



Telecom Regulatory Authority of India



Recommendations

on

**“Spectrum, Roaming and QoS related requirements in
Machine-to-Machine (M2M) Communications”**

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CHAPTER I: INTRODUCTION

- 1.1 Machine-to-machine (M2M) communication is a broad term that can be used to describe any technology that enables networked devices to exchange information and perform actions without or with minimal human intervention. In M2M communication, sensors attached to any machine relay information of the events that the machine experiences to a central application that analyze this data and take appropriate decisions in real time. Such decisions can trigger actions or provide actionable information.
- 1.2 M2M communication is a technology innovation which can change the life of billions of people using trillions of devices. Industry analysts estimates that the number of connected devices could be anywhere from 20 billion to 100 billion by 2020.¹
- 1.3 M2M communication has the potential to bring substantial social and economic benefits to governments, citizens, end-users and businesses through increase in productivity and competitiveness, improvements in service delivery, optimal use of scarce resources as well as creation of new jobs. Jeff Immelt (Ex-Chief Executive Officer, General Electric) has once quoted regarding value creation by the way of M2M communication:
- “When machines can sense conditions and communicate, they become instruments of understanding. They create knowledge from which we can act quickly, saving money and producing better outcomes.”*
- 1.4 M2M communication is the basis for automated information interchange between machines, appliances or devices, using wired or wireless technologies, and the nerve center for various industry verticals like Smart City, Smart Grid, Smart Water, Smart Transportation, Smart Health etc.

¹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409774/14-1230-internet-of-things-review.pdf

- 1.5 In the near future, there will be an increasing deployment of Smart Grids, Smart Transportation, Smart Cars, Smart Homes etc. especially in the ‘Smart Cities’ framework. Emergence of M2M communication is a key component of evolving “Networked Society”.
- 1.6 The communications infrastructure has evolved significantly over the past couple of years, particularly for wireless. The accessibility and popularity of the Internet, e-mail, Applications at content level and proliferation of smart phones at device level has resulted in anywhere, anytime connectivity. While most of the existing networks were built to connect phones, PDAs, and other information appliances, hitherto unconnected devices and machines are set to benefit from these networks with the advent of M2M communications. Also, widespread coverage, better and faster transmission rates of existing wired and wireless networks, coupled with low costs, are driving rapid growth in the number of devices which are able to connect to an available network.
- 1.7 M2M is a key component of the evolving Internet of Things (IoT) revolution. The terms M2M and IoT are not interchangeable. In fact, M2M is a sub-set of IoT. IoT refers to the inter-connection of many devices and objects utilising internet protocols that can occur with or without the active involvement of individuals using the devices. The IoT is the aggregation of many M2M connections. M2M connections form part of the IoT, along with big data analytics, cloud computing, and sensors and actuators that in combination can run autonomous machines and intelligent systems.²
- 1.8 Few ways in which IoT is changing the world³:
- ◆ **Agriculture:** Farmers have begun employing high tech farming techniques and technologies in order to improve the efficiency of their

² <http://ec.europa.eu/eurostat/documents/42577/3222224/Digital+economy+outlook+2015>

³ <http://telecom.economictimes.indiatimes.com/news/six-ways-iot-is-changing-the-world/56057726>

day-to-day work.⁴ For example, sensors placed in fields allow farmers to obtain detailed maps of both the topography and resources in the area, as well as variables such as acidity, humidity and temperature of the soil. They can also access climate forecasts to predict weather patterns in the coming days and weeks.

- ◆ **Healthcare:** The IoT is slowly allowing the health care industry to reduce its dependency on humans (and hence the associated human errors). IoT is steadily improving health care, comforts to the elderly by reducing hospital visits through remote monitoring and providing early diagnosis and treatment of serious issues.⁵
- ◆ **Manufacturing:** Manufacturing is the biggest industry being impacted by IoT. IoT in manufacturing not only enables automated production processes, prediction of preventive maintenance, but it also gives insight on how to make the entire system work more efficiently.
- ◆ **Energy:** Across the entire energy industry, the IoT is impacting in two ways: safety and efficiency.⁶ Utility companies are beginning to use smart meters. The two way communication of smart meters give utility companies the necessary data to predict demand better, spot outages, and help the company know when to schedule repairs.
- ◆ **Retail:** Retailers are beginning to use Bluetooth beacons in their stores to better reach their customers and offer personalised discounts. Beacons can help keep current customers by creating a more engaging in-store experience. With these beacons, retailers can navigate customers through a store, find what they want and maybe get a few perks for their efforts.
- ◆ **Transportation:** From supply-chain logistics to public transit, IoT solutions are being used in transportation to better business in many ways. For example, by connecting shipping vehicles with sensors to monitor temperature can help ensure goods, especially food, arrive in a

⁴ <http://www.businessinsider.com/internet-of-things-smart-agriculture-2016-10?IR=T>

⁵ <https://www.link-labs.com/iot-healthcare/>

⁶ <http://www.iottechexpo.com/2016/09/smart-cities/iot-changing-energy-industry/>

safe condition. Sensors and smart software can be used to collect data that can help the driver operate the vehicle in a manner that helps save fuel.

- 1.9 Although forecasts indicate a significant opportunity in the field of M2M communication this industry is still in a nascent stage. The M2M ecosystem is composed of a large number of diverse players, deploying innovative services across different networks, technologies and devices. Providing clarity and consistency of regulation for equivalent services, as well as policies that enable growth, will play a significant role in fully capturing its opportunity to stimulate this market.

Government of India's policy and initiatives

- 1.10 Recognizing the potential of IoT/M2M, emphasis is laid in NTP-2012 as: *“To facilitate the role of new technologies in furthering public welfare and enhanced customer choices through affordable access and efficient service delivery. The emergence of new service formats such as Machine-to-Machine (M2M) communications (e.g. remotely operated irrigation pumps, smart grid etc.) represent tremendous opportunities, especially as their roll-out becomes more widespread.”*
- 1.11 Launch of various government programs such as “Digital India”, “Make in India” and “Startup India” will also help immensely in driving the growth of the M2M/IoT industry in the country. In addition, many mega projects have been undertaken by the Government of India, which will help in the effective and sustainable utilization of resources by the application of M2M/IoT technology. Some of the major projects are as follows:
- a) Development of 100 Smart cities proposed by Ministry of Urban Development
 - b) Setting up of 14 Smart Grid pilots by Ministry of Power

- c) Mandating the commercial passenger vehicles of more than 22 seating capacity, to be equipped with GPS, emergency calls etc. by Ministry of Road transport.

1.12 Ministry of Electronics and Information Technology (MeitY) has released a 'Draft Policy on Internet of Things – 2015'. The objectives of this draft policy are as follows:

- i. To create an IoT industry in India of USD 15 billion by 2020. This will also lead to increase in the connected devices from around 200 million to over 2.7 billion by 2020. As per Gartner Report, the total revenue generated from IoT industry would be of USD 300 billion and the connected devices would be 27 billion by 2020 globally. It has been assumed that India would have a share of 5-6% of global IoT industry.
- ii. To undertake capacity development (Human & Technology) for IoT specific skill sets for domestic and international markets.
- iii. To undertake Research & development for all the assisting technologies.
- iv. To develop IoT products specific to Indian needs in the domains of agriculture, health, water quality, natural disasters, transportation, security, automobile, supply chain management, smart cities, automated metering and monitoring of utilities, waste management, Oil & Gas) etc.

1.13 In May 2015, Department of Telecom (DoT) published the “National Telecom M2M Roadmap” after seeking inputs from certain stakeholders from the industry. The Roadmap focuses on communication aspects of M2M with the aim to have interoperable standards, policies and regulations suited for Indian conditions across sectors in the country. In addition, Telecom Engineering Centre (TEC) of DoT has also come out with 9 technical reports on M2M detailing sector specific requirements/use cases to carry out gap analysis and future action plans with possible models of service delivery.

1.14 The DoT through its letter dated 5th January, 2016 (Annexure I), has sought the recommendations of TRAI on three aspects related to M2M communications:

- ♦ Quality of Service in M2M Services
- ♦ M2M Roaming Requirements
- ♦ M2M Spectrum Requirements

1.15 The Authority, while formulating the Consultation Paper (CP), apart from the specific issues referred by DoT through the reference, realised that certain other regulatory aspects including policy and licensing framework for M2M service providers, various technical challenges in implementation, allocation and utilization of various network codes, data protection, and privacy issues also need to be deliberated. Therefore, these issues were also included in the CP. However, the Authority had noted that DoT/TEC is already working on KYC norms, inter-operability and numbering of M2M devices in consultation with the industry. Therefore, these issues were not raised for consultation.

1.16 TRAI issued the CP on 18th October 2016 titled “Spectrum, Roaming and QoS related requirements in Machine-to-Machine (M2M) Communications’ raising specific issues for consideration of stakeholders. On account of M2M communication being an upcoming vertical covering variety of issues the stakeholders requested the Authority to extend the last date for comments and counter comments. Accordingly, considering the requests received from the stakeholders, the last date for submission of written comments was extended upto 6th December, 2016 and for counter-comments upto 14th December, 2016. The industry associations sought further extension of time for sending their comments due to cross-sectoral impact of M2M and IoT. TRAI also wrote to all the State governments/Union Territories (UTs) and various Ministries of Central government seeking their inputs for the sectors those are foreseen to get

impacted with the deployment of M2M devices. Inputs from wider consultation with State governments/UTs and various Ministries would be valuable in forming a comprehensive recommendation by the Authority. Accordingly, the last date for submission of written comments and counter-comments was further extended to 12th January, 2017 and 19th January, 2017 respectively.

- 1.17 In response to the CP, TRAI received 42 comments and 03 counter comments from stakeholders. These were placed on the TRAI website www.trai.gov.in . Considering the complex nature of the subject and involvement of multi-sectoral entities, the Authority decided to conduct two Open House Discussions (OHDs) with stakeholders. The first OHD was conducted at Delhi on 7th April 2017 and subsequently another OHD was conducted at Mumbai on 26th May 2017. After analyzing various issues involved and also considering the comments received from stakeholders in their written responses and during the OHDs, the Authority has finalized these recommendations.
- 1.18 For drafting this recommendation, various documents available in the public domain, published by government agencies/departments, telecom regulators in many countries, research agencies/institutions, academic institutions, telecom vendors, operators and international agencies/forums etc. were referred with the purpose to make the recommendation balanced and comprehensive. Excerpts from certain documents, which had domain relevance, are also included in this recommendation.
- 1.19 The recommendations comprise of five chapters. Chapter-II discusses the Policy framework and technical aspects of M2M. Chapter-III covers the Spectrum, Roaming and QoS aspects for M2M in the country. Chapter-IV touches upon the Data Security and Privacy challenges in M2M ecosystem. Chapter-V lists a summary of the recommendations.

CHAPTER II: POLICY FRAMEWORK AND TECHNICAL ASPECTS OF M2M

- 2.1 M2M communication is in its infant stage world over with certain countries having implemented it in a modest way. The benefits this revolutionary technology can have in the way we live and its cross sector impact has been well understood by international organizations and telecom sector regulators world over. It is expected that in the next 10-15 years, M2M communication will percolate to all facets of human life and will be a game changer for the industry and the economy at large. It is vital to have a policy framework in place, well in time, to foster the M2M communication so that complete benefits of this innovation can be passed on to the citizens. The orderly growth of this sector will demand cross sector policies and regulatory framework.
- 2.2 In the CP, a question was raised as to what should be the framework for introduction of M2M service providers (MSP) in the sector. The Authority sought stakeholders' opinion on whether there is a necessity for amendment in the existing licenses of access service/ISP license and/or licensing authorization in the existing Unified License and UL (VNO) license or it should be kept under OSP Category registration or any other regulatory framework is required for M2M Service providers.
- 2.3 In response, many stakeholders are of the view that M2M services should be allowed to be provided only under UL/UL (VNO) license. Many of them are of the view that since M2M communication services are already being provided by TSPs under their UL/UL (VNO) for the last few years, it should continue to be provided under the UL or a new chapter may be added to their existing license. Some stakeholders have argued that entities who want to resell M2M mobile services and who have created local networks or Platforms and require access to Public Networks for enabling the end-

to-end M2M communication can obtain UL (VNO) License as the reselling of Telecom Services is only allowed in VNO framework.

- 2.4 These stakeholders has cited numerous reasons in their support stating that the underlying network infrastructure for M2M and P2P communication is same; therefore, M2M communication is a Telecom service that comes under the ambit of Indian Telegraph Act. These stakeholders has also mentioned that Authority's recommendation on 'Introducing Virtual Network Operators in telecom sector' dated 1st May 2015 has acknowledged that a system integrator providing the M2M service can acquire a VNO license and get into an agreement with a TSP for such services. One stakeholder has mentioned that if service providers providing M2M services are kept under category of UL/UL (VNO), it will make them accountable for the security & QoS.
- 2.5 The stakeholders having disagreement with registration regime for M2M have further stated that the ecosystem of M2M service is complex, a new entity under OSP category registration may not be able to execute the entire responsibilities in smoother way and it is required to avoid haphazard growing of M2M service providers with unproven track record who can make it more or less an unorganized sector. One stakeholder has pointed that M2M service provider (MSP) Registration does not have any legal sanctity under the governing laws stipulated under the Indian Telegraph Act 1885.
- 2.6 Some stakeholder also added that under a valid registration certificate (say OSP registration); the customer/party can only operate a particular service or platform only for its own use and cannot further resell it. And if M2M Services are allowed under a Registration, it will create a regulatory and revenue arbitrage between UL/UL (VNO) and MSP for offering same services. One of the stakeholders has also highlighted that there are issues of mobility, numbering, roaming and interoperability with M2M Services,

while OSPs do not involve/face these issues. One of the stakeholders requested the Authority to consider recommending to DoT to issue separate KYC guidelines for M2M, which by virtue of the secure nature of communications and the cross industry nature of the market, warrant a simpler KYC process.

