomised delay before switching to a different family of access technology.
DAR_28	If the IoT Device contains a DHIR capable Communication Module (see Section 5.10) and the IoT Device leverages the Communication Module’s IMEI TAC the IoT Device Application shall report, via a secure method, the contents of the following custom nodes to the Communications Module upon initial communication with the Communications Module and at any time that any of the values of the custom node parameters change during the lifecycle of the IoT Device: • Host Device Manufacturer (see requirement DID4) • Host Device Model (see requirement DID5) • Host Device Software Version (see requirement DID6) • Host Device Unique ID (see requirement DID7) At minimum this includes IoT Device updates such as: • IoT Device firmware update by side-loading, USB, or other local methods; • IoT Device firmware update using a remote server.

5 Communication Module Requirements (Normative Section)

5.1 Standards Compliance

MSC1	The Communications Module shall be compliant with 3GPP specifications [1] unless otherwise stated within this document.
MSC2	The Communications Module shall be certified by the GCF and/or the PTCRB.
MSC3	The Communications Module shall investigate, and meet as required, the mobile network operator requirements for the target market(s).

5.2 Network Efficiency Requirements

NER1	The Communications Module shall support (dependent upon the target mobile network operator) at least one of the following requirements: 1) Radio Policy Manager (as defined in section 8) implemented within the Radio Baseband Chipset; OR 2) Connection Efficiency requirements (as defined in section 7) implemented within the Communication Module Firmware; OR 3) 3GPP Connection Efficiency features (as defined in section 9) implemented within the Radio Baseband Chipset. Note: Option 3 requires the target mobile network operator to have implemented the required 3GPP optional features.
NER2	If the Communications Module supports more than one family of communications access technology (for example 3GPP, TD-SCDMA, Wireless LAN) the device should implement a protection mechanism to prevent frequent ‘Ping-Pong’ between these different families of communications access technologies.
NER3	The Communication Module shall support the mechanism to control the number of RRC Connection Establishment and temporal offset for cell selection as defined in 3GPP TS36.331 [3]

5.3 IPv6 Requirements for Communication Modules that Support IPv6

The following requirements are only applicable to Communication Modules that support IPv6.

- The final target is IPv6 only connectivity, once most of the Internet will be IPv6.
- Remaining IPv4 services will be reachable through NAT64.
- Before IPv6 only connectivity stage is reached, a dual stack will be used to push migration towards IPv6.
- During the dual stack period, IPv4 rationalization solutions will be used.

IP1	The IoT Communications Module should not send unsolicited messages (Router Solicitation for example).
IP2	The IoT Communications Module should send only a AAAA DNS Query.
IP3	The IoT Communications Module management system should be IPv6 based.
IP4	The IoT Communications Module shall support the following IPv6 functionality: • Neighbour Discovery Protocol (apart from the exceptions noted in 3GPP TS 23.060 (3G) or TS 23.401 (LTE) • Stateless Address Auto Configuration • ICMPv6 protocol • IPv6 addressing architecture • IPv6 address text representation
IP5	The IoT Communications Module should support the following IPv6 functionality: • Privacy Extensions for Stateless Address Auto-configuration in IPv6 • ROHC for IPv6 • IPv6 Router Advertisement Flags Options • Path MTU discovery • IPsec version 2 tunnel mode (IKE2)

5.4 Requirements for Communication Modules that Support LTE

The following requirements are only applicable to Communication Modules that support LTE.

CML1	If voice calling over LTE is required by the IoT Service, the Communication Module should support VoLTE (Voice over LTE) as per GSMA IR.92 [16].

5.5 Requirements for Communication Modules that Support Fast Dormancy

The following requirements are only applicable to Communication Modules that support Fast Dormancy.

CFD1	The Fast Dormancy algorithm within the Communications Module should be triggered based on IoT Device data inactivity following suggested time parameters: • 5 to 10 (the specific value in range is to be defined by Mobile Network Operator) seconds for networks with PCH RRC State support (URA-PCH or Cell PCH) • Trigger disabled for networks without PCH RRC State support (URA-PCH or Cell PCH) The Communications Module should ensure that background IP or IMS data flows would not be suspended by the Signalling Connection Release Indication (SCRI). Fast Dormancy best practices from GSMA TS.18 “Fast Dormancy Best Practices” [14] shall be followed.

5.6 (U)SIM Interface Requirements

MSI1	The Communications Module shall support (U)SIM OTA management. See 3GPP TS31.102 [4]
MSI2	The Communications Module should support remote provisioning as defined in GSMA SGP.01 “Remote Provisioning Architecture for Embedded UICC Technical Specification“ [5].

5.7 Security Requirements

MSR1	The Communications Module shall implement a unique global IMEI and protect it against tampering. For details, please refer to 3GPP document TS 22.016 [6].
MSR2	The Communications Module shall detect the removal of a powered UICC and terminate all network connections and services authenticated by the (U)SIM application on that UICC. Upon the removal of a powered UICC all temporary network authentication data related to the UICC should be deleted by the Communications Module.
MSR3	The Communications Module shall implement appropriate security measures to prevent unauthorized management (such as diagnostics, firmware updates etc.) of the Communications Module.
MSR4	The Communications Module shall implement a SIM lock function which allows the IoT Device to be locked to a specific UICC or range of UICCs. The state of the lock shall be remotely configurable.

5.8 Device Management

DM1	The Communications Module should support a standards based over the air device management protocol such as OMA DM [8] or OMA LightweightM2M [15].

DM2	The Communications Module should support a standards based firmware update mechanisms such as OMA FUMO [9].
DM3	The Communications Module should support a “reset to factory settings” via remote and local connection.
DM4	The Communications Module should support “time resynchronisation” via remote and local connection.

5.9 Subscription Identifier Requirements

Given the large potential number of IoT Devices, some national numbering and identification plans have been extended to avoid numbering exhaustion. The structure of these identifiers (MSISDN/Directory numbers, IMSIs) are defined in ITU-T Recommendations E.164 and E.212, and 3GPP TS 23.003.

IR1	The Communications Module shall support 15 digit Directory Numbers/MSISDNs.
IR2	The Communications Module shall support 2 and 3 digit based Mobile Network Codes IMSIs.

5.10 Requirements for Communication Modules that Support Device Host Identity Reporting (DHIR) (Normative Section)

As Communication Modules are certified for use on a network and integrated into various IoT Device Hosts the IMEI TAC range of the Communications Module is often leveraged by the integrator of the IoT Device Host. For example, the PTCRB requirement is that not more than 10,000 units of the IoT Device Host can use the IMEI TAC range of the Communications Module however it has frequently been seen that those rules are not always followed. In this situation the Mobile Network Operator has no traceability to the type of IoT Device Host that the Communications Module is installed in and the number of those devices which are present on the network. This lack of traceability is problematic for several reasons including when field issues are discovered with a particular device and the Mobile Network Operator is unable to pin point exactly what those devices are on its network.

This section defines the requirement for the Communication Module to support a capability which reports IoT Device Host information.

This service utilizes a subset of the OMA Device Management standard. New custom OMA-DM nodes have been defined to collect the information from the IoT Device Host into which the Communication Module is integrated.

It will be necessary for an MNO to define a server the OMA DM client will use to report this information to the network.

DID1	The Communications Module shall utilise the OMA DM specification [8] in order to implement the requirements within this section.
DID2	The following standard nodes, as detailed in the OMA specification shall be supported by the Communications Module in order for the MNO to gain visibility of the Communications Module's detail and other pertinent Info. **OMA Specification Support—OMA Device Management (DM) v1.2 or v1.3** The Communications Module shall support OMA "Device Management" (DM) v1.2 or 1.3 specifications [8] and mandatory requirements contained within OMA "Enabler Release Definition for OMA Device Management" (ERELDDM_1.2) [11] for device provisioning/management.
DID3	**Support for IoT Device Host Reporting in the Device Detail Management Object** For Communications Modules embedded in an IoT Device Host, the IoT Device Host details shall be supported in an extension node within the Device Detail Management Object. These shall match the values for the associated PTCRB or GCF submission from requirement IDR4. The Communications Module shall support four new custom nodes defined in DID4, DID5, DID6 and DID7.
DID4	The following OMA-DM node has been defined to specify information related to the manufacturer of the IoT Host Device, this field will need to match the IoT Device Host manufacturer name that is referenced in the Mobile Network Operator lab certification of the IoT Device. **Type:** Host Device Manufacturer **Occurrence**: One **Format:** String **Name**: DevDetail/Ext/HostMan **Access Type**: GET The IoT Device Host manufacturer will be maintained in the node by the Communications Module OMA DM client.
DID5	The following OMA-DM node has been defined to specify the Model name/number of the IoT Device Host. This shall match the model name/number used in the certification of the IoT Device. **Type:** Host Device Model **Occurrence:** One **Format**: String **Name:** DevDetail/Ext/HostMod **Access Type**: GET The IoT Host Device model will be maintained in the node by the Communication Module OMA DM client.

DID6	The following OMA-DM node has been defined to specify the software version of the IoT Device Host, this information shall be populated by the IoT Device Host manufacturer, shall match the version of SW certified by PTCRB and must be updated whenever the SW is updated on the device. **Type**: Host Device Software Version **Occurrence:** One **Format**: String **Name**: DevDetail/Ext/HostSwV **Access Type**: GET The IoT Host Device software version will be maintained in the node by the Communication Module OMA DM client
DID7	The following OMA-DM node has been defined to specify the unique ID allocated to the IoT Device Host by the certifying Mobile Network Operator. Mobile Network Operators' may decide to include this field if they need a way to monitor for uncertified devices used on the network. **Type:** Host Device Unique ID **Occurrence:** One **Format:** Alphanumeric String **Name:** DevDetail/Ext/HostUniqueID **Access Type:** GET The IoT Device Host Unique ID is assigned by the Mobile Network Operator and will be stored in this node.
DID8	**Interface Between Communications Module and IoT Device Host** The Communication Module manufacturer shall provide a mechanism for the IoT Device Host to populate the information into the custom nodes (DID4 ~ DID7). It is at the Communication Module manufacturer's discretion to determine how to make the fields available to the host manufacturer to populate. This interface must be a secure interface which cannot be subject to reverse engineering or monitoring such that the content identifying the host device to cannot be compromised and potentially utilized to create cloned host devices utilizing a similar IMEI TAC range.
DID9	**Device Description Framework Submission** The Communications Module manufacturers shall submit the Device Description Framework (DDF) for the Communications Module to the Mobile Network Operator. Communications Module manufacturers shall ensure that the DevDetail, DevInfo and DM Account objects reflect the actual properties and information in use in the Communications Module.
DID10	**Device Management Bootstrap DM Server Settings** The Communications Module shall support the factory loading of DM Server settings that are required to connect to the MNO DM server. The Communications Module manufacturer shall obtain the most current values from the MNO and configure these into the module before shipping them to distribution channels. If multiple MNOs are to be supported by a common module the Communications Module supplier should implement a methodology to differentiate MNO DM server settings based on the MNO of the UICC.

DID11	**[DMBOOT] Complete Setup Option using NETWPIN** The Bootstrap process shall use NETWPIN, and devices shall not prompt the user with a confirmation prompt to complete the set up.
DID12	**[DMBOOT]- DM Accounts** Communications Modules shall support only 3 DM Accounts per MNO.
DID13	**[DMBOOT]- Expose Factory Bootstrap Account Parameters on the Device** To facilitate troubleshooting during the testing process the Communications Module manufacturer shall provide a means of exposing the factory bootstrap account parameters on the module. This shall be provided via a means to which the tester can select and read (but not modify) the parameters in each factory bootstrap account. Another means would be for the module manufacturer to provide a device utility.
DID14	**DM Client support for Nonce Resynchronization** The DM client that uses MD5 or HMAC authentication for security must support client initiated nonce resynchronization. This is required should the nonce value become stale. The module manufacturer shall use the same authentication type on the module during IOT and production server testing and throughout the life of the device.
DID15	**Device Management Protocol v1.2 or v.1.3** The Communications Module shall support all mandatory requirements of [DMPRO_1.2] or [DMPRO_1.3].
DID16	**Generic Alert—DM 1.2 or 1.3** The Communications Module shall support the generic alert capabilities specified in [DMPRO_1.2] or [DMPRO_1.3].
DID17	**Device Management Tree and Descriptions DM 1.2/1.3 - TStamp Support** In addition to the mandatory properties of nodes, the Communications Module shall also support the TStamp property.
DID18	**Device Management Tree and Descriptions DM 1.2/1.3 - VerNo Support** In addition to the mandatory properties of nodes, the Communications Module shall also support the VerNo property.
DID19	**Management Tree Requests - TNDS Attribute** The Communications Module shall support requests for a part of a management tree using the Struct attribute. Requests of the form: Get <URI>?list=TNDS where <URI> is any subset of the management tree including the root shall be supported.
DID20	**MIME Type - WBXML Encoded Management Objects** The Communications Module shall support the MIME type application/vnd.syncml.dmddf+wbxml and associated WBXML encoded management objects [DMTND_1.2] or [DMTND_1.3].