2.7 According to some stakeholders, M2M ecosystem typically has device management, connectivity management, application management and analytics. Out of all the elements, TRAI should regulate only the connectivity provider in the complete M2M value chain. Connectivity can be provided by using licensed band or unlicensed band. Connectivity provider using licensed band are already regulated through UL/UL (VNO) license. For those connectivity providers who use unlicensed band, they suggested to have registration regime. The stakeholders opined that majority of M2M services globally are not being offered on telecom resources (licensed). Many new approaches are experimented and adopted. There can be many local instances in M2M communication in which services (short range applications) are provided using unlicensed band. In such cases the communication remains local and not gets onto any public network. However, short range applications on RFID, ISM band are not covered under licensing norms in India. The stakeholders therefore suggest that the ISPs and TSPs are regulated entities under the current law. It is essential to put in place and define a regulatory framework for unlicensed spectrum band.

2.8 One stakeholder suggested to have amendment to the existing policy framework for the unlicensed bands to allow M2M/IoT equipment to operate on the condition that it comply with the international standards such as FCC Part 15-247 and EN 300 220. It also states that in US, Mexico and European countries, companies can provide services without license if they comply with standards.

- 2.9 Another stakeholder proposed that for M2MSP, who are offering connectivity management, should have regulatory obligation to register through an online self declaration process with periodic updates. Information regarding frequency band being used, possible range, power and expected device density could be indicative information that maybe provided by the entity responsible for connectivity management of the devices. It should be the responsibility of the entity to ensure that the communication is local and does not get onto any public network. In this context it is important to mandate obligations for reporting any security breaches that may happen on the platform with details of action taken.
- 2.10 One stakeholder, with the assumption that M2M service provider is an entity that takes telecom resources from TSPs to provide M2M services, has suggested having licensing for M2MSP. According to the stakeholder, the M2M value chain will primarily include three or four elements. The backbone of the M2M communications will be provided by the Communication service provider; the application/platform service provider and cloud service provider, also called M2M Service Provider (MSP) would be the second constituent of the M2M communication value chain, with the end-user being the final end of the chain. In between the end-user and the application/platform service provider, there can be an additional layer of M2M user or M2M bulk user. As most of the M2M communications will be over data only devices, the primary network requirement will be of data services only. In India, this comes under the scope of access services and Internet services authorizations, as defined in the Unified Licence issued under the section 4 of Telegraph Act 1885. Entity already providing these services should not require any other license to operate end to end M2M services.
- 2.11 This stakeholder expressed that the M2M service provider offering cloud, application/platform (common service layer) plays important roles in M2M

communications, as it communicates, stores, and processes vital information, it should not be left out of the regulatory oversight. These service providers may be permitted to offer their services only in association with a Unified License holder with Access/Internet services/Virtual Network Operator authorization. In case the MSPs wish to offer their services on a standalone basis then they should be brought under the licensing regime by introducing a new chapter on M2M service providers under the Unified License. This will ensure that the existing security obligations under the license will be complied with. Requirements for the new MSP authorization should be the same as applicable under such Licenses.

- 2.12 Contrary to the idea of a licensing regime for M2MSP who takes telecom resources from TSPs to provide M2M services, some stakeholders have suggested a simple registration process that includes a light-touch regulation for M2MSP/M2MAP, if they are not already covered under any DoT prescribed license guidelines.
- 2.13 According to these stakeholders, the role of M2MSP is that of an entity that bundles various components needed for an M2M application (e.g. buys connectivity from an MNO or MVNO, designs and manufactures or acquires a telematics device, develops software, provides a data center and a help desk, develops sensors, and designs the whole of it) and markets the resulting product or service. Connectivity is just a part in the entire value chain of IoT/M2M. Generally, the MNOs provide the connectivity part of the M2M service as a telecom operator along with the SIM provisioning and related billing services. M2MSP would always be using the underlying TSP's network for connectivity which is based on global best practices for reliability, security and privacy. Any other party in the supply chain is merely a subcontractor of the product manufacturer. The product manufacturer is regulated by rules on product safety and

homologation and should not be further regulated as one who merely uses the connectivity of an MNO for its own internal purposes.

- 2.14 The stakeholders expressed that the MNO, as the network operator providing the telecommunications service may properly be subject to regulation as a telecom provider, but the manufacturer who incorporates the service into its product or uses the service for its own internal purpose should not be subject to any telecom regulation. Moreover, the telecom license can only regulate the underlying connectivity which is already part of the license provided to mobile operators. There is no need for subjecting the entire value chain to licensing. The M2MSP is a non-network service provider. Consequently, no license should be prescribed for M2MSP.
- 2.15 However, if any regulation is required then all M2MSP utilising telecom facilities from authorized TSPs should be governed by light touch regulations like a registration policy as is in the case of OSP registration with some additional mandatory obligations. A registration based regime should serve as a means to collect statistical information for identifying the number of M2M players in the industry. The registration requirement for M2MSP should be in the form of a simple intimation or a notification. There should not be any requirement to register SIM to facilitate deployment and ease of registration requirements.
- 2.16 One stakeholder opined that there are far too many stakeholders involved in the M2M chain apart from MNO/MVNO like System Integrator (SIs), software developers, vendor companies, solution providers, distributor or sellers, etc. To require registration by each of them would result in a vast bureaucracy, drive up social costs unnecessarily and undermine efficiency. None of these entities should be required to register with DoT. If M2MSP registration is required, then it is the enterprise that first puts the wirelessly enabled finished good on the market in India who should be responsible to register as an M2MSP and to pass along, through its supply

chain, requirements for reporting information needed to satisfy its KYC compliance requirements. Moreover, the definition of an M2MSP should be limited to the provision of M2M services to third parties. This distinction would exclude the need for M2M devices used exclusively internal to an organization (i.e., not sold as a product to a third party). Unless the M2MSP provides a service to a third party, many businesses using M2M applications for self-use could be unnecessarily subject to registration.

2.17 One stakeholder has further elaborated that the current definition of the OSP Category covers all the applications that may be used in M2M solutions and it may be the ideal category to retain for M2MSP. Another stakeholder has stated that M2MSP must however be subject to all the Security norms and regulations as applicable to licensed Service Providers.

2.18 The stakeholders supporting registration mechanism for providing M2M services have cited various reasons in support of their thought. These stakeholders opined that M2M is a complex market. It is appropriate to describe it as an amalgam of multiple technologies. Customers need a partner that can help them with all stages of their deployments - whether it is the choice of hardware module, application design, or integration with existing infrastructure. Additionally, professional services and operational support tools should be available to deliver a compelling customer experience. All of these areas need a partnership approach. There should be approach of a 'Solutions Provider' instead of a 'Services Provider' approach, which may best be done by the OSP. One stakeholder has submitted that to ensure a level playing field and apply the conditions of 'same service same rules' for all, it is proposed that regulation for M2MSP to be introduced in the form of 'Registration'.

2.19 The stakeholders supporting registration mechanism gave numerous reasons for disagreeing with a licensing regime for M2M service provider. One stakeholder has stated that a reason for licensing M2M may be the

fact that there is the use of a scarce natural resource viz. spectrum involved plus licensing guarantees an interference free operation. Also, number allocation being involved suggests licensing is a prerequisite but there would be thousands of such Service providers across different verticals; it would be practically infeasible to administer and manage the process of licensing. One stakeholder expressed that there is need for identification of M2MSP as a separate entity to provide and manage end to end M2M horizontal IoT platform services based on the oneM2M standard.

2.20 One stakeholder has opined that keeping registration optional or mandatory only to a specific class of services would be appropriate. Mandating registration will also negatively impact the application providers that do not have any presence in India and solely offer their services over the application layer. Such a condition will be problematic given that many M2MSP will be unable to adequately disclose the nature of services and their registration may fall outside the actual description disclosed.

2.21 The stakeholders in disagreement with a licensing regime for M2M service provider has also put forth that M2M/IoT services are the application services which will ride on the access services/internet access being provided by the TSPs and ISPs respectively. The nature and character of the services does not get covered under Section 4 of the Indian Telegraph Act. M2M is inherently a global business which requires regulatory policies to reflect the global essence and recognize as well as facilitate cross border data flow amongst many other requirements. There are inherent restrictions in voice related licensing framework, which do not always permit free flow of cross border data. Moreover, Machina Research in 2016 has projected that by 2021 there will be merely 8.4% connected devices on cellular connectivity. Since cellular connectivity is projected to be abysmally 8.4%, therefore there is no merit in placing M2M services under

a license. Also, M2M services have very low ARPU. License has huge financial entry cost, recurring license fee and spectrum charges coupled with bank guarantee cost will make the M2M business financially unviable. Requiring M2MSPs to obtain a Unified License or VNO license would result in a regulatory imbalance and a disincentive for efficient deployment of M2M services. Licensing will prevent the entry of new service providers in the M2M space due to inherent advantages of incumbent providers, thus leading to less competition for existing operators.

2.22 The stakeholders also stated that an M2M application/device will work or roam on the connectivity provided by mobile operators (access). The UL (VNO) license restricts multiple MNOs for access services. The existing UL/UL (VNO) license may be amended to facilitate them to provide M2M services, but this may not prevent others to become M2MSP.

2.23 The stakeholders supporting registration for M2M Services have further elaborated that DoT has already identified and proposed a draft framework which is a light touch regulatory based on registration of M2M service provider. At this stage, diverting from registration based framework will lead to contradiction and will cause further delay for rolling out of M2M services in India. In the IoT space, the platform and networks are designed for global deployments and are fundamentally different from traditional networks. M2M services encompass a plethora of other services that have evolved from the IT domain. The prevalent framework for IT domain services is for OSP registration. Since most of the business models for M2M services have a predominance of IT services and that the majority of end user of the M2M services shall be machines, there is a strong case for adoption of the registration framework to be persisted with for M2M Service Providers.

- 2.24 Stakeholders expressed that there is need for close cooperation and liaison between multiple agencies, ministries and stakeholders because M2M Services will be spread across sectors. Regulatory bodies of these sectors must discuss, develop and implement sector specific regulatory sub-framework. They recommended that TRAI should serve as the supervising body for any such coordination frameworks, as communications will be the common link between all sectors.
- 2.25 Some stakeholders are of the view that if any type of light touch framework is envisaged then it should permit Global SIMs used for M2M to be covered by the existing practice of OSP registration. This would be similar to other OSP activities (e.g. call centers), where there is an underlying network operator who has the network license, but the OSP is a non-network operator who still registers its activity with DoT. In this instance, an Indian affiliate of or an entity with a commercial relationship with a global roaming SIM provider would register as an OSP, and then bear responsibility for a high-level KYC compliance for SIMs in India. Few stakeholders opined that the terms and conditions should enable the MSP to obtain numbering resources directly, without any infrastructure requirements or other obligations such as QoS, etc.
- 2.26 One stakeholder opined that since the communications part will always reside with MNO or VNO, the M2M Service Provider should work with the MNOs/VNOs to ensure DoT requirement on KYC/traceability, etc., are met. Notably, quality of service, law enforcement requirements and other regulatory measures are addressed through the MNO network license.
- 2.27 One stakeholder expressed that M2M Service Provider must ensure:
- Compliance to DoT, TEC, TSDSI, IoT and M2M standards
 - Source and integrate telecom resources from authorized TSPs as required for the connected machine and

- Fulfill Machine KYC requirements as recommended in the National M2M Roadmap
- Reasonable and frugal prices for national data access
- Simultaneous/fall back access to alternate machine to machine network technologies such as LoRa, SIGFOX, Z-Wave, WiFi
- Single window integrated service to eliminate device OEMs and Industry players having to go to many access providers
- Maintain an online Portal for OEM and DoT to access Data regarding the M2M Connections [“National M2M roadmap - name and address should be updated on a secured portal, developed by MSP for this purpose or through other suitable on line mechanisms to TSP by M2M service provider”]
- Connection Diagnostics [On Net, On Net with GPRS, GMLC based location]
- Security [eUICC, SIM lock, IMEI lock]
- Ensure proper record of all the devices used in their M2M ecosystem. (User details as well as device details like - IP / MAC address / IMEI, ESN etc).
- Facilitate the traceability and monitoring regarding M2M device & usage
- Maintain details of all the customers of M2M services i.e. physical ownership of the machines fitted with SIMs, shall be maintained by the MSP.
- Update information like details of M2M devices i.e. IMEI, ESN, etc. / Make, Model, Registration number, etc. of the machines (Cars, Meters, POS, etc.) & corresponding physical custodian’s name and address. Changes in the customers and machines details must also be updated by the MSP.
- Ensure the Quality of Service (QoS) as stated by the regulator.
- Follow the regulations related to the disaster management/emergency services as instructed by TRAI.
- Ensure privacy of the users.

2.28 One stakeholder mentioned that IoT can be segmented into critical and massive applications. Critical IoT applications have stringent requirements on availability, delay and reliability; examples include traffic safety, automated vehicles, industrial applications and remote surgery in healthcare. Whereas, massive IoT, on the other hand, is characterized by a very large number of connections, small data volumes, low-cost devices and stringent requirements on energy consumption; examples include smart buildings, smart metering, transport logistics, fleet management. The stakeholder expressed that as M2M comes with a peculiar challenge having two extremes of massive-M2M and critical-M2M and the range in-between, demanding different treatment, there is a need for end to end capabilities to support services with required quality of services and scalability involved from underlying network and M2M enablement layer.