DID21	The following OMA-DM node has been defined to specify the IMEI SV for the Communications Module. Mobile Network Operators' may decide to include this field if they need a way to monitor for uncertified devices used on the network. **Type:** IMEI SV Occurrence **Occurrence:** One **Format:** Numeric String (2 digit SV) **Name:** DevDetail/Ext/IMEISV **Access Type:** GET The Communications Module IMEI is reported in DevInfo/DevId with the SV to be stored in the IMEI SV node.
DID22	**Support for Operating System Details in the Device Detail Management Object** The current Operating System details for the Communications Module shall be reported in an extension node within the Device Detail Management Object. **Type:** Operating System Name. For example: Android. **Occurrence:** One **Format:** String **Name:** DevDetail/Ext/OSName **Access Type:** GET **Type:** Operating System Version. For example: 4.4 **Occurrence:** One **Format:** Numeric String **Name:** DevDetail/Ext/OSVersion **Access Type:** GET
DID23	**or 1.3** The Communications Module shall support the DevInfo, DevDetail and DMAcc objects as mandated in [DMSTDOBJ_1.2] or [DMSTDOBJ_1.3].
DID24	**Device Management Notification—DM 1.2 or 1.3** The Communications Module shall support notification as specified in [DMNOTI_1.2] or [DMNOTI1.3]. Note that features of sections 5 and 6 of [DMNOTI_1.2] or [DMNOTI_1.3] are mandatory.
DID25	**GET Default APN** The Communications Module shall include the module default APN in the response to the OMA DM GET (device details). Note: the ModifiedTimeStamp field and value shall be included in the Extra node of each setting to indicate when the setting was modified (using UTC). If this field is absent, then the setting was not changed, and remains the factory setting.

DID26	**REPLACE Default APN** The Communications Module shall immediately replace the default APN after it has completed the OMA DM REPLACE command to replace APN, and should not require a module power cycle or reset. The default APN may have multiple instances stored in different memory areas of the module, all instances shall be replaced. APN replacement should not require user validation or acknowledgement. The new APN shall persist through power cycle. The new APN shall persist through factory reset of the device.
DID27	**ADD Default APN** Typically the Device Management server assumes the module already has management nodes for managing the default APN, so it would attempt to send a REPLACE command to replace the default APN. If that should fail, then it tries to send the ADD command with the new value of the default APN. The ADD command for the following targets should be interpreted as adding new management nodes on the module to manage the default APN. Subsequent REPLACE command to these nodes shall affect the default APN. The added management nodes do not need to persist through factory reset, but they must persist through power cycle. The APN change resulting from the ADD command shall persist through power cycle and factory reset. Adding default APN management nodes should not require user validation or acknowledgement. The add command shall take effect immediately after the command is complete, and should not require a device power cycle or device reset.
DID28	**Communications Module Initiated Update—Generic Alert** For Communications Module initiated updates, modules shall use the Generic Alert format for the update request sent to the server.
DID29	**Communications Module Initiated Session following a non-FOTA update** Communications Modules which are updated using one of the following scenarios shall automatically initiate a session with the Device Management platform to report device details from the Device Detail Management Object new device details following the update. This is needed to keep back-end systems in sync with the new device details. • Module update by sideload/USB • Module update using a proprietary OEM Device Management server The details from the Device Detail Management Object reported to the Device Management server shall include at minimum the following: • IMEI • Current Firmware version • Actual WLAN MAC address (not the default WLAN MAC address) • Original Firmware version • Previous Firmware version • Date stamp for initial activation of the device • Date stamp for last software update on the device
DID30	**Communications Module Initiated Update—Alert Type** For Communications Module initiated updates, devices shall use the OMA FUMO alert type “org.openmobilealliance.dm.firmwareupdate.devicerequest”.

DID31	**Communications Module Initiated Update—URI** For Communications Module initiated updates, the URI in the alert message sent by the module must point to the dynamic node representing a single firmware update management object in the tree.
DID32	**Communications Module Initiated Update—Data** For module initiated updates, the data element shall be included in the alert message to indicate the implementation details.
DID33	**Support Secure Technology for End-2-End Connections in DHIR** **Summary:** The secure connection technology must meet contemporary and evolving requirements for authentication and data privacy over the targeted end-to-end connection within the scope of this requirement. • Authentication of the server by the client device must be supported by way of X.509 public key technologies, commonly known as “certificates”. • Authentication of the client by the server is permitted. • Secure transport protocol must include TLS 1.0 and TLS 1.1. o Secure transport protocol support for TLS 1.2 is strongly recommended • Secure transport protocol should not support any version of SSL. • The cipher suite used for data encryption should be based on contemporary, strong ciphers as commonly supported in TLS 1.0 or greater o Support for TLS 1.2 is strongly recommended. • Certificates may be issued by a certificate authority of the carrier’s choice. • Certificates should abide by contemporary standards for signature strength. • No IP address shall be used in the bootstrap account for the server URL Only FQDN shall be used in the bootstrap account for the server URL for an https connection

6 IoT Service Provider Requirements (Normative Section)

MCR1	If permissible for the IoT Service, any IoT Service Platform which communicates to multiple IoT Devices shall avoid synchronized behaviour and employ a randomized pattern for accessing the IoT Devices within the IoT Service Platform's domain.
MCR2	If the (U)SIM subscription associated with an IoT Device is to be placed in a temporarily inactive state (i.e. the subscription is to be disabled for a fixed period of time), the IoT Service Provider shall first ensure that the IoT Device is temporarily disabled to restrict the device from trying to register to the network once the SIM is disabled. Before the (U)SIM subscription associated with an IoT Device is changed to a permanently terminated state, the IoT Service Provider shall ensure that the IoT Device is permanently disabled to stop the device from trying to register to the network once the SIM is permanently disabled. Note: The IoT Service Provider should carefully consider permanently terminating IOT devices which are not easily serviceable as it would require manual intervention (i.e. a service call) to re-enable the IoT Device.
MCR3	If the IoT Service Platform uses SMS triggers to wake up its IoT Devices, the IoT Service Platform should avoid sending multiple SMS triggers when no response is received within a certain time period.
MCR4	The IoT Service Platform should be aware of the state of the IoT Device and only send 'wake up' triggers when the IoT Device is known to be attached to the mobile network.
MCR5	The IoT Service Platform should authenticate the IoT Device prior to data communication. The strength of authentication used should be appropriate to the IoT Service

7 Connection Efficiency Requirements (Normative Section)

This section contains a set of non-standardised features which, when implemented within the Communications Module, will help protect the mobile network from signalling overload.

CER1	The Communications Module shall correctly observe the cause codes sent in reject messages from the network in response to service requests sent from the IoT Device. If the network denies a service request with a reject message the IoT Device Application shall assess the reject cause code and, if appropriate, a retry may be attempted. The Communications Module shall support the cause code behaviour described in section 7.5. Namely: • IoT Devices shall not retry a service request that has been rejected by the network with a reject cause code related to IoT Device identification. The causes related to device and (U)SIM subscription identification are defined in 3GPP TS 24.008 Annex G.1 [12]. • IoT Devices shall not attempt to use a service and/or network for which it is not subscribed. • IoT devices shall not re-attempt a service request until the Network has responded to the previous attempted service request or the appropriate timer has expired in the IoT Device for the procedure as defined by the 3GPP specifications [1].
CER2	The Communications Module shall support Network Friendly Mode as described in section 7.1
CER3	Dependent upon the IoT Service requirements, IoT Devices shall minimize reattempted service requests using time-spaced, randomized and exponentially delayed retry schemas. • The Communications Module shall support Back-Off Trigger as described in section 7.2 • The Communications Module shall support Back-Off Timer as described in section 7.3
CER4	The Communications Module shall support the logic flow described in section 7.4

7.1 Network Friendly Mode

Network Friendly Mode is a non-standardised feature of the Communications Module that polices the amount of times the Communications Module can perform IMSI attach, GPRS attach, PDP Context activation and SMS-MO in order to reduce the amount of MSUs generated towards the HPLMNs HLR, SMSC or GGSN.

NFM1	The Communications Module shall allow the IoT Device Application to switch the Network Friendly Mode on and off using an AT-command. In addition, the module shall allow the application to switch the start timer on and off using the same command. Start timer can be used for e.g. smart metering applications to spread network wake-up attempts. • Example: AT+NFM=[<NFM Active>[,<Start Timer Active>]] • Example response: OK to indicate success or ERROR to indicate that something went wrong. <NFM Active> • 0 - Deactivated • 1 - Active <Start Timer Active> • 0 – Disable Start Timer • 1 – Enable Start Timer Start Timer: • Start Timer applies only if active (<Start Timer Active > is 1). • If Start Timer is enabled the Start Timer will be started at every power cycle and the registration procedures will be allowed only at Start Timer expiry.
NFM2	The Communications Module shall allow the IoT Device Application to query for a report of the currently stored parameters <NFM Active> and <Start Timer Active> using an AT command. • Example: AT+NFM? • Example response: +NFM: <NFM Active>,<Start Timer Active>
NFM3	The Back-off Base Interval is the time between re-attempts of whatever action previously failed. The Back-off Base Intervals shall be interpreted by the Communications Module as an amount of seconds.

NFM4	The Communications Module shall allow the IoT Device Application to configure the Back-off Base Intervals using an AT-command. - Example:AT+NFMC=[<NFMPar1>[,<NFMPar2>[,<NFMPar3>[,<NFMPar4>[,<NFMPar5>[,<NFMPar6>[,<NFMPar7>[,<STPar>]]]]]]]] Parameters: - <NFMPar1> - NFM iteration counter 1 time interval in seconds 1-15360 – (default is 60); - <NFMPar2> - NFM iteration counter 2 time interval in seconds 1-15360 – (default is 120); - <NFMPar3> - NFM iteration counter 3 time interval in seconds 1-15360 – (default is 240); - <NFMPar4> - NFM iteration counter 4 time interval in seconds 1-15360 – (default is 480); - <NFMPar5> - NFM iteration counter 5 time interval in seconds 1-15360 – (default is 960); - <NFMPar6> - NFM iteration counter 6 time interval in seconds 1-15360 – (default is 1920); - <NFMPar7> - NFM iteration counter 7 time interval in seconds 1-15360 – (default is 3840); - <STPar> - ST time interval in seconds 1-15360 – (default is 60); Start Timer: - If STPar is the number contained in the parameter <STPar> then the value of the ST timer is calculated with the following formula Start Timer = 1 + (IMSI % STPar)
NFM5	The Back-off Base Intervals should be implemented within the Communications Module an array or vector able to store a set of minimum seven (7) four (4) digit numbers.
NFM6	If the IoT Device Application sends an AT-command (requesting IMSI attach/GPRS attach/PDP Context Activation/SMS-MO) to the Communications Module during the countdown of the Back-off Timer, the Communications Module shall ignore the command and send an error message to the IoT Device Application that includes the time left of the Back-off Timer.
NFM7	If a power-cycle of the Communications Module is performed while the Back-off Timer is counting down, the countdown will re-start. It should be possible (i.e. when the Communications Module undergoes a soft reset), that the Back-off Timer will persist its state so that it can restart from that persisted state instead of restarting from the beginning.

NFM8	The Communications Module shall allow the IoT Device Application to query for a report of the supported range of values for parameters <NFM Active> and <Start Timer> using an AT command. • Example: AT+NFM=?
NFM9	The Communications Module shall allow the IoT Device Application to query for a report of the currently stored parameters using an AT command. • Example: AT+NFMC? • Example response: +NFM: <NFMPar1>,<NFMPar2>,<NFMPar3>,<NFMPar4>,<NFMPar5>,<NFMPar6>,<NFMPar7>,<STPar>
NFM10	The Communications Module shall allow the IoT Device Application to query for a report of the supported range of values for parameters <NFMPar1>, <NFMPar2>, <NFMPar3>, <NFMPar4>, <NFMPar5>, <NFMPar6>, <NFMPar7> and <STPar> using an AT command. • Example: AT+NFMC=?

7.2 Back - Off Triggers

BTR1	The Communications Module shall police the frequency of attempts per timeframe to perform IMSI attach and enable the Back-off Timer Flag if the attempt fails. The Back-off Timer Flag indicates whether the Back-off has been triggered or not
BTR2	The Communications Module shall police the frequency of attempts per timeframe to perform network attach and enable the Back-off Timer Flag if the attempt fails.
BTR3	The Communications Module shall police the frequency of attempts per timeframe to perform PDP Context activation and enable the Back-off Timer Flag if the attempt fails.
BTR4	The Communications Module shall police the frequency of attempts per timeframe to perform SMS-MO and enable the Back-off Timer Flag if the attempt fails.