2.29 Further, the stakeholder opined that M2M communications is different from other mobile network communication (Human-to-Human communications) services as it involves potentially very large number of communicating devices with, to a large extent, little traffic per device. Also, more and more M2M devices using a connection with a Mobile Network Operator (MNO) will result in expansion of the M2M traffic share from the total mobile traffic volumes. M2M traffic can in some circumstances put enormous strain on mobile network infrastructure and, in severe cases, can disrupt or diminish the capability and quality of service the MNO can offer to not only M2M devices but also other human end users. As a consequence, this could result in following network congestion situations:

- ♦ Radio Network Congestion: Radio network congestion because of mass concurrent data transmission takes place in M2M applications.
- ♦ Core Network Congestion: When a high number of M2M Devices are sending/receiving data simultaneously, data congestion may occur in the mobile core network or on the link between mobile core network and M2M Server where the data traffic is aggregated.

- ♦ Signalling Network Congestion: Congestion in the signalling network is caused by a high number of M2M Devices trying almost simultaneously to attach to the network or to activate/modify/deactivate a connection. Also some M2M applications generate recurring data transmissions at precisely synchronous time intervals (e.g. precisely every hour or half hour). Hence, the network should be able to deal with small amount of data when transferring without generating an overhead.

The stakeholder suggested that to avoid a large number of active M2M devices disrupting the MNO's capability and quality of service to not only M2M devices but also other end users, a number of guidelines must be formulated for M2M service providers and Home Operators, Serving Operators, M2M device manufacturers and application developers.

2.30 One stakeholder proposed that in order to secure the global play e2e interoperable, uniform, affordable and secure M2M eco-system, India should follow the global cloud platform architecture for M2M Platforms to ensure economies of scale and reach. The key requisite to ensure a massive global play necessitates that fragmentation at various layers is avoided. A fragmented ecosystem would entail complex connectivity across the layers including congestion at signaling, core and access network of MNOs/TSP.

Analysis

A. Regulatory Framework

2.31 M2M ecosystem⁷ is very complex and is entirely different from the standard telecom ecosystem. It is more diverse and involves multiple stakeholders. Connectivity provider forms an important part of this complex ecosystem. In order to derive a regulatory framework which adequately address and foster each of the incumbent players in the M2M

⁷ ANNEXURE II :M2M ecosystem

ecosystem, it is necessary to understand all the layers involved and their interplay and interdependence.

2.32 The M2M/IoT ecosystem⁸ typically consist of –

- I. Device Manufacturer/Provider: The device provider is responsible for devices providing raw data to the network provider and application provider according to the business model. This category will encompass the M2M chip-set manufacturer, the M2M module manufacturer and the end device manufacturer (for e.g. a car manufacturer or an air conditioning manufacturer) who integrates the M2M module in his device).
- II. Connectivity/Network provider: The network provider/ operators are the connectivity providers who own the underlying network to provide connectivity and related services for M2M Service provider. In particular, the network provider can perform the following main functions:
 - access and integration of resources provided by other providers;
 - support and control of the M2M/IoT capabilities infrastructure;
 - Offering of M2M/IoT capabilities, including network capabilities and resource exposure to other providers.
- III. M2M service provider (MSP): It is an entity that provides M2M Common Services ⁹ (registration, discovery, security, group

⁸ITU-T (REC Y.2060 Overview of the Internet of things):

<https://www.itu.int/rec/T-REC-Y.2060-201206-1>

oneM2M (Technical Specification - Requirements):

http://www.onem2m.org/images/files/deliverables/Release2/TS-0002-Requirements-V2_7_1.pdf

oneM2M (Technical Specification - Common Terminology):

- https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwit7s_e6_fPAhVLP48KHQvIAiQQFggdMAA&url=http%3A%2F%2Fwww.onem2m.org%2Fcomponent%2Frsfiles%2Fdownload_file%2Ffiles%3Fpath%3DoneM2M_Showcase%25255ConeM2M_Service_Layer_Platform.pdf%26Itemid%3D122&u_sg=AFQjCNFDvn4E6z-Y5Gx4yvDPc7ECAtXjLw&sig2=cdBHcLjxkjiGSOuYMfv0yg
- http://www.onem2m.org/images/files/deliverables/Release2/TS-0011-Common_Terminology-V2_4_1.pdf

⁹ http://www.onem2m.org/images/files/deliverables/Release2/TS-0001-%20Functional_Architecture-V2_10_0.pdf

management, data management & repository, subscription & notification, device management, application & service management, communication management, network service exposure, location, service charging & accounting) to Application provider. DoT has defined M2MSP¹⁰ as an entity that collects and analyse data from M2M devices and platforms. Authority has used the abbreviation of MSP to indicate M2M service provider in this recommendations. Many stakeholders have used the abbreviation M2MSP, which is one and the same.

- IV. M2M Application provider: It is an entity that realizes the service logic of an M2M Application and utilizes capabilities/resources provided by the network provider, device provider and M2M service provider, in order to provide M2M applications to end users.
- V. End user: Individual or company who uses an M2M solution.

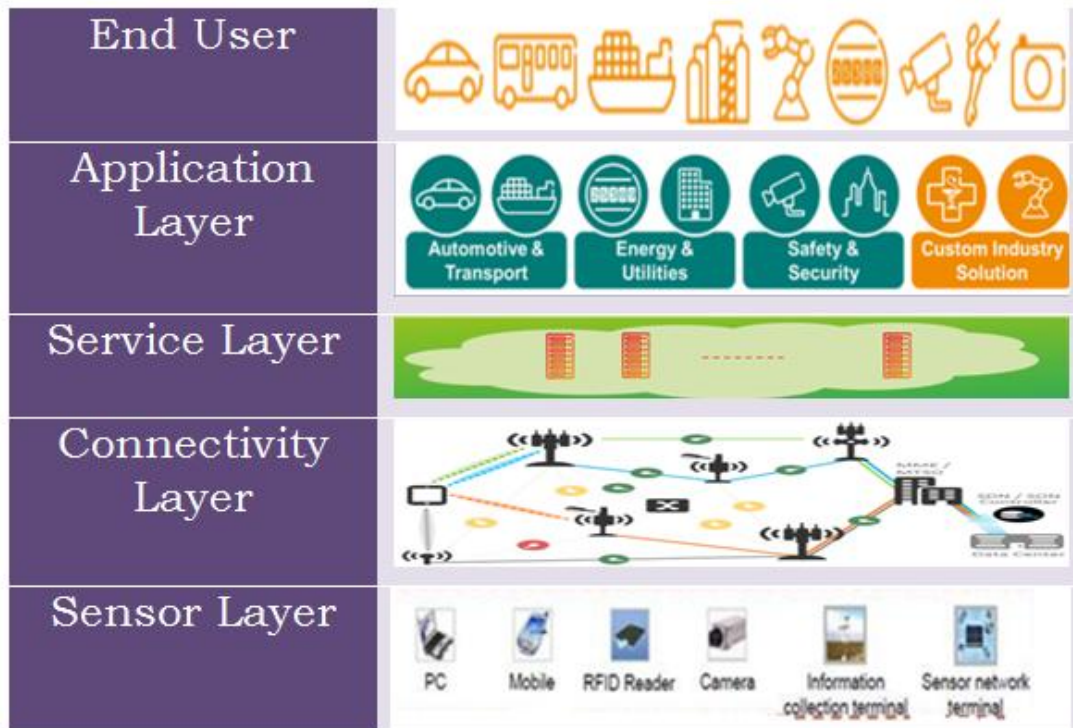


Figure 2.1: M2M ecosystem

¹⁰ <http://www.dot.gov.in/sites/default/files/National%20Telecom%20M2M%20Roadmap.pdf>

2.33 It is however pertinent that M2M market experiences an orderly deployment and growth in the country. An orderly growth will accrue direct and indirect benefits to all the stakeholders, mainly the consumers. The entire ecosystem has to be brought up cohesively and should add value to the citizens using such services as well as contribute to the economy of the country. Due to the complex nature of M2M ecosystem, regulations cannot be 'one-fit-for-all' for all the layers. The conceptual architecture of M2M depict that network connectivity is an essential element of the entire gamut, however, the proportionate value of connectivity/network part is relatively minuscule in comparison to the entire ecosystem. The network part can either be wired or wireless medium, shall cater as infrastructure for transport and exchange of data/information between multiple layers. Most of the customization and innovations in M2M segment will take place in the area of delivery of services, thus mostly concerning with devices and applications. Therefore, each layer of M2M ecosystem has to be uniquely addressed while deliberating on the regulatory framework.

Regulatory Framework for Connectivity Provider

2.34 Connectivity provider plays a central and critical role in the M2M ecosystem. In general, the M2M ecosystem has two networking landscapes; connectivity using licensed spectrum which are mainly provided by Mobile Network Operators (MNOs) or Mobile Virtual Network Operators (MVNOs) and connectivity through unlicensed spectrum.

2.35 The Authority has highlighted in the CP that various wired and wireless technologies can be leveraged for M2M communication. Some of the wireless technologies are mentioned in Table 2.1. Generally, the technologies in WPAN, WLAN, HAN, LPWAN, use unlicensed spectrum whereas in WAN, licensed spectrum is used.

Table 2.1: Wireless technologies

TYPE OF NETWORK	TECHNOLOGIES
Wireless-Personal Area Network (WPAN)/ Wireless-Local Area Network (WLAN)	INSTEON, IrDA, Bluetooth, BLE, Z-Wave, Zigbee, Body Area Network RFID, WiSUN, Wi-Fi
Wide Area Network (WAN)	GSM, CDMA, WCDMA, LTE, Satellite communication, LTE-A
Low Power Wide Area Network (LPWAN), <i>specifically designed for Machine-type communication (MTC)</i>	Sigfox, LoRa, Weightless, Ingenu, SilverSpring's Starfish, Cyan's Cynet, Accellus, Telensa, Waviot

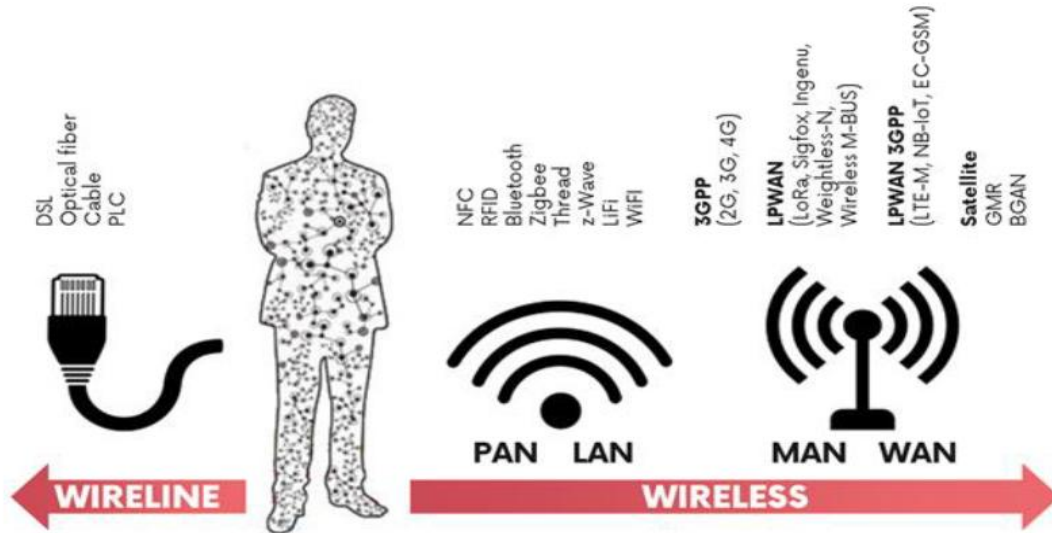


Figure 2.2: A plethora of technologies to satisfy a multitude of IoT's connectivity needs¹¹

2.36 The mobile network has grown exponentially in the country in the last decade. As on May 2017,¹² there are 665622 2G BTSs, 27341 CDMA BTSs, 348464 3G Node Bs and 461408 4G/LTE eNode Bs operational in the country. Moreover, due to governments' as well as private initiatives, the rollout of optical fiber has increased, to support high speed internet.

¹¹ http://www.arcep.fr/uploads/tx_gspublication/white_paper_loT-01-mapping-071116-eng.pdf

¹² According to the data submitted by TSPs to TRAI

Also, the International Internet bandwidth owned by various service providers is reported to be 2,600 Gbps during the quarter ending March-2017 as compared to 2,028 Gbps during the previous quarter¹³. Thus, the telecom network is a ready infrastructure that can be leveraged for providing connectivity and services in M2M. Moreover the telecom access technologies are rapidly evolving to meet the requirements of M2M communication/IoT, for example, narrowband IoT (NB-IoT) is a new cellular access technology, specifically tailored to form an attractive solution for emerging low power wide area (LPWA) applications. The QoS parameters for these technologies are measurable and enforceable. Operation in licensed spectrum also provides predictable and controlled environment, which enables efficient use of the spectrum to support massive volumes of devices. Thus, incumbent telecom operators are natural candidates for providing connectivity and services in M2M sector. However, the TSPs should harness the ready availability of their networks, all over India, to provide M2M connectivity and services. The telecom operators (ISPs/TSPs) viz. CMTS, UASL and UL holders can either offer customized M2M services on their own or they can lease out the resources to resellers. The resellers of telecom services in the country are covered under UL (VNO) licensing regime.

- 2.37 Globally, the network operators are aggressively trying to garner M2M/IoT space, which will eventually add to their revenues even though the average revenue per connection (ARPC) in M2M services is quite low in comparison to conventional voice and data business. Machina Research report sponsored by Cisco on ‘Service Provider Opportunities & Strategies in the Internet of Things’¹⁴, has provided the scale of the top ten service providers in global IoT, by cellular connections. The report indicated that leading global players such as Vodafone and AT&T reported nearly 20 million M2M

¹³ http://www.trai.gov.in/sites/default/files/Indicator_Reports_050720174.pdf

¹⁴ <http://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/mobile-internet/service-provider.pdf>

connections each at the end of 2014 and AT&T indicated over a year ago that revenues for the M2M unit were already in excess of USD 1 billion.

- 2.38 Globally both licensed and unlicensed spectrum is used for offering M2M services. M2M deployments using unlicensed spectrum is substantial. The large scale adoption of Bluetooth for wearable devices is one such example, where, network is not based on licensed spectrum. Many new approaches ¹⁵, for example, LPWAN technologies viz. LoRa, SigFox, Weightless-N; WPAN/WLAN technologies viz. INSTEON, IrDA, Bluetooth, BLE, Z-Wave, Zigbee, WiSUN and other proprietary mesh networks, which are specifically designed for machine-type communication (MTC) and that use unlicensed spectrum, are being experimented and adopted.
- 2.39 The Authority is of the view that licensee having licensed spectrum have certain exclusive rights in terms of usage and are also shielded for any interference etc. In contrast unlicensed spectrum user has no exclusive rights on the spectrum resource and thus guarantee of access and minimum QoS parameters are difficult to achieve. Service providers using unlicensed spectrum has no administrative control and thus has to bear all issues related to QoS, congestion etc. without any remedy from licensor/regulator. Keeping in view administrative and technical aspects and issue of SUC; unlicensed and licensed spectrum operations cannot be equated. “One size fits all” regulatory framework cannot be made applicable to both the connectivity providers (licensed and unlicensed) in M2M sector. Accordingly, there should be a separate mechanism to regulate the entities providing M2M services using only unlicensed spectrum.
- 2.40 Connectivity providers using licensed spectrum (TSPs/ISPs) are already under regulation through Unified License (UL) and UL (VNO). The existing

¹⁵ Description about the LPWAN and WPAN technologies were covered in the Consultation Paper

Unified License (UL) and UL (VNO) should be amended to incorporate M2M communication as another type of access service. Also, there should be no need for incumbent license holders to re-apply for the license to extend M2M communication. However, connectivity providers using unlicensed bands are not covered under regulation. It is essential to put in place and define a regulatory framework for them.

2.41 Generally, technologies in WLAN/WPAN are used to provide short range applications between devices in which communication remains local and do not get onto any public network. Since unlicensed spectrum is used and communication remains local, it is not mandatory for these connectivity providers to obtain license.

2.42 However, in the future, in M2M communication ecosystem, apart from licensed connectivity providers, there would be many connectivity providers who will be using technologies in WLAN/WPAN operating in unlicensed spectrum for commercial purposes. For example -M2M home network system: home security sensing, lighting control, HVAC (heating, ventilation and air condition) systems, medicinal gadgets etc. will be based on WLAN/WPAN technologies. In order to avoid, haphazard growth of these connectivity providers and to have administrative control over them, they should be covered under light touch regulation i.e. Registration. They can register through an online self declaration process which should be periodically updated. Information regarding frequency band being used, possible range, power and expected device density could be indicative information that maybe provided by these connectivity providers. It should be the responsibility of the connectivity provider to ensure that the communication is local and does not get onto any public network. However, in some cases, these WLAN/WPAN technologies would require backhaul internet connectivity, to make the connection accessible to the application server or cloud. Unlicensed connectivity providers can have

mutual agreements with licensed connectivity providers to get connected to their servers/cloud. Registration for these connectivity providers would also serve as a means to collect statistical information for identifying the number of such connectivity providers in the industry. Moreover, the online registration will create a database which may be used by the connectivity providers to manage effective spectrum sharing in unlicensed band which will result in high QoS. However, when individuals/organizations use WPAN/WLAN for M2M connectivity for captive, non-commercial use, there will be no need for registration.

2.43 The LPWAN technologies viz. LoRa, SigFox, Weightless-N, operating in unlicensed spectrum, have been developed and designed solely for machine-type communication (MTC) applications addressing the ultra-low-end sensor segment, with very limited demands on throughput, reliability or QoS. Operators can provide maximum coverage at the lowest cost by deploying few base stations as possible which will result in minimal backhaul and energy costs.

2.44 Though LPWAN technologies uses unlicensed spectrum, the extent of network deployment is almost similar to licensed TSPs/ISPs. Network providers utilizing these technologies will have their own base stations, aggregation points, and even gateways. The devices in LPWAN can also roam in other LPWAN networks. Thus, the entities intending to provide services exclusively through the evolving LPWAN technologies or equivalent using unlicensed spectrum shall be covered under light touch licensing. A new authorization under existing UL, viz. UL (M2M) which is light touch and with limited obligations should be introduced for connectivity provider using LPWAN technologies operating in unlicensed band. Such licensees should be allowed to bid for licensed spectrum to provide exclusively M2M services. This will provide an option to the service

providers to enter specifically into M2M connectivity domain as the scale ramp up in the next few years.

- 2.45 The LPWAN networks can be deployed in large geographical areas such as Metro cities, states or Pan-India, depending on the business case and market demand. The backend traffic generated through LPWAN networks will be transported to the cloud or servers through internet. Considering different coverage requirements, LPWAN networks can be allowed to be deployed in different geographical areas, viz. National area, Telecom Circle /Metro area and SSA area (for city based coverage). Such areas of operations already exist for ISP licensees under UL. This three layer approach of UL (M2M) license will provide for varying levels of network deployment based on the capability of the provider and market demand. Therefore, UL (M2M) authorisation shall comprise of three categories i.e. UL (M2M) -National area, UL (M2M) -Telecom Circle/Metro area, UL (M2M) SSA/ District area.

B. Critical and non-critical services

- 2.46 M2M services and applications can be differentiated based on its nature as critical and non-critical. A large number of devices and applications in M2M/IoT ecosystem will be non-critical in nature. These devices may be either connected through Personal Area Network (PAN) to a local gateway or there may be SIM based standalone connectivity using cellular network. However, there would be some critical M2M applications that would require robust, resilient, reliable, redundant and secure network. For example, M2M applications in healthcare like remote surgery or a driverless car etc. These kinds of applications require high QoS, ultra reliability, very low latency, very high availability and accountability. If there is any variation in QoS, latency or availability, it can cause substantial damage to customers. It is pertinent that such throughput and

latency sensitive application should run only on robust wired optical fiber, copper network or LTE capable access networks.

2.47 As stated earlier, operation in licensed spectrum has certain exclusive rights in terms of usage and is also shielded for any interference. Also, the QoS parameters are measurable and enforceable. Moreover, the government has administrative control over the licensed connectivity providers. So, critical services should be identified and mandated to be provided by connectivity provider using licensed spectrum. Hence there is a need to identify critical services in which, quality of service, if deficient, could result in serious consequences. Also, the telecom networks should be able to differentiate the critical services from the non-critical services and prioritize the carriage of information on their network based on the critical nature of information.

C. Cross-sectoral impact of M2M

2.48 India has a huge potential for rapid deployment of M2M/IoT services as Government of India (GoI) initiatives viz. Digital India program, Smart Cities, AMRUT etc are M2M/IoT centric. M2M communication services will percolate to various industrial verticals/sectors. The Authority has highlighted in the CP that there will be various types of M2M applications in different industry/verticals. Some verticals and related M2M applications as per industry are given in the table 2.2 below:

Table 2.2: M2M applications

Industry/Vertical	M2M applications
Automotive / Transportation	Vehicle tracking, e-call, V2V and V2I applications, traffic control, Navigation, Infotainment, Fleet management, asset tracking, manufacturing and logistics
Utilities / Energy	Smart metering, smart grid, Electric line monitoring, gas / oil / water pipeline monitoring.
Health care	Remote monitoring of patient after surgery (e-health), remote diagnostics, medication reminders, Tele-medicine, wearable health devices

Safety & Surveillance	Women Safety Bands, Commercial and home security monitoring, Surveillance applications, Fire alarm, Police / medical alert
Financial /Retail	Point of sale (POS), ATM, Kiosk, Vending machines, digital signage and handheld terminals.
Public Safety	Highway, bridge, traffic management, homeland security, police, fire and emergency services.
Smart City	Intelligent transport System, Waste management, Street Light control system, Water distribution, Smart Parking
Agriculture	Remotely controlled irrigation pump, Remote Monitoring of Soil Data

2.49 The customization of services leveraging M2M/IoT will result in experiences that will lead to emergence of new business models specific to a vertical/segment and sometimes it can be cross-sectoral as well. Smart city project is an interesting example of cross-sector M2M/IoT solution. The city is seen as a system of systems- transport, water, energy, etc. Data from these multiple systems are integrated and used by multiple applications in order to offer a holistic view of the city.

2.50 Deployment of M2M communication/IoT networks, which can impact multiple sectors, can be better understood through various use cases. Some use cases are as given below:

- i. **Home Automation:** Numerous IoT-based home management products, such as the thermostats, smoke detectors and security cameras, enable consumers to control devices from virtually anywhere. Support and service notifications for some products can be initiated by the device itself, creating greater customer experiences.
- ii. **Healthcare:** IoT is extending the healthcare provider’s reach by remotely monitoring patient’s heart rate, blood pressure and more. The patient experience is improved through early detection and convenience.
- iii. **Utilities:** Smart Energy meter application enables households to monitor their energy consumption. Graphic displays and analytical tools help

users better manage their energy use. In this case, the M2M/IoT is providing information that enables the customer to better manage services and reduce costs. Automated reminders and suggestions increase customer satisfaction.

- iv. **Self-driving cars:** Multiple trials are underway globally in the field of self-driving cars. However various issues, both legal and ethical, are also being deliberated.
- v. **Entertainment:** Entertainment companies are harnessing the IoT to improve the customer experience using wearable devices. Smart devices such as wristband, captures online profiles of each visitor and can be scanned at park kiosks to access advance ride bookings, receive customer service, etc. The ultimate goal is to increase sales, return visits, word of mouth recommendations, loyalty and brand engagement across channels, activities and time.

2.51 The deployment of M2M and IoT systems in multiple sectors, and their potential impact on individuals and businesses, raises regulatory issues such as licensing, spectrum management, network standards, QoS, data protection, privacy and security etc. Moreover, as the roll out of M2M proliferates and the pace picks up, one can expect a large number of unforeseen issues getting thrown up. Such issues can be sector specific or cross-sector in nature.

2.52 Government/policy makers have a major role to play in shaping market rules that affect M2M/IoT adoption such as appropriate licensing/registration, regulations etc. They have to create a robust and enabling regulatory framework to create sustainable M2M/IoT development and deployments. Moreover, it is incumbent on their part to set out guidelines for data collection, data sharing, use of IoT data, data privacy, data security etc. In addition, they must establish rules about liability and ownership.

- 2.53 Given the nature of the data, proliferation of access points, vulnerability of M2M/IoT-controlled physical assets, the impact of a targeted hacker attack on M2M/IoT deployments will be such that it can give rise to national security risks. Such a risk will have to be managed proactively and in real time.
- 2.54 We are moving towards wireless communications that will support countless emerging use cases and applications with a high variability in their performance attributes. There will be some use cases in M2M sector where devices will only send a few messages, consisting of few bytes, per day such as -temperature information or power consumption information- while others may need to transmit a video stream to guide a relief and rescue operation or a remotely performed medical procedure. Also, the services and applications will be differentiated based on criticality and non-criticality. In this regard, ITU-R finalized in September 2015 its vision for IMT for 2020¹⁶ and beyond, which envisages expanding and supporting diverse families of usage scenarios and applications, including ultra-reliable and low-latency communications (URLLC). The standardization work in 3GPP to support the IMT-2020 requirements in 5G – including the URLLC use case – has been under development. In near future, some of the new applications will demand an end-to-end latency of a few milliseconds, while fields such as wireless automation and control may in addition require reliabilities in terms of ultra-low error rates. Thus, it is a fact that an open, robust, secure and interoperable ecosystem of M2M/IoT will lead to tremendous growth and improvements in quality of life worldwide.
- 2.55 There are issues in M2M sector which are specific to the sectors/verticals. For example - the rules, regulations and data management for automobiles cannot be applied ditto to managing air conditioners or vice versa in M2M

¹⁶ https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-!!PDF-E.pdf

scenario. Data collected by the sensors will be used by multiple applications spread across different sectors. For e.g. Traffic data will be used for traffic management, impact analysis for pollution control and management, by urban development department to study infrastructure adequacy etc. Being cross-sectoral in nature, the challenges in M2M/IoT are not limited to one sector. There are various common issues which have impacts across the entire M2M ecosystem, hence have to be dealt with accordingly.

- 2.56 In order to ensure smooth and efficient roll out of M2M services in our country, there is a need to have co-ordinate efforts by all stakeholders and sectors, especially at the governmental level, rather than working in silos. The multi-stakeholders approach should be used, in which domain experts, government agencies, companies, technology developers etc. from all industry verticals synergise their efforts and information in order to develop standards and rules.
- 2.57 In view of the foregoing, the Authority holds the view that there should be coordinated efforts in managing the M2M/IoT ecosystem with cross sectoral involvement. Domain experts from every vertical which has been considered as potential M2M/IoT market has to get together to address the concerns and also be in advisory role to the policies making bodies of the government. DoT¹⁷ has addressed this issue by forming M2M apex body, M2M review committee and M2M consultative committee.
- 2.58 The Apex body on M2M incorporates participation from heads and senior officials from Ministries and Departments such as Department of Telecommunications, Department/Ministry of Electronics and Information Technology (DeitY), Ministry of Power, Ministry of Road Transport and Highways, Ministry of Health, Ministry of agriculture, Ministry of Urban

¹⁷ <http://www.dot.gov.in/machine-machine-communications>

Development (MoUD), Cyber related representative from National Security Council Secretariat.