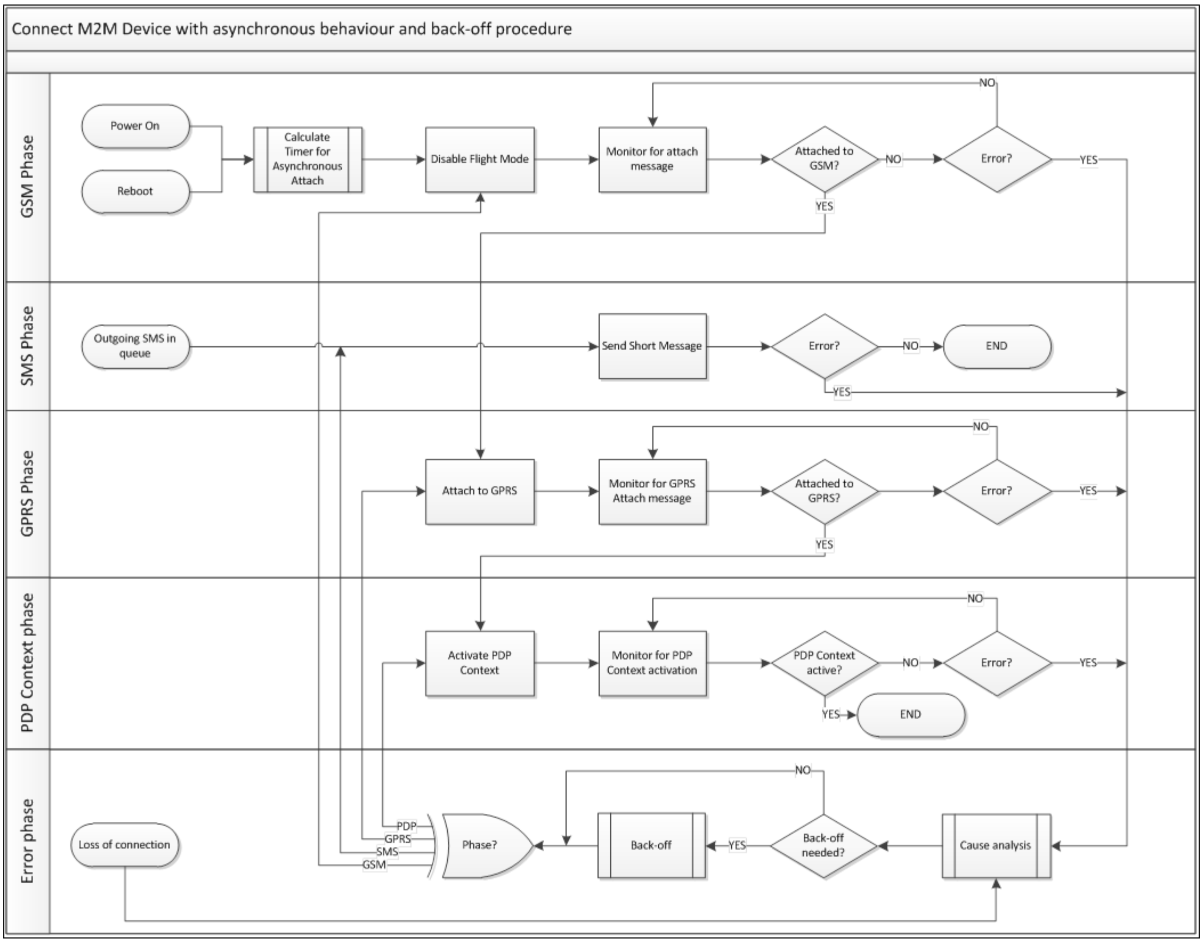
7.3 Back - Off Timer

The Back-off Timer is a dynamic timer with a value is based on a unique value for the device (desirably the IMSI) and the number of consecutive failures (which points to different Back-off Base Intervals).

BTI1	The Communications Module shall have a Network Friendly Mode Flag that indicates its state; • 0 = Deactivated • 1 = Activated

BTI2	The Network Friendly Mode Flag within the Communications Module shall persist through a power cycle.
BTI3	The Communications Module shall have a Back-off Timer Flag that indicate its state; • 0 = Deactivated • 1 = Activated
BTI4	The Back-off Timer Flag within the Communications Module shall persist through a power cycle.
BTI5	The Communications Module shall have a Back-off Iteration Counter that indicates how many failed attach/activation/send attempts have been made. The Back-off Iteration Counter is a counter of current amount of consecutive failures.
BTI6	The Back-off Iteration Counter shall persist through a power cycle.
BTI7	If a reattempt succeed the Back-off Timer shall be reset and the Back-off Iteration Counter shall be reset to 0 (zero).
BTI8	The Communications Module shall use the Back-off Iteration Counter to select the correct Back-off Base Interval.
BTI9	The Communications Module shall calculate the Back-off Timer through the formula: • Timer = Base Interval[Iteration Counter] + (IMSI % Base Interval[Iteration Counter])
BTI10	The Communications Module shall use as many digits from the end of the IMSI as there are digits in the Back-off Base Interval of the Back-off Iteration Counter currently being calculated.
BTI11	The Communications Module should use the time during a Back-off Timer countdown to calculate the next Back-off Timer.
BTI12	The Communications Module shall expire an ongoing Back-off Timer and reset Back-off Iteration Counter if an AT-command is sent to set the Back-off Timer Flag to 0 (zero).

7.4 Logic Flow for Back Off Procedure



7.5 IoT Device Action Linked to Cause Code

The following table contains a list of GSM/UMTS cause codes and proposed actions. LTE cause codes will be added in a future release of this document.

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	GMM cause	SM Cause Code	RP cause code	CP cause code	CME ERROR	CMS ERROR	Cause	Reason	Proposed action (if different from 3GPP TS 24.008)
2							IMSI unknown in HLR	This cause is sent to the device if the device is not known (registered) in the HLR. This cause code does not affect operation of the GPRS service, although it may be used by a GMM procedure.	The Communications Module shall perform a GSM Attach 'Back-off', as defined in section 7 of this document, at next power cycle
	2						IMSI unknown in HLR (NOM1 only)	This cause is sent to the device if the device is not known (registered) in the HLR. This cause code does not affect operation of the GPRS service, although it may be used by a GMM procedure.	The Communications Module shall perform a GSM and GPRS Attach 'Back-off', as defined in section 7 of this document, at next power cycle
3					103		Illegal device	This cause is sent to the device when the network refuses service to the device either because an identity of the device is not acceptable to the network or because the device does not pass the authentication check, i.e. the SRES received from the device is different from that generated by the network.	The Communications Module shall perform a GSM Attach 'Back-off', as defined in section 7 of this document, at next power cycle
	3				106		Illegal device	This cause is sent to the device when the network refuses service to the device either because an identity of the device is not acceptable to the network or because the device does not pass the authentication check, i.e. the SRES received from the device is different from that generated by the network.	The Communications Module shall perform a GSM and GPRS Attach 'Back-off', as defined in section 7 of this document, at next power cycle
4							IMSI unknown in VLR	This cause is sent to the device when the given IMSI is not known at the VLR.	As per 3GPP specifications.
5							IMEI not accepted	This cause is sent to the device if the network does not accept emergency call establishment	The Communications Module shall perform the 'Back-off', as defined in section 7 of this

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	**GMM cause**	**SM Cause Code**	**RP cause code**	**CP cause code**	**CME ERROR**	**CMS ERROR**	**Cause**	**Reason**	**Proposed action (if different from 3GPP TS 24.008)**
								using an IMEI.	document, at next power cycle
6					106		Illegal ME	This cause is sent to the device if the ME used is not acceptable to the network, e.g. blacklisted.	The Communications Module shall perform a GSM 'Back-off', as defined in section 7 of this document, at next power cycle
	6				106		Illegal ME	This cause is sent to the device if the ME used is not acceptable to the network, e.g. blacklisted.	The Communications Module shall perform a GSM and GPRS Attach 'Back-off', as defined in section 7 of this document, at next power cycle
	7				107		GPRS Services Not Allowed	This cause is sent to the device if it requests an IMSI attach for GPRS services, but is not allowed to operate GPRS services.	The Communications Module shall perform a GPRS Attach 'Back-off', as defined in section 7 of this document, at next power cycle
8	8						GPRS services and non-GPRS services not allowed	This cause is sent to the device if it requests a combined IMSI attach for GPRS and non-GPRS services, but is not allowed to operate either of them.	The Communications Module shall perform a GSM and GPRS Attach 'Back-off', as defined in section 7 of this document, at next power cycle
9	9						Device identity cannot be derived by the network	This cause is sent to the device when the network cannot derive the device's identity from the P-TMSI in case of inter-SGSN routing area update.	The Communications Module shall perform a GSM and GPRS Attach 'Back-off', as defined in section 7 of this document, at next power cycle
	10						Implicitly detached	This cause is sent to the device either if the network has implicitly detached the device, e.g. some while after the Mobile reachable timer has expired, or if the GMM context data related to the subscription does not exist in the SGSN e.g. because of a SGSN restart.	As per 3GPP specification
11	11				111		PLMN not allowed	This cause is sent to the device if it requests location updating in a PLMN where the device, by subscription or due to operator determined barring is not allowed to operate.	The Communications Module should not retry the attach attempt on the same PLMN unless prompted externally to do so (i.e. the Communications Module should not automatically retry in the same PLMN).
12	12				112		Location Area not allowed	This cause is sent to the device if it requests location updating in a location area where the device, by subscription, is not allowed to	The Communications Module should not retry the attach attempt on the same LA unless prompted externally to do so (i.e. The

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	**GMM cause**	**SM Cause Code**	**RP cause code**	**CP cause code**	**CME ERROR**	**CMS ERROR**	**Cause**	**Reason**	**Proposed action (if different from 3GPP TS 24.008)**
								operate.	Communications Module should not automatically retry in the same LA).
13	13				113		Roaming not allowed in this location area	This cause is sent to a device which requests location updating in a location area of a PLMN which restricts roaming to that device in that Location Area, by subscription.	The Communications Module should not retry the attempt on the same LA unless prompted externally to do so (i.e. modem should not automatically retry in the same LA).
	14						GPRS services not allowed in this PLMN	This cause is sent to the device which requests GPRS service in a PLMN which does not offer roaming for GPRS services to that device.	The Communications Module should not retry the attempt on the same PLMN unless prompted externally to do so (i.e. modem should not automatically retry in the same PLMN).
15	15						No Suitable Cells In Location Area		The Communications Module should not retry the attempt on the same cell unless prompted externally to do so (i.e. Communications Module should not automatically retry in the same cell).
	16						MSC temporarily not reachable (NOM 1 only)	This cause is sent to the device if it requests a combined GPRS attach or routing are updating in a PLMN where the MSC is temporarily not reachable via the GPRS part of the GSM network.	The Communications Module shall perform the ‘Back-off’, as defined in section 7 of this document, at next power cycle
17	17				615		Network failure	This cause is sent to the device if the MSC cannot service a device generated request because of PLMN failures, e.g. problems in MAP.	The Communications Module shall perform the ‘Back-off’, as defined in section 7 of this document, at next power cycle
20	20						MAC failure	This cause is sent to the network if the (U)SIM detects that the MAC in the authentication request message is not fresh	As per 3GPP specifications
21	21						Sync failure	This cause is sent to the network if the (U)SIM detects that the SQN in the authentication request message is out of range	As per 3GPP specifications
22	22				42		Congestion	This cause is sent if the service request cannot be preceded because of congestion (e.g. no	The Communications Module shall perform the ‘Back-off’, as defined in section 7 of this

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	**GMM cause**	**SM Cause Code**	**RP cause code**	**CP cause code**	**CME ERROR**	**CMS ERROR**	**Cause**	**Reason**	**Proposed action (if different from 3GPP TS 24.008)**
								channel, facility busy/congested etc.)	document, at next power cycle
23							GSM authentication unacceptable	This cause is sent to the network in UMTS if the MS supports the UMTS authentication algorithm and there is no Authentication Parameter AUTN IE present in the AUTHENTICATION REQUEST message	As per 3GPP specifications
32					132		Service Option Not Supported	This cause is sent when the device requests a service/facility in the CM SERVICE REQUEST message which is not supported by the PLMN.	As per 3GPP specifications
33					133		Requested Service Option Not Subscribed	This cause is sent when the device requests a service option for which it has no subscription.	As per 3GPP specifications
34					134		Service option temporarily out of order	This cause is sent when the MSC cannot service the request because of temporary outage of one or more functions required for supporting the service.	The Communications Module shall perform the ‘Back-off’, as defined in section 7 of this document, at next power cycle
38							Call Cannot be identified	This cause is sent when the network cannot identify the call associated with a call re-establishment request.	As per 3GPP specifications
40							No PDP context activated	This cause is sent to the device if the device requests an establishment of the radio access bearers for all active PDP contexts by sending a SERVICE REQUEST message indicating "data" to the network, but the SGSN does not have any active PDP context(s).	As per 3GPP specifications
All other MM codes	All other GMM codes								As per 3GPP specifications
		8					Operator determined barring	This cause indicates that the device has tried to send a mobile originating short message when the device's network operator or service provider has forbidden such transactions.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	GMM cause	SM Cause Code	RP cause code	CP cause code	CME ERROR	CMS ERROR	Cause	Reason	Proposed action (if different from 3GPP TS 24.008)
									Communications Module via AT commands.
		26					Insufficient resources	This cause code is used by the device or by the network to indicate that a PDP Context activation request or PDP Context modification request cannot be accepted due to insufficient resources	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands.
		27			134		Unknown or missing access point name	This cause code is used by the network to indicate that the requested service was rejected by the external packet data network because the access point name was not included although required or if the access point name could not be resolved.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands
		28					Unknown PDP address or PDP type	This cause code is used by the network to indicate that the requested service was rejected by the external packet data network because the PDP address or type could not be recognized.	The Communications Module shall perform a GPRS re-attach (i.e. the Communications Module shall perform a GPRS detach followed by a GPRS attach)
		29			149		User authentication failed	This cause code is used by the network to indicate that the requested service was rejected by the external packet data network due to a failed user authentication (e.g. rejected by Radius)	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands.
		30					Activation rejected by GGSN	This cause code is used by the network to indicate that the requested service was rejected by the GGSN.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands.
		31					Activation rejected, unspecified	This cause code is used by the network to indicate that the requested service was rejected due to unspecified reasons.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands.