2.59 In order to bring M2M industry concerns and regulatory bottlenecks to the notice of Apex body, M2M Consultative Committee has been constituted incorporating representatives from Standardising bodies such as Bureau of Indian Standards (BIS) and Telecom Standards Development Society of India (TSDSI) and sectoral industry representative bodies. Also, in order to support implementation of actionable points evolved from National Telecom M2M Roadmap, M2M Review Committee has been formed under the aegis of Member (Technical), DoT.

2.60 M2M being in its nascent stages will throw up many unforeseen legal and regulatory challenges. Representation of regulatory authorities whose sectors will get impacted by M2M communications like TRAI, Central Drug Standards Control Organization, National Highways Authority of India, Inland Waterways Authority of India, Central Electricity Regulatory Commission, etc. and Ministry of Law and Justice in the Apex body will enable legally sound and sectorally viable policies, rules and regulations being constituted which will foster the M2M ecosystem in the country across all sectors.

2.61 **Accordingly, the Authority recommends that:**

- a) **All access service providers' viz. CMTS, UASL, UL (AS) and UL holders using licensed access spectrum shall be allowed to provide M2M connectivity within the area of their existing authorizations. DoT may suitably amend the license conditions in respective licenses.**
- b) **All Basic Services licensees and ISP licensees shall be allowed to provide M2M connectivity, including on unlicensed band, within the area of their existing authorizations, barring M2M cellular services.**

DoT may suitably amend the license conditions under Basic Service Operators (BSOs) and respective ISP categories.

- c) All UL (VNO) holders shall also accordingly be allowed to provide M2M connectivity as authorized in their existing authorizations. DoT may suitably amend the license conditions of UL (VNO).**
- d) Connectivity provider using WPAN/WLAN technologies for providing M2M connectivity for commercial purposes, operating in unlicensed spectrum, should register with DoT.**
- e) Connectivity provider using LPWAN technologies operating in unlicensed spectrum should be covered under licensing through a new authorization under UL namely UL (M2M). Such licensees should be allowed to bid for licensed spectrum to provide exclusively M2M services, if they desire to provide M2M services in the licensed band.**
- f) UL (M2M) authorization shall comprise of three categories i.e. UL (M2M) Category-A-National area, UL (M2M) Category-B -Telecom Circle/Metro area, UL (M2M) Category -C- SSA/ District area.**
- g) Government, through DoT, should identify critical services in M2M sector and these services should be mandated to be provided only by connectivity providers using licensed spectrum.**
- h) Since M2M is in its nascent stage and needs an integrated national approach on various issues, regulatory authorities whose sectors will get impacted by M2M communications like TRAI, Central Drug Standards Control Organization, National Highways Authority of India, Inland Waterways Authority of India, Central Electricity Regulatory Commission, etc. and Ministry of Law & Justice should also be members in M2M apex body formed by DoT.**

D. Regulatory Framework for M2M Service Provider (MSP)

2.62 As mentioned in para. 2.32, M2M service provider (MSP) is an entity that collects and analyse data from M2M devices and platforms. MSP may also

provide M2M Common Services (registration, discovery, security, group management, data management & repository, subscription & notification, device management, application & service management, communication management, network service exposure, location, service charging & accounting) to Application provider. MSPs are placed under regulated regime in many of the countries. In Singapore M2M Services provider has to apply for SBO (Individual) License. Similarly in many countries MSPs are registered with telecom regulator or licensor to provide the services. Mostly a light touch licensing regime is adopted worldwide for provision of M2M services by interested services providers.

- 2.63 It is necessary that such an entity (MSP) should be covered under regulation either as a licensed entity with certain obligations cast upon it or a registered agency with DoT. But since the MSP is a service provider who doesn't own the network, no license should be prescribed for it.
- 2.64 A registration based regime has been envisaged by DoT in "National Telecom M2M Roadmap 2015"¹⁸ for M2M service providers utilizing telecom facilities from authorized TSPs to address concerns like interface issues with Telecom Service Provider (TSPs), KYC, security and encryption (for the purpose of lawful interception at TSP level). Also, DoT has released M2MSP registration –Draft Guidelines in May 2016. MSP will be governed by DoT guidelines related to communication infrastructure and respective regulations of the Industry vertical in addition to applicable laws of land.
- 2.65 The Authority is in agreement with DoT, to mandate MSPs to register with government under M2M service providers Registration. Registration should serve as a means to collect statistical information for identifying the number of M2M service providers in the industry. Moreover, it may help MSPs to boost their business globally, as registration will provide them

¹⁸ <http://www.dot.gov.in/sites/default/files/National%20Telecom%20M2M%20Roadmap.pdf>

recognition as a registered entity with Government of India. If a connectivity provider (licensed/registered) is also a M2M service provider i.e. connectivity provider is also collecting and analyzing data from M2M devices and platforms, then they should also register with government as MSP.

- 2.66 However, the Authority differs on the fact that a MSP is similar to an OSP. As per New Telecom Policy (NTP) 1999, agencies catering to tele-banking, tele-medicine, tele-trading, e-commerce, etc were allowed to operate by using infrastructure provided by various access providers for non-telecom services under OSP category. In this category Call Centers, both International and Domestic, in the country and services like Network Operation Centers and Vehicle Tracking Systems, were also included. As per the OSP registration terms and conditions, Application Service Providers could take telecom resources from authorized TSPs only and may not infringe upon the jurisdiction of other authorized TSPs and they cannot provide switched telephony.
- 2.67 Unlike MSPs, for OSPs there are no issues of mobility, numbering, roaming, interoperability etc. Also many M2M services are supposed to be mission critical in nature in city operations. Moreover, M2M/IoT services are not only application services which will ride on the access services/internet access being provided by the TSPs and ISPs respectively but also have some definitive challenges in terms of constantly updating personal or sensitive information related to an individual or business.
- 2.68 As per M2MSP Registration –Draft Guidelines May 2016 issued by the DoT, *“At the time of registration, M2MSP shall provide the details of Services in which he will be operating. M2MSP shall provide the details of proposed geographical area of operations, location of their IT setup/ core network at the time of registration.”*

2.69 In addition to this, the Authority is of the view that MSP shall provide the details of the connectivity provider who would be providing connectivity for their M2M application. It is important to note here that there can be more than one connectivity provider depending upon the use case.

2.70 **Accordingly, the Authority recommends that:**

- a) M2M Service Providers (MSPs) should register as M2M service provider as envisaged by DoT. This registration will be exclusive for the MSP and not part of existing OSP registration. Exclusive guidelines for MSP Registration should be issued. MSPs to provide details of the connectivity provider who would be providing connectivity in their M2M application.**

E. Regulatory Framework for Device Manufacturer

2.71 In the CP, the Authority sought stakeholders' suggestion on additional measures, if any, at device level that would ensure security of data in M2M communication.

2.72 In response, some stakeholders submitted that device specific regulatory guidelines should be framed for M2M devices. Guidelines for mobile and WiFi devices (IMEI) can be used to frame these regulatory guidelines.

2.73 Some stakeholders were of the view that it is critical to establish capacity, capabilities and institutions which can do security testing of M2M hardware and software for its secure usage.

2.74 One stakeholder submitted that M2M devices should be tested by certified agency like TEC. Another stakeholder was of the view that sensitive M2M/IoT devices and applications should be certified by an independent public authority (e.g. through separate National Trust Center).

- 2.75 Another stakeholder was of the view that unique identifiers such as IMEIs and ESNs may not suffice to secure M2M as they can be easily tampered with. There is a need to combine other M2M device attributes to strengthen M2M device/sensor level security. Experiment to derive and use device biometric like PUF (an Aadhaar like identified for device) may be considered. Additional security in sensors may be incorporated by IMEI & SIM PAIR LOCKING so that sensor shall work with the SIM configured by MSP. However the reverse is not encouraged i.e. locking by TSP, as it will unnecessarily bind MSP with TSP.
- 2.76 One stakeholder suggested that TRAI should facilitate a regulatory framework, which mandates 3GPP standards for cellular M2M devices. Another stakeholder expressed that the small size and limited processing power of many connected devices could inhibit robust security measures. Also, some connected devices are low-cost and essentially disposable and therefore it may be difficult to update the software or apply a patch.

Analysis

- 2.77 The M2M devices will be generating huge amount of data, at times data which are personal in nature, during its life cycle. One of the points where data security can be compromised is at the device layer itself. Hence, to ensure data protection, “Security by design” principle should be implemented. M2M device manufacturer should also be regulated by rules of product safety.
- 2.78 Earlier there was an issue where IMEI of mobile devices/handsets were duplicated/ cloned. This created roadblock in the implementation of blocking of lost/stolen mobile, posing a serious threat to national security and consumer safety and impacted mobile trade. One of the major reasons, identified for presence of such devices in India was due to import of handsets/devices having duplicated/fake/non-IMEI. With regard to this

issue TRAI, in August 2012, recommended to Department of Commerce the following-

- a. Allow import of only such mobile devices/handsets in India that have obtained a certificate that the mobile devices being imported are having genuine, unique and non-duplicated IMEIs.
- b. Maintain a common database on all ports of entry of such devices (i.e. airports, sea-ports, dry-ports and FPOs) so that duplicated/fake/non IMEI mobile devices are not allowed to enter in the country.

2.79 In order to avoid a recurrence of similar situation in M2M sector, the government should provide similar guidelines for manufacturing/importing of M2M devices to India. It should be mandated to build enough protections in the device which would prevent their take-over and usage to disrupt the traffic. What constitutes reasonable security for a given device will depend on a number of factors, including the amount and sensitivity of data collected and the costs of remedying the security vulnerabilities. Also, since different devices may be subject to different levels of security risks, the guidelines should prescribe a graded level of security certification so that the low risk devices do not have to deal with the burden of the regulation.

2.80 M2M devices that are not being manufactured as per standards can behave in an unexpected or rogue fashion, leading to issues such as signaling storms. Moreover, as most of M2M applications would be operating in unlicensed band, the government should issue specific standards for devices to be used in the M2M ecosystem, in line with international standards organizations.

2.81 In Germany, there is a neutral and independent trust center “TÜViT”¹⁹ for ICT. They assess security and quality characteristics against recognised

¹⁹ <https://www.tuvit.de/en/home/>

criteria and standards. TÜViT evaluations and certifications create the necessary trust in IT products, systems and processes, and in IT infrastructure. Similar to this, for testing and certification of M2M devices and applications (hardware and software), Government should create a National Trust Centre (NTC). Also, only certified devices should be allowed to be used in M2M communication ecosystem.

2.82 Accordingly, the Authority recommends that:

- a) Device manufacturers should be mandated to implement “Security by design” principle in M2M device manufacturing so that end-to-end encryption can be achieved.**
- b) The government should provide comprehensive guidelines for manufacturing/ importing of M2M devices in India.**
- c) A National Trust Centre (NTC), under the aegis of TEC, should be created for the certification of M2M devices and applications (hardware and software).**

F. Entry Fee, Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG) for UL M2M and MSP

2.83 The Authority further has sought comments of stakeholders on the Entry Fee, Performance Bank Guarantee (if any) or Financial Bank Guarantee etc. in case a licensing framework for M2MSP is proposed.

2.84 The stakeholder supporting licensing regime for M2M services has suggested that for the incumbent TSPs holding Access service/ISP licenses, there should not be any additional entry fee, PBG/FBG etc. as M2M is at nascent stage and putting additional entry fee etc. may discourage the incumbent TSPs in offering these services. For new service providers, the entry fee, PBG/FBG etc should be the same as applicable under UL/UL (VNO) Licenses.

- 2.85 In response, some stakeholders who are suggesting registration for M2MSP instead of UL/UL (VNO) license have stated that M2MSP is an entity that takes telecom resources from TSPs to provide M2M services, therefore there should be no entry fee, PBG or FBG. Whereas, one stakeholder stated that should a licensing framework regrettably be proposed, it proposes a waiver for all M2M fees to stimulate the market. This approach would reduce the detrimental impacts of imposing licensing requirements.
- 2.86 Some stakeholders has stated that since it does not recommend any type of licensing framework for MSP, there should be no entry fee, Performance Bank Guarantee or Financial Bank Guarantee. Another stakeholder submitted that the obligations for Entry Fee, Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG), etc. should be similar to OSP registration. Whereas, one stakeholder has stated that as registration similar to OSP category registration is proposed, there should be no Performance Bank Guarantee (if any) or Financial Bank Guarantee etc.
- 2.87 One stakeholder has submitted that TRAI's regulations regarding OSP in context of entry fees and bank guarantee may be applied to MSPs. There shall be no Entry Fee for the MSP's and the Bank Guarantee shall be Rs. 50 Lakhs or Rs. 1 Crore as applicable under section 4(A) or 4(B), Chapter IV of OSP regulations.

Analysis

- 2.88 The M2M market cannot be measured by the same yardstick as consumer voice and data services. Global experience of M2M deployment has brought out that the monthly average revenue per connection (ARPC) for M2M is far lower than the average revenue per user (ARPU) for consumer telecom services. Thus providing connectivity for M2M is an incremental,

cumulative market for TSPs/ISPs. The M2M market grows organically, and is not subject to consumer service marketing hype. M2M, therefore, can be defined by metrics such as scale and margin, and not averages such as ARPU.