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	**GMM cause**	**SM Cause Code**	**RP cause code**	**CP cause code**	**CME ERROR**	**CMS ERROR**	**Cause**	**Reason**	**Proposed action (if different from 3GPP TS 24.008)**
		32			132		Service option not supported	This cause code is used by the network when the device requests a service which is not supported by the PLMN or the APN is invalid.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands.
		33			133		Requested service option not subscribed	This cause is sent when the device requests a service option for which it has no subscription. The difference between this and CMEE 132 is that the network may support the requested option, but the user is not subscribed to that option.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands.
		34			134		Service option temporarily out of order	This cause is sent when the MSC\SGSN cannot service the request because of temporary outage of one or more functions required for supporting the service.	If a second mobile network is available, the Communications Module shall attempt to connect via the alternate mobile network. If no other mobile network is available, the communications module shall all perform a Back-off, as per section 7 of this document.
		35					NSAPI already used	This cause code is used by the network to indicate that the NSAPI requested by the device in the PDP Context activation is already used by another active PDP Context of this device.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the Communications Module via AT commands
		36					Regular PDP Context deactivation	This cause code is used to indicate a regular device or network initiated PDP Context deactivation.	If the Communications Module has not requested the PDP context deactivation it is likely this is due to idle timeout. Immediate reactivation of PDP Context by the Communications Module is OK.
		37					QoS not accepted	This cause code is used by the device if the new QoS cannot be accepted that were indicated by the network in the PDP Context Modification procedure.	As per 3GPP specifications
		38			615		Network Failure	This cause code is used by the network to indicate that the PDP Context deactivation is caused by an error situation in the network.	The Communications Module shall perform a Session Management Back-off, as per section 7 of this document, blocking immediately any new service requests sent by to the

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	GMM cause	SM Cause Code	RP cause code	CP cause code	CME ERROR	CMS ERROR	Cause	Reason	Proposed action (if different from 3GPP TS 24.008)
									Communications Module via AT commands
		39					Reactivation requested	This cause code is used by the network to request a PDP Context reactivation after a GGSN restart.	The Communications Module may re-establish the PDP Context immediately, but upon failure go to back-off.
		40					Feature not supported	This cause code is used by the device to indicate that the PDP Context activation initiated by the network is not supported by the device.	As per 3GPP specifications
		43					Unknown PDP context	This cause code is used by the network or the device to indicate that the PDP context identified by the Linked TI IE in the secondary PDP context activation request or a network requested secondary PDP context activation is not active.	As per 3GPP specifications
		56					Collision with network initiated request	This cause code is used by the network to indicate that the device-initiated request was rejected since the network has requested a secondary PDP context activation for the same service using a network-initiated procedure.	As per 3GPP specifications
		112					APN restriction value incompatible with active PDP context	This cause code is used by the network to indicate that the PDP context(s) or MBMS context(s) have an APN restriction value that is not allowed in combination with a currently active PDP context.	As per 3GPP specifications
			8			8	Operator determined barring	This cause indicates that the device has tried to send a mobile originating short message when the device's network operator or service provider has forbidden such transactions.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			10			10	Call barred	This cause indicates that the outgoing call barred service applies to the short message service for the called destination.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	**GMM cause**	**SM Cause Code**	**RP cause code**	**CP cause code**	**CME ERROR**	**CMS ERROR**	**Cause**	**Reason**	**Proposed action (if different from 3GPP TS 24.008)**
			21			21	Short message transfer rejected	This cause indicates that the equipment sending this cause does not wish to accept this short message, although it could have accepted the short message since the equipment sending this cause is neither busy nor incompatible.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			22			27	Destination out of service	This cause indicates that the destination indicated by the Device cannot be reached because the interface to the destination is not functioning correctly. The term "not functioning correctly" indicates that a signalling message was unable to be delivered to the remote user; e.g., a physical layer or data link layer failure at the remote user, user equipment off-line, etc.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			28			28	Unidentified subscriber	This cause indicates that the subscriber is not registered in the PLMN (i.e. IMSI not known).	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			29			29	Facility rejected	This cause indicates that the facility requested by the Device is not supported by the PLMN.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			30			30	Unknown subscriber	This cause indicates that the subscriber is not registered in the HLR (i.e. IMSI or directory number is not allocated to a subscriber).	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			38			38	Network out of order	This cause indicates that the network is not functioning correctly and that the condition is likely to last a relatively long period of time; e.g., immediately reattempting the short message transfer is not likely to be successful.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	**GMM cause**	**SM Cause Code**	**RP cause code**	**CP cause code**	**CME ERROR**	**CMS ERROR**	**Cause**	**Reason**	**Proposed action (if different from 3GPP TS 24.008)**
			41			41	Temporary failure	This cause indicates that the network is not functioning correctly and that the condition is not likely to last a long period of time; e.g., the Device may wish to try another short message transfer attempt almost immediately.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			42			42	Congestion	This cause indicates that the short message service cannot be serviced because of high traffic.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			47			47	Resources unavailable, unspecified	This cause is used to report a resource unavailable event only when no other cause applies.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			50			50	Requested facility not subscribed	This cause indicates that the requested short message service could not be provided by the network because the user has not completed the necessary administrative arrangements with its supporting networks.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			69			69	Requested facility not implemented	This cause indicates that the network is unable to provide the requested short message service.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
			81			81	Invalid short message transfer reference value	This cause indicates that the equipment sending this cause has received a message with a short message reference which is not currently in use on the MS-network interface.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
				17			Network failure	This cause is sent to the MS if the MSC cannot service an MS generated request because of PLMN failures, e.g. Problems in MAP.	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.

For Communication Module Manufacturers					For IoT Device Application Developers				
MM Cause Code	GMM cause	SM Cause Code	RP cause code	CP cause code	CME ERROR	CMS ERROR	Cause	Reason	Proposed action (if different from 3GPP TS 24.008)
				21			Congestion	This cause is sent if the service request cannot be actioned because of congestion (e.g. no channel, facility busy/congested, etc.).	The Communications Module shall perform an SMS Back-off, as per section 7 of this document, blocking immediately any new SMS TX requests sent to the Communications Module via AT commands.
					148		Unspecified GPRS error		As per 3GPP specifications

8 Radio Policy Manager Requirements (Normative Section)

This section contains a set of non-standardised features which, when implemented within the Communications Module, will help protect the mobile network from signalling overload.

8.1 Overview

Radio Policy Manager (RPM) objectives are as follows:

- Protect the Network by performing “Connection Aggression Management” which is necessary when the device is aggressively trying to access the network following various NAS reject scenarios
- Enhance Device Operation by making sure the device is back to normal operating mode following a network failure/reject scenario.

8.2 Radio Policy Manager Requirements

8.2.1 General

RPG1	**Default RPM Parameter Settings** The Radio Baseband Chipset shall use default RPM parameter settings (see RTC10) saved within the Communication Module Firmware when RPM parameters are not present on UICC.
RPG2	**RPM Activation Control – (U)SIM Present, RPM Parameters Present** If the UICC contains RPM parameters, RPM functionality shall be enabled/disabled within the Radio Baseband Chipset based on the setting of the parameter “RPM_ Flag” on the UICC. Note***:*** UICC based RPM parameters, if present, shall take precedence over any Communication Module Firmware based RPM parameters.
RPG3	**RPM Activation Control – (U)SIM Present, RPM Parameters Not Present** If the UICC does not contain the RPM parameters, RPM functionality shall be enabled/disabled based on the default setting of the parameter “RPM_ Flag” saved within the Communications Module Firmware.
RPG4	**RPM Activation Control - Roaming Status** The enabling/disabling of RPM functionality within the Radio Baseband Chipset shall be independent of whether the IoT Device is roaming or not.
RPG5	**RPM Parameter Reconfiguration** All RPM parameters shall be reconfigurable as per RTC7 “RPM Parameters Remote Management”, RTC8 “RPM (U)SIM Parameters” and RTC9 ”RPM (U)SIM Parameter Updates”.

RPG6	**RPM Version Implemented** At each power up, the Radio Baseband Chipset shall write “RPM version Implemented” to file “EF-RPM Version Implemented” on the (U)SIM card. The update to this file should be done as early as possible in the power up process. The current version of RPM specified in this document is 2, (i.e. the Radio Baseband Chipset will write 2 to file “EF-RPM Version Implemented” if its implementation of RPM complies with this version of the requirement). The version number will be updated when new version of RPM requirement is released.

8.2.2 Mobility Management

RMM1	**RPM Operation Management Counters** RPM Operation Management Counters (C-BR-1, C-R-1, and C-PDP-1 to C-PDP-4) are used to assist monitoring and debugging RPM operation issues. These counters are saved in the (U)SIM. Functionalities related to RPM Operation Management Counters shall be disabled if RPM parameters are not present on the (U)SIM.
RMM2	**Reset RPM Operation Management Counters** All RPM Operation Management counters shall be reset to 0 if “RPM parameters” or “RPM Operational Management Counters Leak Rate” is updated by OTA. Note: This can be determined from the FILE LIST TLV object in the REFRESH command.
RMM3	**Control Number of Reset** In permanent MM/GMM/EMM reject scenarios described in RMM6 “Handling of “Permanent” MM/GMM/EMM Reject”, RPM shall allow up to N1 application initiated software resets per hour. This requirement shall be disabled if N1 is set to 0. Note: RPM initiated resets shall be excluded from N1. User initiated hardware resets shall always be allowed and excluded from N1. EMM Reject causes are only applicable to E-UTRAN capable devices.
RMM4	**Increment Counter C-BR-1** RPM shall increment counter C-BR-1 by 1 for every reset that it denies access to the mobile network triggered by requirement RMM3. The counter shall not roll over. (i.e. 0xFF+1=0xFF).
RMM5	**Reset Counter/timer Related to N1** UE internal counter/timer related to N1 shall be reset when UE successfully registers on CS & PS domain. C-BR-1 shall not be reset.

RMM6	**Handling of “Permanent” MM/GMM/EMM Reject** RPM shall wait for time T1 and reset the Radio Baseband Chipset when the following “permanent” MM/GMM/EMM reject causes are received: • MM Reject Cause # 2 (IMSI Unknown in HLR) • MM Reject Cause # 3 (Illegal MS) • MM Reject Cause # 6 (Illegal ME) • GMM Reject Cause # 2 (IMSI Unknown in HLR) • GMM Reject Cause # 3 (Illegal MS) • GMM Reject Cause # 6 (Illegal ME) • GMM Reject Cause # 7 (GPRS Services not allowed) • GMM Reject Cause # 8 (GPRS Services and Non-GPRS Services not allowed) • EMM Reject Cause #2 (IMSI unknown in HSS) • EMM Reject Cause #3 (Illegal UE) • EMM Reject Cause #6 (Illegal ME) • EMM Reject Cause #8 (EPS services and non-EPS services not allowed) • EMM Reject Cause #7 (EPS services not allowed) This requirement shall be disabled if T1 is set to 0. Note: Timer shall not be re-started if an instance of the same timer is already running. EMM Reject causes are only applicable to E-UTRAN capable Radio Baseband Chipsets.
RMM7	**Increment Counter C-R-1** RPM shall increment counter C-R-1 by 1 when reset is triggered by T1. The counter shall not roll over.
RMM8	**Stop Timer Related to T1** UE internal timer related to T1 shall be stopped when UE is reset (hardware or software). In other words, RPM shall not reset the Radio Baseband Chipset if it is already reset by the IoT Device Application or Communications Modem.
RMM9	**Handling of Location Update Ignore** If Location Update Request is ignored by network, RPM shall ensure that any PS related service request from IoT Device Application will not trigger additional Location Update Request on top of requests that would have been sent by the Communications Module without the service request.
RMM10	**Handling of Attach Request Ignore** If Attach Request is ignored by network, RPM shall ensure service request from IoT Device Application will not trigger additional Attach Request on top of requests that would have been sent by Communications Module without the service request.

8.2.3 Session Management

RSM1	**Handling of PDP Context Activation Request Ignore** If RPM determines that a PDP Context Activation Request has been ignored by the network, RPM shall use back-off algorithm to ensure that no more than F1 PDP Context Activation Requests are sent to the same APN every hour. See RSM7 “Minimum Requirement of Back-off Algorithm in PDP Context Activation Reject/Ignore Scenarios” for the minimum requirement of the back-off algorithm. This requirement shall be disabled if F1 is set to 0.
RSM2	**Increment Counter C-PDP-1** RPM shall increment counter C-PDP-1 by 1 when PDP Context Activation Request is ignored by RPM because of requirement RSM1 “Handling of PDP Context Activation Request Ignore”. The counter shall not roll over.
RSM3	**Handling “Permanent” SM Reject Causes** If PDP context activation is rejected with the following “permanent” reject causes: • #8 (Operator Determined Barring) • #27 (Missing or Unknown APN) • #28 (Unknown PDP Address or PDP type) • #29 (User Authentication Failed) • #30 (Activation Rejected by GGSN) • #32 (Service Option Not Supported) • #33 (Requested Service Option Not Subscribed) RPM shall use back-off algorithm to ensure that no more than F2 PDP Context Activation Requests are sent to the same APN every hour. See RSM7 “Minimum Requirement of Back-off Algorithm in PDP Context Activation Reject/Ignore Scenarios” for the minimum requirement of the back-off algorithm. This requirement shall be disabled if F2 is set to 0.
RSM4	**Increment Counter C-PDP-2** RPM shall increment counter C-PDP-2 by 1 when PDP Context Activation Request is ignored by RPM because of requirement RSM3 “Handling “Permanent” SM Reject Causes”. The counter shall not roll over.