- 2.89 For connectivity provider using licensed band, the existing licensing conditions stipulated under CMTS/UASL/UL provides cellular operators to share portion of Adjusted Gross Revenue (AGR) in the form of License Fee (LF) and Spectrum usage Charges (SUC) with the government. Consequent upon KYC norms, numbering resources are available to the TSPs, they will be able to start full-fledged SIM based M2M services. Accordingly, TSPs are liable to pay LF and SUC on account of M2M services, as applicable.
- 2.90 For connectivity provider using technologies in WPAN/WLAN operating in unlicensed band, there should not be any Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG). A nominal fee maybe charged to cover administrative cost.
- 2.91 For connectivity provider using technologies in LPWAN operating in unlicensed band, and having the authorization of UL M2M, the Entry Fee, Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG) should be at par with the provisions made for respective categories under UL ISP. The Authority is of the view that the equivalent of amount prescribed for obtaining authorizations under UL for different ISP categories i.e. ISP Category 'A' for all India as license area, ISP Category 'B' for Telecom circle/ Metro Area and ISP Category 'C' for SSA area shall be applicable for the corresponding authorizations under UL (M2M) Category 'A' for National area, UL (M2M) Category 'B' for Telecom circle/ Metro area and UL (M2M) Category 'C' for SSA area as per the Table 2.3 below.

Table 2.3: Entry Fee, PBG or FBG, Networth, equity for UL (M2M)

Sl. No.	Service Authorization	Minimum Equity (Rs. Cr.)	Minimum Networth (Rs. Cr.)	Entry Fee (Rs. Cr.)	PBG (Rs. Cr.)	FBG (RS. Cr)
1	UL (M2M) "A" (National Area)	Not prescribed	Not prescribed	0.30	2.00	0.100
2	UL (M2M) "B" (Telecom circle/Metro Area)	Not prescribed	Not prescribed	0.020	0.100	0.010
3	UL (M2M) "C" (SSA)	Not prescribed	Not prescribed	0.002	0.005	0.001

2.92 In case of MSP, the Entry Fee, Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG) should be same as envisaged by DoT in “M2M Service Providers Registration –Draft Guidelines May 2016”.

2.93 **Accordingly, the Authority recommends that:-**

- a) **For connectivity provider using technologies in WPAN/WLAN operating in unlicensed band, there should not be any Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG). A nominal fee maybe charged to cover administrative cost.**
- b) **For obtaining authorizations under UL (M2M) Category ‘A’ for National area, UL (M2M) Category ‘B’ for Telecom circle/ Metro area and UL (M2M) Category ‘C’ for SSA area, the amount payable in the form of Entry Fee, PBG, FBG shall be as per the table below-**

Table : Entry Fee, PBG or FBG, Networth, equity for UL (M2M)

Sl. No.	Service Authorization	Minimum Equity (Rs. Cr.)	Minimum Networth (Rs. Cr.)	Entry Fee (Rs. Cr.)	PBG (Rs. Cr.)	FBG (RS. Cr)
1	UL (M2M) "A" (National Area)	Not prescribed	Not prescribed	0.30	2.00	0.100
2	UL (M2M) "B" (Telecom circle/Metro Area)	Not prescribed	Not prescribed	0.020	0.100	0.010

3	UL (M2M) "C" (SSA)	Not prescribed	Not prescribed	0.002	0.005	0.001
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- c) As regard to the case of MSP, the Entry Fee, Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG) should be same as envisaged by DoT in “M2M Service Providers Registration –Draft Guidelines May 2016”.**

CHAPTER III: SPECTRUM, ROAMING AND QOS REQUIREMENTS IN M2M

A. Spectrum

- 3.1 M2M/IoT devices communicate using a range of different protocols, based on their connectivity requirements and resource constraints. It could use both wired and wireless networks. Many of the devices and the services offered through them will require flexibility and mobility and hence would prefer wireless network. These can include short-range radio protocols such as ZigBee, Bluetooth and WiFi; mobile phone data networks, or bespoke networks for M2M like Sigfox, LoRA etc to name a few.
- 3.2 Many research organizations have predicted astronomical deployment of connected devices by year 2020. India will also be an active ground for the deployment of M2M services. Considering the huge deployment of devices, and many of which will be on the wireless domain, there is a need to ensure adequate availability of spectrum to meet their connectivity needs. In order to clearly identify the bands as well as the quantum of spectrum for M2M communication, the Authority raised the issue of the quantum of spectrum required to meet the demand of M2M services with a horizon of 10-15 years. The Authority also sought to identify the spectrum bands most suitable for M2M communication. The specific issue of exploring technical feasibility of utilizing a portion of center gap spacing in the 700 MHz APT band plan in band-28 configuration, say 3 MHz (751-754 MHz), for M2M operations as a long term perspective as unlicensed band for M2M/IoT usages was also raised in the CP. Inputs were also sought on bands which could be delicensed to meet the requirement of M2M communication.
- 3.3 In response, many stakeholders who opposed identifying exclusive quantum of spectrum for M2M expressed the view that spectrum is a scarce national resource and can be utilized for multiple

technologies/services out of which the usage of spectrum for the provision of M2M communication services will be a small portion. Thus, no single or multiple frequency bands should be defined for M2M, per se, since such a step will not only cause huge revenue loss to the national exchequer (due to limited use of spectrum) but also lead to sub-optimal usage of precious spectrum resources (due to non-usage of spectrum for other services/technologies). Thus, there is no strong case for the designation of specific frequency bands only for M2M communication services, since it can be carried out over 2G, 3G, 4G and 5G networks. Current 2G networks support low bandwidth M2M applications, such as vending machines, while existing 3G and 4G-LTE support high bandwidth M2M applications such as streaming video for applications like CCTV. However, the latest M2M cellular standards – in 3GPP Release 13 – support all Low Power Wide Area (LPWA) M2M applications (in almost all licensed mobile bands). These stakeholders strongly favor technologically-neutral policies, and opine that it should be left to spectrum licensees to manage and employ their spectrum in an optimized fashion for the mix of traffic types that may be simultaneously using licensed bands. Any spectrum allocated would best be used by expanding public mobile networks which provide new capacity across all applications and users, and not dedicated to particular use such as M2M. As far as spectrum is concerned, India has shifted from spectrum deficit era to spectrum surplus era.

- 3.4 These stakeholders are of the view that, as long as TRAI continues its positive efforts to license sufficient additional amounts of spectrum for mobile use, it will be able to support the requirements of conventional mobile users and wide area M2M – as mobile operators can bid for more spectrum in line with growing demand. Any decision to mandate that all IoT services must use specific, dedicated licensed or unlicensed spectrum would damage market competition, struggle to meet all IoT use cases, and may lead to services which are not commercially viable. They opined that

India should continue to engage at the ITU and monitor global developments for future spectrum use with respect to 5G in order to benefit from global harmonization through the ITU and as a result of market forces.

3.5 These stakeholders, on the issue of identification of spectrum bands most suitable for M2M, stated that IoT with licensed & unlicensed/de-licensed bands is still getting discussed in different forums across the globe and considering global references may work in a wide spectrum band from VHF to UHF including licensed and unlicensed spectrums. Most of the network standards and device standards are also evolving towards the use of technologies like Low Power Wide Area (LPWA), which will run on the existing licensed spectrum. International Harmonization of M2M/IoT Bands is still work in progress. Hence, any premature de-licensing of bands would prevent us from taking full advantage of the benefits from international harmonization. Moving in line with spirit of technology neutral spectrum regime, these stakeholders believe that no separate spectrum should be earmarked for M2M services.

3.6 Some stakeholders argued for more delicensed spectrum and stated that the existing de-licensed frequency band of 865-867 MHz would not be sufficient to cater to the billions of connected/smart devices that would be deployed in the near future. Currently the unlicensed space is 2MHz only available in 866 MHz and 433 MHz. As IoT devices grow exponentially in number, this space is going to be totally inadequate and needs to increase. While the 2 MHz may have been adequate for earlier requirements. They have brought out that the US and European regulators are in the process to extend the ISM band by a minimum to 17 MHz in a move to push their respective IoT ecosystem. These stakeholders cited various global cases of identification of additional delicensed spectrum to accommodate M2M.

- 3.7 One stakeholder, in addition to the bands identified in Table 2.3 of the CP, recommended the use of frequency band of 0-500 KHz for narrowband M2M communications and 2-200 MHz for broadband M2M communications. Given that use of additional bands for M2M is being tested currently or in the light of any new technologies (uptake of 5G across globe) which may evolve in the future, TRAI must keep provisions for accommodating the same in any regulatory framework for M2M related spectrum management.
- 3.8 Another stakeholder urged the GoI to benchmark its plans for the release of spectrum against ongoing activities leading up to the World Radiocommunication Conference (WRC)-19 at the International Telecommunication Union (ITU), as well as in leading jurisdictions such as the European Union (EU) and the United States. Two stakeholders are of the view that M2M is in initial phase in India, it is not possible to predict the exact requirement of spectrum. So, we can start with the existing spectrum allotted to TSPs and same may be reviewed after 2 years.
- 3.9 One of the stakeholders supported the European Commission's suggestion as LPWA Ultra Narrow Band IoT (UNB IoT) are generally user friendly types of wireless products with low spectrum load and good spectrum sharing properties. With the existing 2 MHz Short Range Devices (SRD) band, spectrum allocated for M2M/IoT communication in India would not be sufficient, as compared to the existing 24 MHz ISM band in Europe and 26 MHz SRD band in U.S. for M2M/IoT communication. In Asia Pacific, the regulators have allowed frequency band range from 4 to 20 MHz for M2M/IoT communication in the unlicensed spectrum band. Hence, the stakeholder proposed to allocate frequency band of 5 to 18 MHz in the sub-1 GHz band on license-exempt basis allocation.
- 3.10 On the issue of spectrum bands most suitable for M2M one stakeholder is of the view that over 35 MHz have been provisioned for PMRTS and

CMRTS. There may be a possibility of freeing spectrum after the examination of the current usage of PMRTS and CMRTS. Freed spectrum can be earmarked to meet the demand of M2M communications. Stakeholder proposed the following band for delicensing and are placed in order of preference:

- a) 855-866 MHz (12 MHz)
- b) 917-922 MHz (5 MHz)
- c) 810-820 Mhz. (10 MHz)

A strong Adjacent Channel Leakage Ratio (ACLR) guideline should be in place for unlicensed spectrum usage.

3.11 Another stakeholder suggested that the 864-869 MHz should be delicensed. Already 865-867 is delicensed for low power devices, and extending it upwards will allow harmonization with European bands for both LAN and WAN use (Z-wave, LoRa and Others). Another stakeholder stated that TRAI has also recommended for the V band to be delicensed which if permitted, can be considered for M2M Communication in line with Global harmonisation trends. Despite the fact that there are other bands in sub-GHz band which have been identified for license exemption for indoor applications, albeit for low power usage viz. 433-434 MHz and 865-867 MHz. Though it is believed that 400 & 800 MHz bands have become preferred candidate bands for IoT worldwide, it is preferred that sub 700 MHz bands should not be delicensed/unlicensed for usage for M2M/IoT purposes.

3.12 One stakeholder, while not supporting separate spectrum for M2M also stated that if TRAI intends to de-license the spectrum required for the provision of one type of mobile service, then it requires a large deliberation over the spectrum policy for mobile services in India. It would be unfair that on the one hand, P2P mobile services are offered over licensed spectrum bands and on the other M2M mobile services are offered over

unlicensed spectrum bands. Such a proposal will create a non-level playing field and destabilize the whole spectrum licensing framework.

- 3.13 On the issue of exploring technical feasibility of utilizing a portion of center gap spacing in the 700 MHz APT band plan in band-28 configuration, say 3 MHz (751-754 MHz), for M2M operations as a long term perspective as unlicensed band for M2M/IoT usages, most of the stakeholders almost unanimously opposed the proposal and stated that at this stage of consultation process, it is not clear if this spectrum portion for NB-IoT (M2M) is in unlicensed FDD mode or TDD mode. It may not be possible to use the duplex gap (748 to 758 MHz) of Band 28 for NB-IoT applications because this band has a dual duplexer and filter design that would essentially need at least 10 MHz of clear duplex gap to avoid any uplink-downlink type of interference issues. There are several concerns related to use of this centre gap for unlicensed deployment. Interference in licensed usage from unlicensed usage could devalue the entire 700 MHz band. Sufficient technical study is needed for such co-existence before parameters like guard band, Max-transmit power, Adjacent Channel Interference (ACI) mask can be quantified. Trade-off between delicensed spectrum vs. (interference, energy efficiency, impact on MBB systems on the adjacent licensed carrier) needs evaluation. If centre gap of this band is used for unlicensed deployments, there is risk of no global harmonization as different regions/countries have different band plans in this band. Therefore, delicensing of part/entire center gap of APT 700 MHz band will not have global or even regional support for creating a M2M ecosystem and there will be no economies of scale. The de-licensing of the spectrum would create a non-level playing field between the operators who have invested in acquiring the spectrum from previous auctions and those who would have access to the spectrum without paying anything for the same.

- 3.14 These stakeholders also stated that the TSPs would use their licensed

spectrum in the 700 MHz band to offer P2P and M2M mobile services. The revenue projections from M2M mobile services will be a significant factor for determining the market value of the 700 MHz band. However, if some portion of the 700 MHz band is unlicensed, it will adversely affect the valuation of the 700 MHz band and cause a huge revenue loss to the exchequer as TSPs would be reluctant to pay a huge amount for this premium spectrum, given the huge risk of interference. Further, it will affect the level playing field as one TSP would be paying Rs.11,435 crore for one MHz for offering P2P or M2M mobile services while another would end up paying nothing for an unlicensed portion in the same spectrum band for offering M2M mobile services.

- 3.15 One stake holder is of the view that for optimum and efficient utilization of the 700 MHz band spectrum, around 5 MHz bandwidth of the centre gap of 10 MHz between uplink & downlink of this band may be safely used for M2M communication. However, before moving ahead, proper testing in this direction is required to ensure technical feasibility & for avoiding any interference issues.
- 3.16 Another stakeholder agreed to the proposal of delicensing a portion of the said band and stated that the sensitivity of equipment in this band can be highly degraded due to high BTS transmitter's in licensed band. Hence recommended a minimum 3-4 MHz frequency separation from the BTS Transmitters of the licensed operations.

Analysis

- 3.17 The Authority appreciates the fact that effective roll out M2M communication services will depend on the adequate availability of the fundamental resource, which is electromagnetic spectrum. M2M/IoT can be deployed using a wide range of different protocols, based on their connectivity requirements and resource constraints. It could use both

wired and wireless networks. Many of the devices and the services offered through them will require flexibility and mobility and hence would prefer wireless network. These can include short-range radio protocols such as ZigBee, Bluetooth and WiFi; mobile phone data networks, or bespoke networks for M2M like Sigfox, LoRA etc.

3.18 Owing to wide variety of technologies used and range of deployable services, it may not be possible to come out with a single description of the spectrum requirements for M2M services. The spectrum requirements can vary with the services offered based on the specific nature of that service and its criticality and QoS requirements. For example, Sub GHz spectrum can be appropriate for M2M services which require wider area coverage and better building penetration. In some services, which are critical in nature, preference will be for licensed spectrum in place of delicensed bands due to better data delivery reliability. Tailor-made technologies which cater for M2M services may require specific spectrum assignments to meet their unique technology needs.

3.19 The spectrum requirement for a M2M service will be based on the technology through which that particular service is extended. A wide range of existing and emerging technologies can be used to provide M2M service.

- **Mobile Technologies:** The time tested mobile technology will be one of the main contenders in providing M2M services. Many technical enhancements are under consideration which will enable the existing mobile networks to support a wider range of M2M services more efficiently and thereby enabling telecom service providers to support these services by using much of their existing infrastructure. These enhancements include an air interface capable of efficiently supporting IoT services within a 200 KHz channel bandwidth called NB-IoT and IoT-optimised variants of the LTE standard used for 4G services. In the longer term, 5G networks will emerge that will efficiently support a range

of M2M services.

- **LPWA Technologies:** Many tailor made technological innovations have come up with protocols which are optimized for M2M services. These technologies have wider coverage when deployed in Sub GHz bands. These protocols can work with both licensed and delicensed spectrum.
- **Personal and local area Technologies:** Customer M2M services such as health tracker, room temperature and light controllers etc can be based on general purpose technologies like Bluetooth or WiFi to cater for short range connectivity. Specific optimized versions of Bluetooth and WiFi for M2M services are also emerging.

3.20 The Authority of the view that the connectivity part of the M2M services is to be treated at par with any other access service. The Authority supports spectrum to be technology neutral and should be available for deployment of all technologies at the discretion of the service provider. Designation of specific frequency band for technologies/services will result in sub optimal use of the spectrum which is a scarce natural resource. Developments are taking place globally in multiple bands for provision of M2M technologies alongside other technologies and associated services. Hence the **Authority is not in favor of earmarking any spectrum bands exclusively for the use of M2M technologies/services.** However, while considering the likely high influx of connected devices due to M2M/IoT services, there will be a need to identify more spectrum for access services, which otherwise might clog the available licensed and delicensed bands of spectrum available for access technologies. The requirement of such additional requirement of spectrum can be analysed under the following heads:

- a) Licensed access spectrum
- b) Delicensed access spectrum

Licensed Access Spectrum

3.21 There are many advantages of using licensed spectrum for M2M

communication. The foremost amongst them is the reliability attached with licensed spectrum in delivery of services. Licensed spectrum provides for high quality of service delivery over a wide area and is not likely to experience interference issues. Cellular networks using licensed spectrum have extensive network already in existence which will provide for faster roll out of M2M services over the length and breadth of the country. Global harmonization achieved in licensed spectrum for cellular networks also provides for economies of scale.

3.22 Since M2M communication is passing through its infancy globally, most of the planning and estimations are done based on projection by various research organizations. Machina Research 2016²⁰ has projected that by 2021 there will be approximately 8.4% connected devices on cellular connectivity. This implies that a majority of the potential M2M service providers may not be utilizing the traditional cellular networks alone. In India licensed spectrum availability scenario for cellular networks has improved considerably in last few years. The present allocation of licensed spectrum in India is given in Table 3.1.

Table 3.1: Radio frequency bands in India for Cellular networks

Frequency	Range of frequency (MHz)	Paired / Unpaired	Primary usage in India
800 MHz	Uplink: 824-844 Downlink: 869-889	Paired	CDMA and EVDO services FD-LTE
900 MHz	Uplink: 890-915 Downlink: 935-960	Paired	2G 3G (HSPA+)
1800 MHz	Uplink: 1710-1765 Downlink: 1805-1860	Paired	2G 4G FD-LTE
2100 MHz	Uplink: 1920-1980 Downlink: 2110-2170	Paired	3G services(HSPA+)
2300 MHz	2300-2400	Unpaired	TD-LTE
2500 MHz	2535-2555 2635-2655	Unpaired	TD-LTE

²⁰ <https://machinaresearch.com/news/press-release-global-internet-of-things-market-to-grow-to-27-billion-devices-generating-usd3-trillion-revenue-in-2025/>

3.23 As can be seen, there is sufficient spectrum available, spread over various bands for cellular networks. In India, the telecom sector is undergoing a consolidation phase, resulting in mergers of telecom service providers. These mergers also have provided incumbent merged entities with sufficient spectrum. More spectrum in the efficient 700 MHz band as well as additional spectrum in the bands 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2600 MHz, 3.3 to 3.4 GHz and 3.4 to 3.6 GHz is likely to be made available for auction in near future.

3.24 At the global level, deliberations on licensed spectrum as well as unlicensed spectrum suitable for M2M communications/IoT are under progress. This issue was extensively deliberated and discussed in WP5D of ITU-R during WRC-15 cycle. The outcome was Recommendation ITU-R M.2083-0²¹ which is on “IMT Vision -Framework and overall objectives of the future development of IMT for 2020 and beyond”. This document envisions *“The proliferation of smart devices (e.g. smartphones, tablets, televisions, etc.) and a wide range of applications requiring a large amount of data traffic have accelerated demand for wireless data traffic. Future IMT systems are expected to provide significant improvement to accommodate this rapidly increasing traffic demand. In addition, future IMT systems are expected to provide gigabit-per-second user data rate services. The currently available frequency bands and their bandwidth differ across countries and regions and this leads to many problems associated with device complexity and possible interference issues. Contiguous, broader and harmonized frequency bands, aligned with future technology development, would address these problems and would facilitate achievement of the objectives of future IMT systems. In particular, bandwidths to support the different usage scenarios (e.g. enhanced mobile broadband, ultra-reliable and low-latency communications, and massive machine type communications) would vary. Report ITU-R M.2376 provides information on the technical feasibility of IMT*

²¹ https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-!!PDF-E.pdf

in the frequencies between 6 and 100 GHz. It includes information on potential new IMT radio technologies and system approaches, which could be appropriate for operation in this frequency range. The theoretical assessment, simulations, measurements, technology development and prototyping described in the Report indicate that utilizing the bands between 6 and 100 GHz is feasible for studied IMT deployment scenarios, and could be considered for the development of IMT for 2020 and beyond.”

3.25 This report further states *“In addition to the conventional human-to-human or human-to-machine communication, IMT-2020 will realize the Internet of Things by connecting a vast range of smart appliances, machines and other objects without human intervention.” “ITU will complete its work for standardization of IMT-2020 no later than the year 2020 to support IMT-2020 deployment by ITU members expected from the year 2020 onwards.” “In the medium-term (up to about the year 2020) it is envisaged that the future development of IMT-2000 and IMT-Advanced will progress with the ongoing enhancement of the capabilities of the initial deployments, as demanded by the marketplace in addressing user needs and allowed by the status of technical developments. This phase will be dominated by the growth in traffic within the existing IMT spectrum, and the development of IMT-2000 and IMT-Advanced during this time will be distinguished by incremental or evolutionary changes to the existing IMT-2000 and IMT-Advanced radio interface specifications (i.e. Recommendations ITU-R M.1457 for IMT-2000 and ITU-R M.2012 for IMT-Advanced, respectively).”*

3.26 Based on this vision document and work in Working Party 5D (WP5D), WRC-15 decided to study the spectrum needs of IMT-2020 (commonly known as 5G) vide Agenda Item 1.13 (of WRC-19) Resolution 238. *“Agenda Item 1.13 to consider identification of frequency bands for the future development of International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in*

accordance with Resolution 238 (WRC-15)”

- 3.27 Similarly, MTC (Machine Type Communication – commonly referred to as M2M/IoT) requirements were also needed to be studied by WP5D vide Agenda item 9.1.8 (of WRC-19) in the Annex to Resolution 958- *“Studies on the technical and operational aspects of radio networks and systems, as well as spectrum needed, including possible harmonized use of spectrum to support the implementation of narrowband and broadband machine-type communication infrastructures, in order to develop Recommendations, Reports and/or Handbooks, as appropriate, and to take appropriate actions within the ITU Radiocommunication Sector (ITU-R) scope of work.”*
- 3.28 Conference Preparatory Meeting (CPM-01) of WRC-19 decided to create a focus group under Study Group 5 to create relevant CPM text regarding spectrum identification for IMT-2020. This focus group has been named as **Task Group 5/1 (TG 5/1)**. All working parties were required to give their inputs to TG 5/1 within a specified timeframe. The timeline and process for IMT-2020 in ITU-R is very tightly scheduled. Due to this the timelines for the TG 5/1 has also been finalized and is as given below:

Table 3.2: Timelines for the TG 5/1

1st Meeting (May 2016)	Agree structure of TG 5/1 Development of a work plan for AI 1.13 Consider contributions received
2nd Meeting (May 2017)	Begin drafting of CPM Text (Focusing on background section) Decision on the need to prepare ITU-R Recommendations and /or ITU-R Reports Consideration of a potential format structure for sharing and compatibility studies Compile information received from concerned groups Begin sharing and compatibility studies on candidate frequency bands
3rd Meeting (Sep 2017)	Drafting of CPM Text Continuation of sharing and compatibility studies on potential candidate frequency bands

4th Meeting (Jan 2018)	Drafting of CPM Text Finalize the results of sharing and compatibility studies on candidate frequency bands
5th Meeting (Apr 2018)	Drafting of CPM Text Finalize the results of sharing and compatibility studies on candidate frequency bands
6th Meeting (Sep 2018)	Completion of draft CPM Text

3.29 Based on available information, the work plan decided for MTC studies by WP5D is shown in figure 3.1²². From the timeline it can be seen that the work on technical requirements and frequency requirements will start from June 2017 meeting onwards keeping 30th Meeting of WP5D (June 2018) as target meeting to finalize its input and submitting them to CPM. Some work was done on the requirements of various use cases and industries and a draft document (ITU-R M.[IMT.BY.INDUSTRIES]) has been prepared.

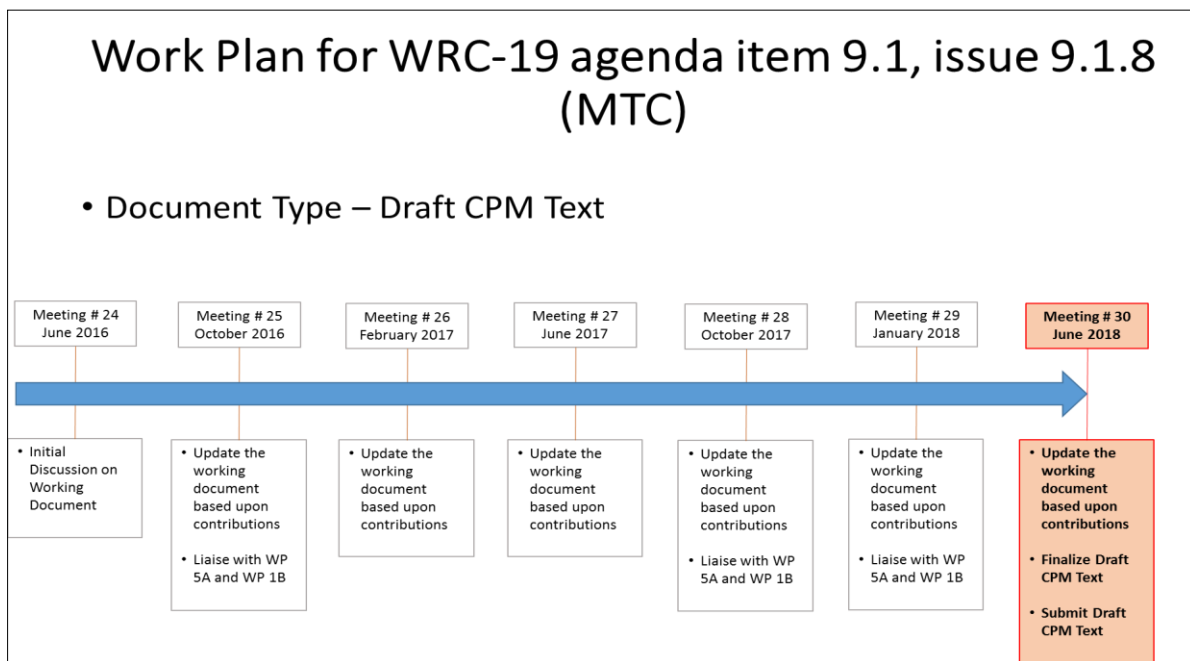


Figure 3.1: Work plan decided for MTC studies by WP5D

²² <https://www.itu.int/md/R15-WP5D-C-0530/en>

- 3.30 Some work on identification of spectrum for MTC/IoT/M2M will also commence from 27th Meeting of WP5D (June 2017). A working document towards a preliminary draft new Report ITU-R M.[IMT. MTC/NB.BB.IOT/SPECTRUM] has been created.
- 3.31 From the above information, it can be derived that the work in ITU-R on IMT-2020 and MTC is under progress so as to ensure that there is maximum global alignment which will ensure economies of scale and a harmonized usage of spectrum for these IMT applications. Since it is not possible to predict futuristic usage and deployments of various services using these newer versions of technologies, parameters for which have still not been frozen by ITU-R, it will be premature to take any decision in terms of identifying any proprietary technology and any specific spectrum bands for these usages. It is essential to wait for getting standardization work initiated so as to ensure that there is a level playing field for all players.
- 3.32 Considering the Indian scenario brought out in para. 3.22-3.23 as well as the global deliberations on the spectrum for IMT-2020, IMT Advanced and MTC as given in para. 3.24-3.30, the Authority is of the view that licensed spectrum available with the telecom service providers as on date as well as the spectrum likely to be made available in the near future is sufficient to meet the requirement of deploying M2M services in India in the near future. Once the global standardization process is completed and spectrum identified for 5G and MTC in WRC-19, it will be prudent to revisit the spectrum requirement of access services including MTC, in order to achieve global harmonisation.