RSM5	**Handling "Temporary" SM Reject Causes** If PDP context activation is rejected with the following "temporary" reject causes: • #25 (LLC or SNDCP failure) • #26 (Insufficient resources) • #31 (Activation Rejected, Unspecified) • #34 (Service option temporarily out of order) • #35 (NSAPI already used) • #38 (Network failure) • #102 (No response, timeout) • #111 (Protocol error, unspecified) RPM shall use back-off algorithm to ensure that no more than F3 PDP Context Activation Requests are sent to the same APN every hour. See RSM7 "Minimum Requirement of Back-off Algorithm in PDP Context Activation Reject/Ignore Scenarios" for the minimum requirement of the back-off algorithm. This requirement shall be disabled if F3 is set to 0.
RSM6	**Increment Counter C-PDP-3** RPM shall increment counter C-PDP-3 by 1 when PDP Context Activation Request is ignored by RPM because of requirement RSM5 "Handling "Temporary" SM Reject Causes". The counter shall not roll over.
RSM7	**Minimum Requirement of Back-off Algorithm in PDP Context Activation Reject/Ignore Scenarios** The back-off algorithm shall be used to ensure that no more than Fx PDP Context Activation Requests are sent to the same APN within 1 hour. Assuming enough PDP Context Activation Requests are received by RPM, the back-off algorithm shall allow at least MAX (0.05*Fx, 1) of PDP Context Activation Requests to be sent to the same APN within each 15 minutes window. Ideally the back-off algorithm will come to a steady state after 1 hour. The goal of the algorithm is to avoid excessive number of network connection attempts within short timeframe and at the same time to allow reasonable number of network connection attempts to pass through in order to restore service. This is especially important for IoT Devices that are deployed remotely without easy access by the End Customer or the Mobile Network Operator. Note*:* Fx is the upper limit for the number of requests that the back-off algorithm should allow in an hour. It is OK (more desirable) if the actual number of requests allowed is less than that.
RSM8	**PDP Context Activation/Deactivation Management** RPM shall allow no more than F4 PDP Context Activation Requests each followed by a PDP Context Deactivation Request to be sent to the same APN within one hour (i.e. F4 PDP Context Activation/ Deactivation pairs per hour). After the limit F4 is reached, RPM shall ignore subsequent PDP Context Activation Requests to the same APN. This requirement shall be disabled if F4 is set to 0.

RSM9	**Increment Counter C-PDP-4** RPM shall increment counter C-PDP-4 by 1 when PDP Context Activation Request is ignored by RPM because of requirement RSM8 “PDP Context Activation/Deactivation Management”. The counter shall not roll over.

8.2.4 Timers and Counters

RTC1	**RPM Timer Values** Value of RPM parameter T1 shall be within a time window of [-10%, +10%] of the average value specified in default parameters stored in the Communications Module and on the (U)SIM card.
RTC2	**Reset Timers/counters In PDP Reject/ignore Requirements** The Radio Baseband Chipset’s internal timers/counters in PDP reject/ignore requirements shall be reset after a PDP context is successfully activated.
RTC3	**RPM Behaviour upon (U)SIM Change** All RPM parameters should be reset upon UICC change. Determination of UICC change should be based on ICCID.
RTC4	**Periodic Decrement of RPM Operation Management Counter C-BR-1** If LR-1 is NOT 0, C-BR-1 shall be decremented by 1 every LR-1 hours if C-BR-1 is greater than 0. C-BR-1 shall never be negative. C-BR-1 shall not be decremented if LR-1 is 0.
RTC5	**Periodic Decrement of RPM Operation Management Counter C-R-1** If LR-2 is NOT 0, C-R-1 shall be decremented by 1 every LR-2 hours if C-R-1 is greater than 0. C-R-1 shall never be negative. CR-1 shall not be decremented if LR-2 is 0.
RTC6	**Periodic Decrement of RPM Operation Management Counter C-PDP-1 to C-PDP-4** If LR-3 is NOT 0, C-PDP-1/C-PDP-2/C-PDP-3/C-PDP-4 shall be decremented by 1 every LR-3 hours if C-PDP-1/C-PDP-2/CPDP- 3/C-PDP-4 is greater than 0. C-PDP-1/C-PDP-2/C-PDP-3/CPDP- 4 shall never be negative. C-PDP-1/C-PDP-2/C-PDP-3/C-PDP-4 shall not be decremented if LR-2 is 0
RTC7	**RPM Parameters Remote Management** Mobile Network Operators will use their (U)SIM OTA mechanism to manage RPM parameters remotely. The Communication Module based RPM parameters shall not be managed by the Mobile Network Operator.

<table>
<tr><td><b>RTC8</b></td><td><b>RPM (U)SIM Parameters</b>
The following RPM parameters shall be present on the Mobile Network Operator’s (U)SIMs (see RPG2 “RPM Activation Control – (U)SIM Present, RPM Parameters Present”) as follows:<ul><li>DF-ARMED AGENT - 3F00/7F66/5F40 (linked file to ADF (USIM)/7F66/5F40)</li><li>EF-RPM Enabled Flag - 3F00/7F66/5F40/4F40 (linked file to ADF (USIM)/7F66/5F40/4F40)</li><li>EF-RPM Parameters - 3F00/7F66/5F40/4F41 (linked file to ADF (USIM)/7F66/5F40/4F41)</li><li>EF-RPM Operational Management Counters Leak Rate - 3F00/ 7F66/5F40/4F42 (linked file to ADF (USIM)/7F66/5F40/4F42)</li><li>EF-RPM Operational Management Counters - 3F00/7F66/5F40/ 4F43 (linked file to ADF (USIM)/7F66/5F40/4F43)</li><li>EF-RPM Version Information 3F00/7F66/5F40/4F44 (linked file to ADF (USIM)/7F66/5F40/4F44)</li></ul></td></tr>
<tr><td><b>RTC9</b></td><td><b>RPM (U)SIM Parameter Updates</b>
If the (U)SIM based RPM parameters are updated via OTA, the (U)SIM shall issue a REFRESH command of Refresh Type FILE CHANGE NOTIFICATION and also containing a FILE LIST TLV object.
The Radio Baseband Chipset shall then re-read the (U)SIM based RPM Parameters and start using the updated parameters. All RPM related counters/timers shall be reset after RPM parameters are updated via OTA.</td></tr>
<tr><td><b>RTC10</b></td><td><b>RPM Parameter Default Value</b>
RPM parameter default values are listed below:
<table>
<tr><th>Name</th><th>Description</th><th>Value</th></tr>
<tr><td><b>RPM_Flag</b></td><td>Indicates whether RPM functionality is to be enabled or disabled at power up</td><td>1 (ON)</td></tr>
<tr><td><b>N1</b></td><td>Max number of SW resets per Hour allowed by RPM following “permanent” MM/GMM/EMM reject</td><td>20</td></tr>
<tr><td><b>T1</b></td><td>Average time before RPM resets modem following permanent MM/GMM/EMM reject</td><td>60 minutes</td></tr>
<tr><td><b>F1</b></td><td>Max number of PDP Activation Requests per Hour allowed by RPM following a PDP Activation Ignore Scenario</td><td>60</td></tr>
<tr><td><b>F2</b></td><td>Max number of PDP Activation Requests per Hour allowed by RPM following a “Permanent” PDP Activation Reject</td><td>30</td></tr>
<tr><td><b>F3</b></td><td>Max number of PDP Activation Requests per Hour allowed by RPM following a “Temporary” PDP Activation Reject</td><td>60</td></tr>
<tr><td><b>F4</b></td><td>Max number of PDP Activation/ Deactivation Requests per Hour allowed by RPM</td><td>30</td></tr>
</table></td></tr>
</table>

8.3 RPM (U)SIM Requirements

8.3.1 EF-RPM Enabled Flag Description

This EF indicates if the RPM functionality on the device is to be enabled or disabled at power up. The file shall reside under the DF-ARMED AGENT on both the SIM and USIM applications.

General File Information

Path	3F00/7F66/5F40/4F40 (this is a linked file to ADF(USIM)/7F66/5F40/4F40)
File Type	Transparent
File Body Size	1 byte
Number of Records	N/A
Record Size	N/A
Invalidated at Personalization?	No
Readable and Updateable When Invalidated?	No
Redundancy in Physical File Implementation (to support high update frequency)?	No

Access Conditions

Operation	**Mode**	
	Local	**Remote (OTA)**
Read	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification
Update	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Invalidate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Rehabilitate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification

Structure and High Level Contents

Byte	Parameter	Description	Contents
1	RPM Enabled Flag	Indicates whether RPM functionality is to be enabled or disabled at power up	• 0x00 - RPM shall be disabled at power up • 0x01 to 0XFF - RPM shall be enabled at power up

8.3.2 EF-RPM Parameters

Description

This file contains the RPM parameters that are used for the various scenarios defined in the RPM requirements. The file shall reside under the DF-ARMED AGENT on both the SIM and USIM applications.

General File Information

Path	3F00/7F66/5F40/4F41 (this is a linked file to ADF(USIM)/7F66/5F40/4F41)
File Type	Transparent
File Body Size	32 bytes
Number of Records	N/A
Record Size	N/A
Invalidated at Personalization?	No
Readable and Updateable When Invalidated?	No
Redundancy in Physical File Implementation (to support high update frequency)?	No

Access Conditions

Operation	Mode	
	Local	Remote (OTA)
Read	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification
Update	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Invalidate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification

Rehabilitate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification

Structure and High Level Contents

Byte	Parameter	Description	Contents
1	N1	Max number of SW resets per Hour allowed by RPM following “permanent” MM/GMM/EMM reject	0x00 – The requirement is disabled 0x01 to 0xFF - defines the number of resets per hour
2	T1	Average time before RPM resets modem following permanent MM/GMM/EMM reject	0x00 – The requirement is disabled 0x01 to 0xFF - defines in 6 min increments the time to reset after receiving a permanent MM/GMM/EMM reject, i.e. MM#2
3	F1	Max number of PDP Activation Requests per Hour allowed by RPM following a PDP Activation Ignore Scenario	0x00 – The requirement is disabled 0x01 to 0xFF – The max attempts allowed
4	F2	Max number of PDP Activation Requests per Hour allowed by RPM following a “Permanent” PDP Activation Reject	0x00 – The requirement is disabled 0x01 to 0xFF – The max attempts allowed
5	F3	Max number of PDP Activation Requests per Hour allowed by RPM following a “Temporary” PDP Activation Reject	0x00 – The requirement is disabled 0x01 to 0xFF – The max attempts allowed
6	F4	Max number of PDP Activation/Deactivation Requests per Hour allowed by RPM	0x00 – The requirement is disabled 0x01 to 0xFF – The max attempts allowed
7-32	RFU	Reserved for Future Use	Set to 0x00

Note***:*** All other values are reserved

8.3.3 EF-RPM Operational Management Counters Leak Rate

Description

This file contains the leak rate for RPM operation management counters. The file shall reside under the DF-ARMED AGENT on both the SIM and USIM applications.

General File Information

Path	3F00/7F66/5F40/4F42 (this is a linked file to ADF(USIM)/7F66/5F40/4F42)
File Type	Transparent
File Body Size	6 bytes
Number of Records	N/A
Record Size	N/A
Invalidated at Personalization?	No
Readable and Updateable When Invalidated?	No
Redundancy in Physical File Implementation (to support high update frequency)?	No

Access Conditions

Operation	**Mode**	
	Local	**Remote (OTA)**
Read	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification
Update	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Invalidate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Rehabilitate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification

Structure and High Level Contents

Byte	**Parameter**	**Description**	**Contents**
1	LR-1	Leak rate for C-BR-1	0x00 - C-BR-1 shall not be decremented 0x01 to 0xFF - defines number of hours before C-BR-1 is decremented by 1.

2	LR-2	Leak rate for C-R-1	0x00 - C-R-1 shall not be decremented 0x01 to 0xFF - defines number of hours before C-R-1 is decremented by 1.
3	LR-3	Leak rate for CPDP- 1 to C-PDP-4	0x00 - C-PDP-1 TO C-PDP-4 shall not be decremented 0x01 to 0xFF - defines number of hours before C-PDP-1 TO C-PDP-4 is decremented by 1.
4-6	RFU	Reserved for Future Use	Set to 0x00

8.3.4 EF-RPM Operational Management Counters

Description

This file contains the RPM operation management counters that are used to assist monitoring and debugging RPM operation issues. The file shall reside under the DF-ARMED AGENT on both the SIM and USIM applications.

General File Information

Path	3F00/7F66/5F40/4F43 (this is a linked file to ADF(USIM)/7F66/5F40/4F43)
File Type	Transparent
File Body Size	32 bytes
Number of Records	N/A
Record Size	N/A
Invalidated at Personalization?	No
Readable and Updateable When Invalidated?	No
Redundancy in Physical File Implementation (to support high update frequency)?	No

Access Conditions

Operation	**Mode**	
	Local	**Remote (OTA)**
Read	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification

Update	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification
Invalidate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Rehabilitate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification

Structure and High Level Contents

Byte	**Parameter**	**Description**	**Contents**
1	C-BR-1	Counter related to N1	0x00 to 0Xff. Indicate number of control actions triggered by N1.
2	C-R-1	Counter related to T1	0x00 to 0xFF. Indicate number of control actions triggered by T1.
3	C-PDP-1	Counter related to F1	0x00 to 0xFF. Indicate number of control actions triggered by F1.
4	C-PDP-2	Counter related to F2	0x00 to 0xFF. Indicate number of control actions triggered by F2.
5	C-PDP3	Counter related to F3	0x00 to 0xFF. Indicate number of control actions triggered by F3.
6	C-PDP-4	Counter related to F4	0x00 to 0xFF. Indicate number of control actions triggered by F4.
7-32	RFU	Reserved for Future Use	Set to 0x00

8.3.5 EF-RPM Version Implemented

Description

This EF contains the version of RPM that has been implemented and shall be updated by the IoT Device on each power up. The file shall reside under the DF-ARMED AGENT on both the SIM and USIM applications.

General File Information

Path	3F00/7F66/5F40/4F44 (this is a linked file to ADF(USIM)/7F66/5F40/4F44)
File Type	Transparent

File Body Size	1 byte
Number of Records	N/A
Record Size	N/A
Invalidated at Personalization?	No
Readable and Updateable When Invalidated?	No
Redundancy in Physical File Implementation (to support high update frequency)?	No

Access Conditions

Operation	Mode	
	Local	Remote (OTA)
Read	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification
Update	ALWAYS	Requires 3GPP TS 31.115 Message Integrity Verification
Invalidate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification
Rehabilitate	ADM1	Requires 3GPP TS 31.115 Message Integrity Verification

Structure and High Level Contents

Byte	Parameter	Description	Contents
1	RPM Version Information	Indicates the version of RPM implemented in the device	0x00 - No Version Information 0x01 - Version 1 0x02 - Version 2 0x03 - Version 3 .. .. 0xFF - Version 255

9 3GPP Connection Efficiency Features (Normative Section)

3GPP provides a number of features to protect mobile networks' from excessive signalling from large numbers of devices in two principle situations:

1. When an IoT Service (associated many IoT Devices) causes a large number of IoT Devices to communicate over a mobile network at the same time; and/or
2. When many IoT Devices are roamers and their serving network fails, then they all attempt move onto a local competing network, and potentially overload this network.

The 3GPP connection efficiency features and their associated IoT Device requirements are described in this section.

It should be noted that both the IoT Device and the Mobile Network must implement these 3GPP features for them to be of benefit to the IoT Service Provider and Mobile Network Operator.

9.1 Rejection of IoT Device Requests with Back-off Timer

When performing mobility management procedures (e.g. location update or routing area update procedures), or session management procedures (e.g. PDP context activation) the mobile network can reject the IoT Device's request with a back-off timer to the device, so that the IoT Device does not re-attempt the request for the specific period of time indicated in the back-off timer.

In 3GPP TS23.401 and TS23.060, two different types of control for the back-off timer are available:

1. APN based congestion control: The network may reject the Session Management requests (e.g. Activate PDP Context Request, PDN Connectivity Request) it receives from devices to a certain APN. This can help the operator to control the amount of traffic using a specific APN.
2. Mobility management congestion control: The network may reject Mobility Management requests (e.g. Attach Request, Routing Area Update, Tracking Area Update) from IoT Devices.

The IoT Device shall support both APN based congestion control and mobility management congestion control.

9.2 Handling of Low Access Priority Indicator

3GPP Release 10 introduces the concept Low Access Priority Indicator (LAPI). The operator can set LAPI in “low priority” IoT Devices, where the application(s) can tolerate longer access delays. The LAPI can be used by the network to reject such an IoT Device from access, and assign a back-off timer preventing the device from immediately repeating the access attempt.

3GPP Release 10 provides an Extended Wait Timer which provides the ability for the mobile network to reject a request with a longer back-off timer than was defined in previous 3GPP releases.

The IoT Device shall support Low Access Priority Indicator (LAPI) and Extended Wait Timer.

9.3 Implicit Reject in GSM Radio Network

The GSM base transceiver station (BTS) in the serving network can be used to dynamically and quickly control the (over)load from Low Access Priority devices on its RACH, AGCH and SDCCH channels.

Before requesting a signalling channel, an IoT Device that has LAP assigned shall check the “Paging” and “Access Grant” broadcast channels for 20ms. If the BTS has set the “implicit reject” flag (one flag for circuit switched and one flag for packet switched) then the IoT Device shall not request a signalling channel, but will back off for a locally generated random period.

9.4 Long Periodic LAU/RAU/TAU

The Periodic Routing Area Update (PRU) and Periodic Tracking Area Update (PTU) timers are used in the Packet Switched domain to control the frequency of PRU and PTU.

In 3GPP Release 10, 3GPP TS23.401 and 3GPP TS23.060 specify that HSS/HLR can be configured with a long PRU/PTU timer per device. During Attach/Routing Area Update/Tracking Area Update procedures, the subscribed PRU/PTU timer values are sent to the SGSN/MME in VPLMN. SGSN/MME then forwards the PRU/PTU timer values to the device.

The IoT Device shall support the extended periodic timers, both for PLU (for circuit switched domain) and PRU/PTU (for packet-switched domain).

9.5 Extended Access Barring

3GPP Release 10 Extended Access Barring (EAB), as specified in 3GPP TS23.060, is a method for a GSM/UMTS network to selectively control access attempts from devices configured for EAB (which are considered more tolerant to access restrictions than other devices) in order to prevent overload of the access network and/or the core network, without the need to introduce any new device access classes.

In the case of congestion, the network could restrict access from IoT Devices configured for EAB while permitting access from other devices. When the network determines that it is appropriate to apply EAB, it broadcasts necessary information on the BCCH to provide EAB control for devices.

The IoT Device shall support Extended Access Barring.

9.6 Extended NMO-I

Network Mode of Operation I (NMO-I) enables an IoT Device to perform combined attach towards the packet switched domain. Otherwise, the IoT Device will perform individual attaches to the circuit switched and packet switched domains.

When a large number of roaming IoT Devices attach to a VPLMN, failure of one mobile network might have a domino effect on the other local competing networks, potentially leading to failure of all the networks. The use of combined attach reduces the signalling load on the serving network. However, this might not be beneficial for the operator to apply for all categories of IoT Devices.

Extended NMO-I is introduced in 3GPP Release 10 to allow the mobile network operator to control if a device should perform combined attach or not.

The IoT Device shall support Extended Network Mode of Operation I (NMO-I).

9.7 Minimum Periodic Search Timer

Pre-“3GPP Release 10” roaming devices do a background search for “more preferred” mobile networks in that country using the timer EF_{HPPLMN} (Higher Priority PLMN search period) which is typically set to 6 or 12 minutes. Consequentially if the most preferred network fails, masses of roaming devices would move to a non-preferred network in that country and, every 6 or 12 minutes attempt (and fail) to return to the preferred network.

The “minimum periodic search timer” is intended to reduce the frequency of this behaviour.

The device shall use the larger of the “minimum periodic search timer” and the value in EF_{HPPLMN} to control its background search for more preferred networks.

The IoT Device shall support Minimum periodic search timer.

9.8 Attach with IMSI Indicator

If this indicator is set when registering with a new mobile network, the device will present its IMSI rather than a temporary identify. This reduces the signalling load on the new network, as it doesn’t have to try and resolve the temporary id and subsequently request the IMSI from the device. This will help a recipient network if it has to manage an incoming ‘avalanche’ of device registrations coming from a failed network.

The disadvantage of setting this parameter is that if the device moves between networks and attaches using the IMSI, then any active PDP context will be torn down. This would also be the case if the device presented an unresolvable TMSI to the new network.

Note that if the device is moving between equivalent mobile networks (based on the Release 99 equivalent feature) then Attach with IMSI is not invoked.

The IoT Device shall support the Attach with IMSI indicator.

9.9 Timer T3245

The Timer_T3245_Behaviour parameter controls whether timer T3245 is used by the IoT Device. If T3245 is used, then on expiry it causes the device to erase the forbidden network list and to remove any “invalid SIM” setting. The value of T3245 is defined in 3GPP TS 24.008, and is randomly chosen by the device from the range 24 to 48 hours.

The T3245 timer should be used by IoT Devices which are not easy to service. For example, if a smart meter receives a fatal error such as “IMSI unknown” it will add the network to the forbidden list and never connect to it. It is expensive to send a service technician to the smart meter to clear the forbidden network list. Therefore, the T3245 expiry acts as an automated mechanism to flush the forbidden network list, thereby enabling the smart meter to function again.

The IoT Device shall support Timer T3245.

9.10 Configuration of 3GPP Release 10 Connection Efficiency Parameters

Correct operation of the 3GPP Release 10 congestion control mechanisms described above relies on optimal configuration of the device and/or subscription parameters by the mobile network operator.

The IoT Device shall support the following mechanisms to configure these parameters:

- **OMA DM**: to re-configure the terminal’s NAS configuration Management Object (MO), see 3GPP TS 24.368
- **SIM OTA**: to configure the USIM’s file EFNASCONFIG (Non Access Stratum Configuration), see 3GPP TS 31.102

Note that if both USIM and OMA DM values are present within the IoT Device, 3GPP have specified that the USIM values take precedence (see TS 22.368 section 7.1.1, and TS 31.102 section 4.2.94).

9.11 Power Saving Mode

The Communications Module should support Power Saving Mode as defined in 3GPP TS 23.682 Release 12 to enable an IoT Device connected to an LTE network to reduce its power consumption and network signalling.

Power Saving Mode is similar to powering-off the device, but the mobile device that uses PSM remains registered with the network so there is no need to re-attach or re-establish the network connection when the device starts transmitting or receiving data.

Annex A Connection Efficiency Use Cases (Informative Section)

Proof of the impact of inefficient IoT Devices can be seen today. The following cases were recently experienced by GSMA Mobile Network Operator members and highlight why the requirements defined within this document are necessary:

A.1 Use of Unintelligent Error Handing Mechanisms

In this case, one of the Mobile Network Operator’s customers had an installed base of approx. 375,000 geographically fixed IoT Devices (for use in the homes of consumers). These devices were located in 6 different European markets and the devices normally communicated via fixed line Ethernet connections. In normal circumstances the IoT Devices periodically communicate with the customer’s server to report on their status, and these status reports must be acknowledged by the customer’s server.

Recently the following sequence of events happened which caused massive disruption and loss of service for a large number of the Mobile Network Operator’s customers:

1. On a particular day, the customer’s server suddenly and unexpectedly stopped acknowledging the status reports from the IoT devices.
2. The devices treated this as a loss of connectivity over their Ethernet network connections and in an attempt to regain connectivity with the server the IoT Devices all started to ‘fall-back’ to a GSM/GPRS network connection.
3. All the devices then switched on their GSM Communication Modules and attempted to send status messages via their local GSM/GPRS network but again the acknowledge messages were not received from the server.
4. In this event the devices would reset the GSM Communication Module, forcing it to re-register to the local GSM network and the IoT Devices would try again to contact the server. Eventually all 375,000 devices ended up in an infinite loop with their GSM modems being rebooted every minute or so.
5. As the number of devices which entered this ‘reboot’ loop grew, the signalling load within the core network of the devices home Mobile Network Operator grew to an unmanageable level. This resulted in one of home network’s HLRs became overloaded with registration attempts, which in turn prevented all devices that use (U)SIMs provisioned in that HLR to register to any GSM network.
6. At this point the home Mobile Network Operator as he now has a much wider issue to address. The Mobile Network Operator has to stabilize their core network signalling and in this case the Mobile Network Operator was forced close down major roaming destinations like Germany, France, Austria, Italy, Spain and the UK. This reduced the signalling load, and then each network connection could be re-established one by one to bring the number of devices trying to register to the network back in smaller, more manageable, numbers.

Overall, it took this Mobile Network Operator approximately 48 hours to completely resolve the problem which classified the event as a ‘critical’ event on their network. If the devices had implemented an intelligent ‘back-off’ mechanism (intended delivery of the Network efficiency project) when loss of connectivity to the server had been detected then this problem would not have occurred.

A.2 Use of insecure IoT Communications Modules

In this case, the Mobile Network Operator's B2B customer had an installed base of 59 IoT devices used to monitor wind and solar power generation. All of the devices used the same make of Communications Modules.

In December 2013 a sudden increase in calls to Gambia, Latvia, Lithuania, UK and Falkland Islands occurred, all the calls being made by the 59 IoT devices. In total approx. 17,000 calls were made before the Mobile Network Operator discovered the fraud and implemented the necessary countermeasures.

Upon further investigation it was discovered:

- All of the Communications Modules within the IoT Devices had been left configured with default usernames and passwords.
- The hacker had discovered the temporary public IP addresses of the IoT Devices and then logged on to each device using the default username and password.
- The hacker then configured the Communications Modules within the IoT Devices to use dynamic DNS addressing to give each device a permanent IP address.
- The hacker then used these permanent IP addresses to connect to the IoT Devices from the 9th to 15th of December and instruct the devices to make calls.

As a result of this hack, the Mobile Network Operator and its customer incurred a financial cost estimated at 150,000 euros for the ~17,000 illegal calls made by the IoT Devices.

If the IoT device vendor had properly configured the security features provided by the Communications Modules within their IoT Devices this event would not have occurred.

A.3 Radius Server Overload

After an SGSN outage tens of thousands IoT devices that belong to an IoT Service Provider re-register to the GPRS network.

There is no throttling activated on the receiving GGSN, so all requests to activate a PDP Context on the IoT Service Provider's APN is processed.

The APN is configured to authenticate through a RADIUS server hosted by the IoT Service Provider which resides on the remote end of a VPN that terminates in the GGSN.

The RADIUS server is not scaling well and the IoT Service Provider has not added enough resources to the RADIUS server to cater for this peak of authentication requests.

The first thousand requests go through but after that the RADIUS server start to experience problems to respond in a timely manner.

In turn the GGSN resend authentication requests that have timed out, putting even more load on the RADIUS server.

Finally, the RADIUS server's CPU utilization hit 100% and the GGSN starts to suffer from the vast amount of PDP Context activation requests that cannot be authenticated and times out.

The IoT Devices do not have a back-off feature and send new requests to activate PDP Context as soon as the previous times out.

The Mobile Network Operator needs to disable all the IoT Devices' (U)SIMs and re-activate them in batches in order for the RADIUS server to be able to authenticate the requests.

Lessons learned:

- Mobile Network Operators should have a throttling mechanism on GGSNs per APN.
- IoT Application Developers' need to implement a back-off feature for such scenarios.
- IoT Service Providers' back-end engineers must communicate with their organization and request information about active (U)SIMs in order to have the appropriate resources available for RADIUS and back-end systems.

A.4 Fake IMEI case

The existence of IoT devices with fake/incorrect IMEIs presents a problem to the Mobile Network Operator. The problem occurs because there are no regulations to check the IMEIs of devices passing customs clearance and as a result, devices with fake/incorrect IMEIs are easily spreading between different markets without any resistance.

Based on Mobile Network Operator experience there is several typical scenarios of fake/incorrect IMEI:

- Copied IMEI for particular consignment of IoT Devices, where the chip which stores the IMEI was not properly coded by manufacturer.
- Substituted IMEI for the IoT Device, taken from the IMEI range dedicated to different type of device and as a consequence the Network has a misunderstanding of device type.
- Fake IMEI which has been re-flashed by the IoT Device Maker from its original value.

A.5 3GPP Standards Non-compliance Cases

3GPP standards non-compliance has been faced for several devices or even types of devices in signalling flow cases.

Device capabilities which have sent to the Network are different in comparison with real device behaviour, the following cases are most typical:

- False information regarding supported frequencies has been sent to the Network, e.g. GSM 1900 instead of GSM1800
- False information regarding the class of output radio power

These false capabilities stresses the Network and behaves abnormally in terms of Network <-> device interaction.

Incorrect response on technical parameter and requirements which sent by the Network in system information messages:

- Much more often Periodical Location Update independently from Network sent parameters. Ignoring of predefined network parameter of Periodical Location Update interval. Doubled or even tripled signalling load on the Network.
- Frequent reload of the device with related signalling flow such as IMSI attach, GPRS attach which increases Network load. The procedure of reloading mechanism is pre-programmed in device application and could be not optimized to the real Network conditions. E.g. losing of the satellite connections to GPS module of the device could be a criteria for initiation of the device rebooting by its application. It could be a reason for additional network load if car with such device installed could be parked under hangar roof for ex.

- Device inability to make Network attach being sent IMSI attach requests while misunderstanding of Network standard signalling respond which cause devices restart and consequent frequent attach requests.

A.6 Other Reported Examples

- Digital Picture Frame –If the device's cloud based server is not available, the device would start to ping the server every 5 seconds to re-establish network connection. When an Mobile Network Operator has thousands of such devices in their network doing the same exhibiting the same behavior, it results in a "denial of service" attack.
- M2M Device – When configured with an invalid APN or a deactivated (U)SIM the device still attempts to obtain PDP context at a very aggressive rate, unnecessarily consuming network resources and if deployed on a large scale, would congest or crash the network.
- M2M Device Behaviour after Network Outages – After a network outage, when the network comes back up, a large number of devices will see the network and all attempt to access at the same time. The network is unable to respond to all these simultaneous requests. This puts these devices into a state where they are continually attempting to access and potentially crash the SGSN.

Annex B Connection Efficiency Protection Mechanisms Within Mobile Networks (Informative Section)

Mobile networks operators will implement protection mechanisms within their mobile networks to protect their networks from any harm caused by inefficient IoT Devices and IoT Applications.

This annex lists some of the protection mechanisms that network operators may use, usually as a ‘last resort’, within their networks and describes the impact that such mechanisms may have on the IoT service.

It is recommended that IoT Device makers and IoT Application developers be proactive and implement the requirements listed in this document rather than rely on the network operator’s protection mechanisms. Implementing protection mechanisms within the device will mean the IoT Device maker and IoT Service Provider are best placed to monitor and address device and service performance issues without their services being impacted by Network Operator actions.

B.1 Use of SIM Toolkit Applications

Some operators implement a SIM toolkit application within their SIM card that detects inefficient IoT Device behaviour such as repeated device reboots or aggressive network connection reattempts. If the SIM application detects such behaviour it will temporarily disable the network access credentials within the SIM thus preventing the IoT Device from being able to connect to the network for a period of time. The time period that the SIM disables the network access credentials will increase until the IoT Device behaviour returns to normal.

B.2 Use of Dynamic Billing

Some operators will implement dynamic billing so that IoT customers are subject to different network charges at different times of the day. Such a mechanism could be used, for example, to discourage the mass synchronised behaviour of IoT Devices at certain periods of the day.

B.3 Barring of Network Connectivity

Some operators continuously monitor IoT Device behaviour from within their networks and will temporarily disable the subscriptions associated with IoT Devices if they are creating abnormally high levels of signalling or data load on the network. Network operators will usually apply temporary restrictions for short periods of time until the device behaviour returns to normal. If the IoT Device continues to perform inefficiency, and impacts the overall performance of the network and, potentially, other users of the network, the network operator may permanently disable the subscription associated with the problematic device.

Annex C Advice for IoT Application Developers (Informative Section)

C.1 Bandwidth Awareness and Efficient Network Connection Usage Advice

Special consideration must be taken by IoT developers when developing applications that will communicate over wide area wireless networks because of the fundamental differences in the operation of wire area wireless networks compared to ‘fixed’ wireline networks or local wireless (wireless LAN) networks.

The constraints and limitations of mobile networks should be considered by the developer of an IoT Device Application. Operating within these limitations will potentially result in reduced data upload/download volumes, improved IoT Service reliability and responsiveness, and (if applicable) reduced IoT Device power consumption.

As an example of developer best proactive this section provides advice to IoT Applications Developers who are developing applications that will communicate via 3G networks. Similar considerations should also be applied when developing IoT applications that will communicate using other network technologies (2G, 4G etc).

Apart from data traffic volume, there are key features in a mobile network that require consideration by the IoT Device Application developer. One such feature within 3G networks is Fast Dormancy, a feature that aims to minimise network signalling and battery consumption, both key issues given the increasing number of IoT Devices.

When an IoT Device Application requests data to be sent or received over a mobile network, the Communications Modem switches from an ‘idle mode’ to a ‘dedicated’ channel state that consumes about 60-100 times more power compared to the ‘idle mode’. In addition to this, the very process of switching from the idle to the dedicated state requires network signalling messages that also take a certain amount of time. Keeping the Communications Modem in a high power state is not ideal as it will both consume network resources and increase the IoT Device’s power consumption.

Between the idle and dedicated channel states there are few more radio resource control (RRC) states that come into use. Fast dormancy technology defines an algorithm that dictates when the Communications Module can be switched to lower state after the last data transmission. Figure 3 below shows how the power drops after a certain period of inactivity in data transfer. Times T1 and T2 are network dependent.

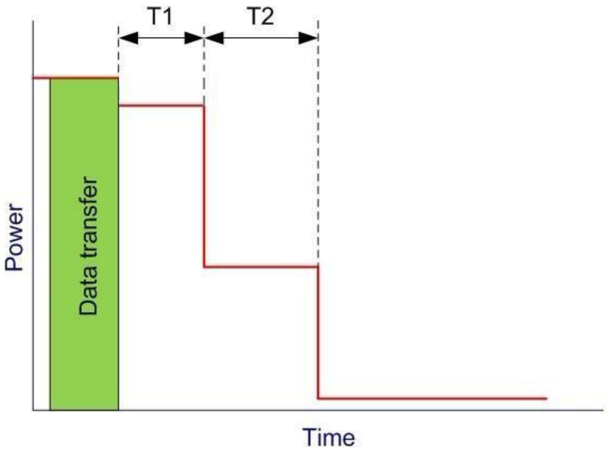


Figure 3: Power Consumption – Example 1

Once the state has switched to idle, establishing a new network connection may require the exchange of between 24-28 signals with the network, which could take one to two seconds.

This is an example of when the app has many short network connections over a specific period of time:

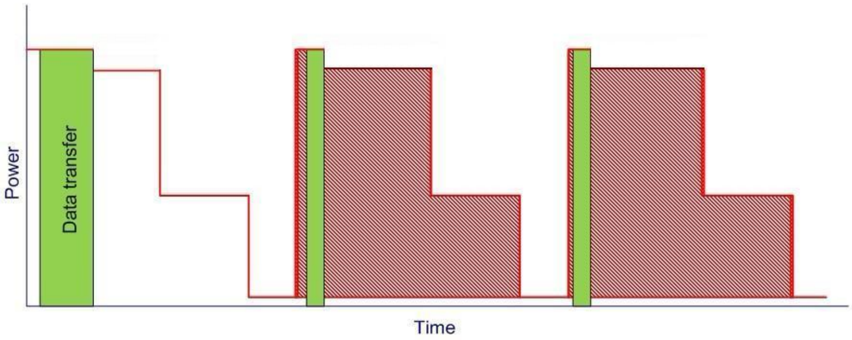


Figure 4: Power Consumption – Example 2

The red-hatched areas in Figure 4 show the overhead in battery usage compared to Figure 5 when all network connections are synchronised and completed in the same time.

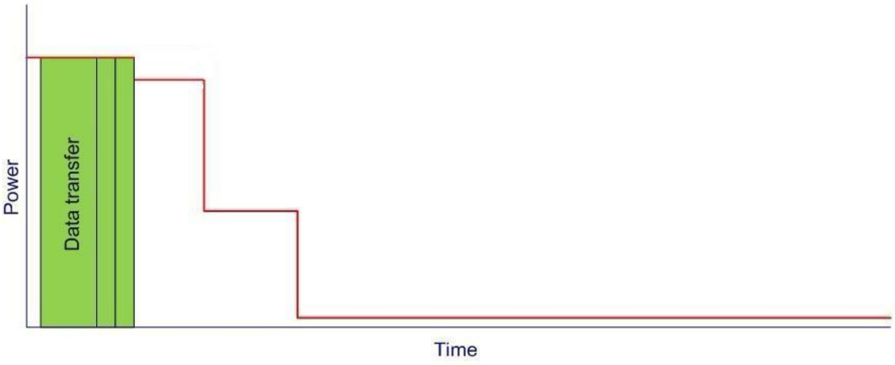


Figure 5: Power Consumption – Example 3

Although most of the timers and conditions of switching between the channel states are network dependent, it is good to at least have an example of the approximate characteristics.

According to tests that have been done by XMPP Foundation:

- Dedicated channel (the highest level) consumes about 380mA. The time before dropping to the lower state is approximately eight seconds
- FACH (shared channel – intermediate level) consumes about 140mA. In order to keep this state and prevent switching into the higher power mode, the packet sizes are recommended to be around 128 bytes and, after deducting TCP and TLS overheads, this leaves only about 70 bytes of actual data. Timeout before switching to the lower state is around eight seconds.

The general recommendation is to transfer data in one go and to not spread out network activities if at all possible.

C.2 IoT Device Application Scaling Advice

IoT Device Applications should be designed to ensure that network activity is not concentrated at specific times and is tolerant of geographical loading problems.

IoT Services are frequently synchronised to a standard clock source and this can result in frequent updates by multiple IoT Devices at exactly the same time (especially for IoT Services that are used by large numbers of End Customers). This can cause overloads to both the IoT Service Platform and the mobile radio network. IoT Services should be designed to spread network activity by different IoT Devices across as wide a time period as possible to reduce such overloads.

To illustrate the point let us take a closer look at example of a IoT Service that checks for service updates periodically (e.g. every 30 minutes), but not necessarily at exact times (e.g. XXhr:00min, XXhr:30min). In such cases, it would be ideal to evenly spread the network activity timings (i.e. the timings which IoT Device Application checks for updates) across devices as in Figure 6 below.

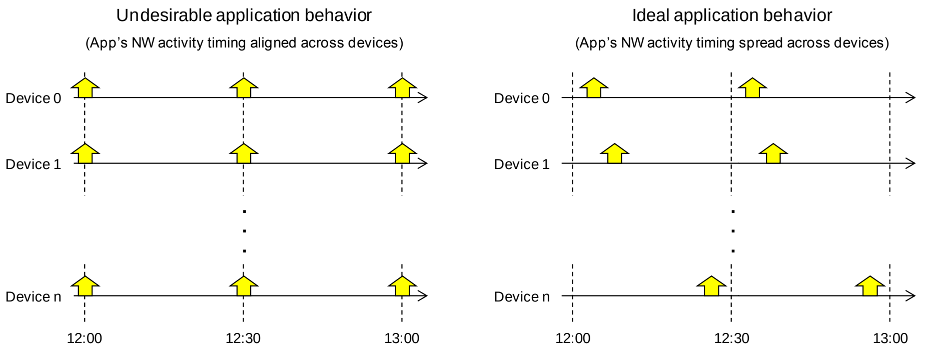

Undesirable application behavior
(App's NW activity timing aligned across devices)
Ideal application behavior
(App's NW activity timing spread across devices)
Device 0
Device 1
Device n
Device 0
Device 1
Device n
12:00
12:30
13:00
12:00
12:30
13:00

Figure 6: Spreading an IoT Device Application's Network Activity Timing

One way to realise such behaviour would be to schedule network activity timings using relative times (e.g. “30 min from the current time”), and using a timing which would not be aligned across IoT devices as the base timing. For example, the base timing can be the time of the IoT Device boot-up.

Other IoT Services may require data retrieval from servers at exact times of a day (e.g. 05hr:00min, 11hr:00min, 17hr:00min) when the latest information is made available. In such cases, it would be better to spread the network activity timings (i.e. the timings which the IoT Device Application retrieves data) across IoT Devices within an acceptable time window (e.g. 5min) as in Figure 7 below.

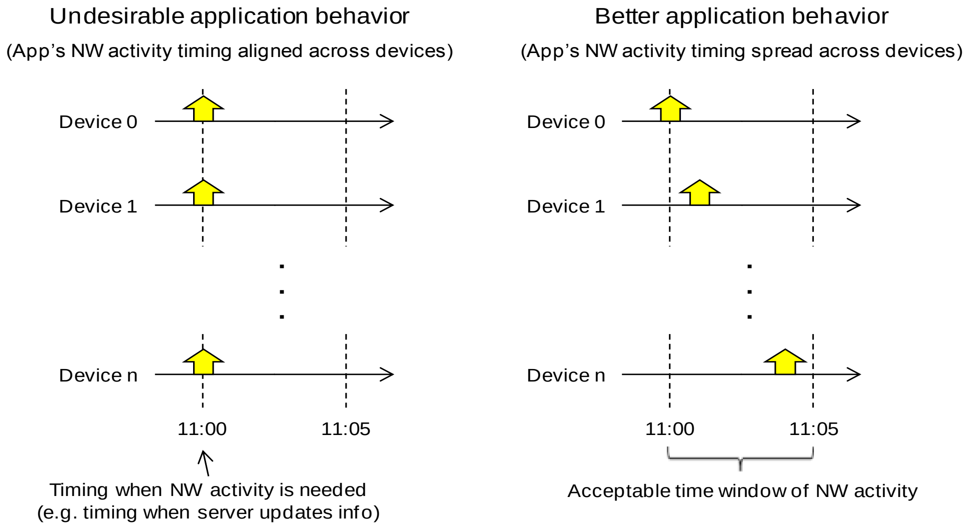

Undesirable application behavior
(App's NW activity timing aligned across devices)
Better application behavior
(App's NW activity timing spread across devices)
Device 0
Device 1
Device n
Device 0
Device 1
Device n
11:00
11:05
11:00
11:05
Timing when NW activity is needed
(e.g. timing when server updates info)
Acceptable time window of NW activity

Figure 7: Spreading an Application's Network activity timing within an acceptable window

Such behaviour can be realised by including a random offset (within a desired time window) when scheduling network activities. E.g. "Activity at 17hr:00min + offset", where the offset is defined with a random function having an uniform distribution within the desired window.

IoT Device Application developers are recommended to avoid, as much as possible, using exact times for an IoT Device Application's network activities, and to use randomisation design techniques to spread network activity timings across different IoT Devices. The network capacity of a local area will be significantly lower than the product of the number of IoT Devices and their assigned bandwidth. On occasions there may be large numbers of IoT Devices in a specific location. In general, IoT Device Applications should use some randomisation design techniques to spread network synching and connectivity load.

Annex D Device Diagnostic Requirements (Informative Section)

This section contains requirements which the GSMA intend to further develop and incorporate into the normative section of this document in a future release.

D.1 Remote Diagnostics Recommendations

RDR1	The Communications Module should support secure and authenticated OTA protocols to implement the diagnostic requirements stated in RDR2. Examples of related OTA protocols are OMA DiagMon [7], OMA DM [8] and OMA FUMO [9].
RDR2	The Communications Module should support the following diagnostic features: • Respond to “ping” query via ICMP; • Report module/device/subscription IDs (IMSI / ICCID / MSISDN); • Report current serving cell ID, received signal level / Received Signal Code Power (RSCP), scrambling code, location area ID; • Report current neighbour cells info; received signal level, ids; • Report the parameters which are related to the network access and applications (i.e. APN, SMSC number, IP, Port); • Report stored history of radio link quality data; • Report circuit-switched call log (mobile-originated and mobile-terminated); • Storage of key events in non-volatile memory then allows the log of these events to be uploaded via TCP/IP; • Start and stop log storage via remote commands; • Attach status (including reason for attach failures); • PDP context status (including reason for context establishment failures); • Report a log of failures (e.g. SMS send failure, software update failure, PIN code failures etc); • Report hardware/software/firmware versions; • Report status of device integrity check of the HW/SW/configuration files of the Communications Module; • Report status of device integrity check of the HW/SW/configuration files of the host device; • Report battery charge level; • Report packet transfer history statistics (number of Tx, number of Rx, retries); • Report last 5 IP addresses with which the Communications Module communicated; • Report SMS transfer history statistics (i.e. number of Tx, number of Rx, retries); • If Communication Module has location capability, report location; • If Communication Module or host device has a real-time clock capability, report local time; • Upload selected area of Communication Module’s memory (supplied

	address, length); • Download an application to the Communication Module's RAM; • Remove an application in the Communication Module's RAM; • Check status of peripheral devices attached to Communication Module; • Report re-boot history (stored in non-volatile memory); • Report stored history of local servicing of the Communication Module or the host device by technicians (including their ids); • Re-boot Communication Module on remote command; • Report the total amount of memory currently being used and the amount of free memory.

D.2 Local Diagnostic Requirements

LDR1	The Communications Module shall support a local interface (for example RS-232, USB or other interface) over which local diagnostic information may be obtained. The diagnostic interface should allow: • Manual reboot; • Check of integrity of the h/w, s/w configuration of the Communication Module and/ or the host device; • Display of the cellular environment (including received signal strength, cell ids for serving and neighbour cells); • List of any stored error codes or logs; • Display of selected log; • Display of non-volatile configuration settings; • Capability to test peripherals connected to the Communication Module; • Sending of at and diagnostic commands to the Communication Module; • Check of battery charge status (if applicable).

Annex E Example Text to be Inserted Into Contracts and RFQs (Informative Section)

This section contains an example of the text that could be adapted and used as a base for an RFQ or contract between a Mobile Network Operator and IoT Service Provider who would like to connect their IoT Devices to the Mobile Network Operator network. Inserting such text will allow the Mobile Network Operator to reference the key requirements within the GSMA Connection Efficiency Guidelines without having to insert the whole document into their RFQ or contracts.

E.1 Example Text

<<<<<<<<<<<<<<<<<<<<<<<<<<<< CUT HERE >>>>>>>>>>>>>>>>>>>>>>>>>>>

x.1 Problem Statement

The predicted large scale growth of IoT Devices will create major challenges for Mobile Network Operators. One major challenge that Mobile Network Operators must overcome is the risk caused by the mass deployment of inefficient, insecure or defective IoT Devices on the Mobile Network Operators' networks. When deployed on a mass scale such devices can cause network signalling traffic to increase exponentially which impacts network services for all users of the mobile network. In the worst cases the mass deployment of such IoT Devices can disable a mobile network completely.

IoT Devices overusing the mobile network can affect not only the devices causing the incident but also other devices on the same IoT Service Platform or those devices of other End Customers.

Network signalling resources are dimensioned assuming an overall device usage profile with a sensible balance between traffic and signalling needs. It is therefore important that IoT Devices using mobile networks adhere to some basic principles before they can be safely connected to mobile networks.

Good design is essential to ensure that IoT Device performance is optimized and to prevent failure mechanisms creating runaway situations which may result in network overload.

x.2 Key Words Used to Indicate Requirement Levels

The use of "shall" in this section means that the definition is an absolute requirement of the Mobile Network Operator.

x.3 Definition of Terms

Term	Description
Communications Module	The communications component which provides wide area (2G, 3G, 4G) radio connectivity. Comprising of Communications Module Firmware, Radio Baseband Chipset and UICC
Global Certification Forum (GCF)	An independent worldwide certification scheme for mobile phones and wireless devices that are based on 3GPP standards. For more information, see http://www.globalcertificationforum.org
IoT Device	The combination of both the IoT Device Application and the Communications Module.
IoT Device Application	The application software component of the IoT Device that controls the Communications Module and interacts with an IoT Service Platform via the Communications Module.

Term	Description
IoT Service Provider	The provider of IoT services working in partnership with a Mobile Network Operator to provide an IoT Service to an End Customer. The provider could also be a Mobile Network Operator.
Mobile Network Operator	The mobile network operator(s) connecting the IoT Device Application to the IoT Service Platform.
PTCRB	The independent body established as the wireless device certification forum by North American Mobile Network Operators. For more information, see http://ptcrb.com

x.4 References

Ref	Document Title	Source
1	GSMA IoT Device Connection Efficiency Guidelines	http://www.gsma.com/connectedliving/gsma-iot-device-connection-efficiency-guidelines/

x.5 IoT Service Provider Requirements

The IoT Service Provider's IoT Service Platform shall conform to the requirements stated in Section 6 of the GSMA IoT Device Connection Efficiency Guidelines [1].

The IoT Service Provider shall only connect IoT Devices to the Mobile Operators Network that conform to the requirements stated in the GSMA IoT Device Connection Efficiency Guidelines [1]. Specifically:

1. The IoT Device Application shall conform to all requirements defined in section 4 of the GSMA Connection Efficiency Guidelines [1].
2. The IoT Device's Communication Module shall conform to all requirements defined in section 5 of the GSMA Connection Efficiency Guidelines [1]. Specifically:
   2.1. The Communications Module shall be compliant with 3GPP specifications unless otherwise stated within the GSMA IoT Device Connection Efficiency Guidelines [1].
   2.2. The Communications Module shall be certified by the GCF and/or the PTCRB.
   2.3. The Communications Module shall investigate, and meet as required, the mobile network operator requirements for the target market(s).
   2.4. The Communications Module shall support (dependent upon the target mobile network operator) at least one of the following requirements:
      2.4.1. Radio Policy Manager as defined in section 8 of the GSMA Connection Efficiency Guidelines [1]; OR
      2.4.2. Connection Efficiency requirements as defined in section 7 of the GSMA Connection Efficiency Guidelines [1]; OR
      2.4.3. 3GPP Connection Efficiency features as defined in section 9 of the GSMA Connection Efficiency Guidelines [1]. Note: This option requires the target mobile network operator to have implemented the required 3GPP optional features.
3. If required by the Mobile Network Operator, the IoT Device shall be certified by the GCF and/or the PTCRB.

<<<<<<<<<<<<<<<<<<<<<<<<<<<< CUT HERE >>>>>>>>>>>>>>>>>>>>>>>>>>>

Annex F Future Considerations (Informative Section)

F.1 Policy Based Aggression Management Solution

The GSMA Connection Efficiency Project also preliminarily evaluated a flexible policy based solution with the goal to provide a unified solution for the requirements outlined in Section 7 (NFM) and Section 8 (RPM) and flexible enough to support future requirements. The policy based solution has two main components: the policy which defines the intended interaction of the Communication Module with the mobile network and a policy enforcement engine within the Communication Module.

Policy: A policy is defined by the MNO based on its network's specific access preferences. The defined policy can be assigned or changed via remote mechanisms (e.g. OMA-DM, SIM-OTA), local mechanisms (e.g. via AT cmd), or set at the factory (i.e. a default policy). The policy is built up using rules where each rule defines an action (e.g. block GRPS Attaches) which is to be taken by the Communication Module when the rule’s conditions are met (e.g. GMM Error =1). The conditions can be compound expressions based on the Communication Module’s current state, as well as counters and timers.

Policy enforcement engine: The policy enforcement engine is code that runs within the Communication Module and is responsible for enforcing the allocated policy. The engine evaluates the rules and executes the actions. Some actions discussed include: Blocking IMSI attach, GPRS attach, PDP context activation and SMS-MO, switching PLMNs, and resetting the Communication Module. Some rule conditions discussed include: counting IMSI attaches, GPRS attaches, PDP context activations and SMS-MO’s and their associated errors.

Example Rule: The following example rules has the Communication Module block GPRS Attaches after a GMM Error codes: x,y,or z is received and then initially back-offs between 10-20 minutes (i.e. Communication Module randomizes in this range), then between 20-30 minutes, then 30-40 minutes thereafter:

Action: [Block] [GPRS Attaches]

Condition: When [GMM errors] [x,y,z] [>=] [1] in [10-20,20-30,30-40] mins

Annex G Document Management

Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
1.0	13-OCT-2014	New PRD CLP.03	PSMC	Ian Smith GSMA
1.1	30-Jan-2014	• DHIR requirements moved to normative section of document. • Requirements NFM8, NFM9 and NFM10 added. • New Annex E • New Annex F • Editorial Corrections	PSMC	Ian Smith, GSMA
1.2	01-Jul-2015	• Updated definitions • Updated Generalised IoT Service Architecture • Clarifications to DAR3 and NFM7 • Requirement DID33 added • General editorial corrections	PSMC	Ian Smith, GSMA

Other Information

Type	Description
Document Owner	GSMA Connected Living Programme
Editor / Company	Ian Smith / 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.