Delicensed Spectrum

- 3.33 Delicensed spectrum also will be a much sought after resource in the deployment of M2M communication. Studies by the European Commission have suggested that a license exempt model is most effective for IoT

development, since it avoids the need for contractual negotiations before devices are manufactured and used, allowing the production of large number of cheap devices. Further, there is no roaming requirement within the country in such bands. Generic Bluetooth, ZigBee and Wi-Fi standards also work in unlicensed spectrum. In Europe SIGFOX, uses the most popular European ISM band (the ETSI and CEPT defined 868-879 MHz) and 902-928 MHz band is used in the USA. A review by the Korean government, found an increasing demand for unlicensed, low-power, long distance communications to connect devices in remote areas.

3.34 International Telecommunication Union's Radio communication sector (ITU-R) has reserved several frequency bands for Industrial, Scientific and Medical (ISM) applications. These ISM bands are unlicensed, and vary slightly from country to country. Popular ISM bands are 433 MHz, 868 MHz, 915 MHz and 2.4 GHz, which are used by wireless communication systems such as remote controls, cordless phones and Wi-Fi etc. Worldwide the 2.4 GHz band became very popular because it is allowed for unlicensed use in all regions. The ubiquity of the 2.4 GHz band makes development and distribution of 2.4 GHz-based products across nations easier. Wi-Fi can also operate in the 5.8 GHz band. However, since the range of 5.8 GHz radios inside buildings is shorter compared to 2.4 GHz, 5 GHz is mainly used in enterprise applications to ensure good Wi-Fi coverage. These existing license-exempt bands are widely used worldwide for M2M communication.

3.35 In India too, two bands 2.4 GHz (2.400-2.4835 GHz) and 5.8 GHz (5.825-5.875 GHz) have been defined as License-exempt bands for indoor and outdoor applications. In addition, 5.15-5.25 GHz and 5.725-5.825 GHz are also available for indoor uses in unlicensed bands. The Authority in its recommendations on various occasions such as recommendations dated 29th August, 2014, 17th November, 2015 and 9th March, 2017 has

recommended to DoT to de-license the V-band (57-64 GHz band) for indoor and outdoor access applications like WiFi hotspots etc. Delicensing the V-band (57-64 GHz) will enable M2M communication in this band if devices are manufactured in this band too. However, DoT is yet to take a call on the recommendations issued by TRAI on the subject.

3.36 Other bands in the Sub-GHz band are also made license exempt for Indoor applications. The specifications of these bands are given in Table 3.3.

Table 3.3: Delicensed bands in Sub GHz band in India

S.No.	Frequency Band	Power Requirements	Use of this frequency band
1	433-434 MHz	Maximum Effective Radiated Power: 10mW Maximum Channel Bandwidth: 10KHz	Indoor applications
2	865-867 MHz	Maximum Transmitted power: 1W Maximum Effective Radiated Power: 4W Maximum Channel Bandwidth: 200KHz	Any low power device or equipment

3.37 With the developments in the field of IoT, 400 MHz band and 800 MHz band have become preferred candidate bands for IoT worldwide. Most of the bespoke technologies for M2M are evolving in the sub GHz license exempt bands. The present allocation of 865-867 MHz is already being used by many services/users. Hence with the roll out of M2M communication systems in this band there is likely to be choking of spectrum.

3.38 According to NFAP-2012, the frequencies in the range 806-824 & 851-869 MHz has been earmarked for PMRTS/CMRTS usage as per the Table 3.4.

Table 3.4: Frequency bands earmarked for PMRTS/CMRTS (As per NFAP-2011)

Frequency band (MHz)	Block size of spectrum allocated	Uses	IND Footnote
806-811, 851-856	2x5 MHz	Mobile Trunk Radio for captive networks.	IND 40

		PMRTS on case to case basis.	
811-814, 856-859	2x3 MHz	Digital PMRTS	IND 41
814-819, 859-864	2x5 MHz	PMRTS	IND 42
819-824, 864-869	2x5 MHz	PMRTS	IND 43

3.39 Based on the information available, PMRTS operators in India are assigned 814-819 MHz/859-864 MHz band for Analog and 811-814/856-859 MHz band for Digital networks. License conditions for PMRTS/CMRTS provides that initially, not more than five channels (frequency pairs) will be assigned for PMRTS Analogue system and for Digital system upto 30 frequency channels (25KHz each) depending on the availability, justification and the actual usage of the same. Further according to the provisions of 'IND43' in NFAP 2011-*“Requirement of public mobile radio trunked systems (PMRTS) and captive mobile radio trunked systems may also be considered, as appropriate, in the frequency bands 819-824 MHz paired with 864-869 MHz”*.

3.40 PMRTS and CMRTS may be considered as appropriate in the band 864-869 MHz as per NFAP India remark IND 43. However there is no frequency assignment of PMRTS/CMRTS in this band. As per IND 82 on NFAP, PPDR communication also can be considered in the band 851-869MHz on case by case basis. In the absence of any frequency assignment in the frequency 868 MHz, as well as considering the fact that global ecosystem for M2M communication has developed robustly in this band, the Authority is of the view that 1 MHz of spectrum from 867-868 MHz can be delicensed to de-clutter this delicensed band.

3.41 Apart from 400 MHz and 800 MHz band, several regulators²³ across the world are allowing LPWA IoT applications in 900 MHz band. 902-928 MHz

²³ http://www.trai.gov.in/sites/default/files/SIGFOX_CP_18102016.pdf

in North America and 920-925 MHz in Korea, Singapore²⁴, Japan, Taiwan, Brunei, Malaysia, New Zealand, & Vietnam have been delicensed for the use of low power devices. CEPT²⁵ in Europe has identified 870–875.6 MHz and 915–921 MHz bands as license exempt bands for countries in EU. In Australia,²⁶ apart from 915-928 SRD band, additional spectrum is made available in 928-935 MHz for new & innovative IoT applications.

- 3.42 There is considerable ecosystem developing in 915-935 MHz bands for low power license exempt devices. Therefore, it would be prudent if a portion of this band is made delicensed in India also. This will help in a faster adoption of IoT in the country. Moreover, it will give an opportunity for Indian manufacturers to compete in the global market. The equipment manufactured in India in this band can be exported to the global market supporting the “Make in India” initiative. In view of the above, the Authority is of the opinion that a chunk of 6 MHz in 915-935 MHz band should be delicensed.
- 3.43 The arrangements mentioned above can provide a total of license exempt spectrum of 10 MHz (considering 1 MHz already delicensed in 433-434MHz) in sub-GHz band. The Authority will revisit the need for further delicensing of bands after analyzing the global scenario post WRC-19.
- 3.44 On the issue of exploring technical feasibility of utilizing a portion of center gap spacing in the 700MHz APT band plan in band-28 configuration, say 3 MHz (751-754 MHz), for M2M operations as a long term perspective as unlicensed band for M2M/IoT usages, the Authority agrees with the views

²⁴

<https://www.imda.gov.sg/~media/imda/files/regulation%20licensing%20and%20consultations/ict%20standards/telecommunication%20standards/radio-comms/imdatssrd.pdf?la=en>

²⁵

<https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0ahUKEwji86SD5s7VAhVJOo8KHc7NDLoQFggrMAE&url=https%3A%2F%2Fcept.org%2Ffiles%2F10899%2FLPRA-2017-ECO-May2017-BE.pptx&usg=AFQjCNHGwqh5UzI5p2H--HceKbwwR0Nx3w>

²⁶ <http://www.acma.gov.au/theACMA/spectrum-reform-of-the-803-960-mhz-band>

of the stakeholders that in the absence of detailed technical studies and interference studies, at present no portion of this band be considered for delicensing.

3.45 **Accordingly the Authority recommends that:**

- a) **Spectrum allocation should be technology and service neutral. No separate spectrum band is to be allocated exclusively for M2M services.**
- b) **Requirement of additional licensed spectrum for access services to meet the projected influx of connected devices due to M2M communication will be revisited by the Authority after WRC-19.**
- c) **In order to facilitate smooth roll out of M2M services utilizing the license exempt spectrum, 1 MHz of spectrum from 867-868 MHz and a chunk of 6 MHz of spectrum at 915-935 MHz is recommended to be delicensed.**
- d) **The Authority on various occasions has recommended to the Government for delicensing the V-band (57-64 GHz). This may be done on priority.**

B. Roaming

3.46 As per the existing framework for telecom access services, the country has been divided into 22 licensed service areas. Licenses are issued separately for each licensed service area. In India, roaming service is the facility provided to a subscriber to avail the services subscribed to in its home network, while travelling outside the geographical coverage area of the home network, by using the visited network. When a subscriber avails mobile services outside his home network (LSA) within the country, national roaming becomes applicable.

National Roaming for M2M devices

3.47 In its objectives, NTP-2012 envisages reviewing of roaming charges with

the ultimate objective of removing the charge across the nation and work towards “One Nation - Free Roaming” concept.

3.48 It is expected that a large number of devices which will be deployed in the M2M ecosystem will be mobile in nature. These devices will travel along the length and breadth of the country. Some of them may need to even cross the national boundaries. Hence, it is very pertinent to have a national and cross- border roaming policy in place for the M2M ecosystem. For example; Fleet management is one of the applications of M2M/IoT. The application of fleet management not only provides live tracking of the fleet on map, but it also provides other useful information such as finding nearest fuel station, providing alerts as notifications on mobile or web application, etc. Moreover, it provides geo-fence of the vehicle in a particular area of travel, so when a vehicle moves out of geo-fence area, the alerts are send via SMS or email. Further analytics can be done on over-speeding, stoppage, fleet summary, driver’s behavior etc, which can improve the performance of the fleet. These kinds of applications may require internet enabled SIM for connectivity to the servers. Also, national roaming in M2M is predominantly required for applications such as asset tracking, emergency service in vehicles etc, to name a few. In view of the roaming requirements in M2M, the Authority has raised the issue for comments of stakeholders on whether national roaming should be free for M2M/IoT devices or some tariff should be there for national roaming.

3.49 In response, most of the stakeholders in their comments have submitted that the tariff for roaming may be left to market forces to decide based on their commercial agreements similar to national roaming agreements in Telecom. Some stakeholders have further added that Regulatory forbearance may be permitted for roaming tariffs to be decided by the Service providers under the ceiling tariffs being set by the Authority. National roaming for M2M/IoT should be allowed without any restrictions.

- 3.50 Some stakeholders have stated that national roaming of M2M/IoT device should be free. As all operators are providing free domestic roaming for data services, it is suggested that free national roaming facility should be extended to M2M services also. Some stakeholders have sought to mandate the TSPs to configure national roaming for M2M/IoT services and it should be free for M2M/IoT devices.
- 3.51 One stakeholder has mentioned that the roaming agreements should be entered by the licensees according to the present terms and conditions mentioned in the Unified License, and decision to charge or free up the national roaming should be the choice of the respective service providers. Whereas, one stakeholder has suggested that critical services such as Emergency Services must be exempted from such charges. Ceiling tariffs for national roaming should also be the same as applicable for TSPs because the network and infrastructure used will be of the TSP's.
- 3.52 One stakeholder has elaborated that roaming for M2M services should be free within India as no single MNO has a good nationwide coverage. This is vital for ensuring that the critical services (e-Health, Women's safety, etc.) can be made available at reasonable prices.
- 3.53 Supporting the idea of providing free roaming, one stakeholder has mentioned that the possible implications for not providing free roaming is that the local service provider will have to ensure that proper SIM and IMEI number is being used for M2M devices. If device is being relocated to other location within India, local service provider will have to provide another SIM. This will require number portability. However, Mobile Number Portability is not allowed as of now in M2M segment.

Analysis

- 3.54 Currently, TSPs are providing mobile services through 2G (GSM, CDMA), 3G (UMTS) and 4G/ LTE networks. Since networks of TSPs are not

ubiquitous, in order to have adequate coverage for their customers, commercial arrangements such as Intra- Circle Roaming (ICR) between the TSPs are required. These arrangements are unilateral or bilateral based on mutual agreements between the TSP's in order to complement each other's network wherever there is a problem or requirement of network coverage.

3.55 The configuration of roaming arrangements is enabled in TSPs network based on the mutual commercial agreement between the seeker and the provider. IMSI ranges of subscribers of visitor's network have to be configured in provider's network. The Mobile Switching Center (MSC) of the visited operator tries to find the IMSI (of the SIM of the mobile device) in its network's HLR. The MSC uses the IMSI to identify the home network of the SIM based on the additional information such as Mobile Country Code (MCC) followed by the Mobile Network Code (MNC). If a roaming agreement exists between the providers, MSC of roaming network provider's contacts the home network's HLR, authenticates mobile device and retrieves the relevant information of the profile of the subscriber. This data (about the visiting subscriber) is stored in the Visiting Location Register (VLR) of the visited network. The VLR keeps a temporary profile of the subscriber, for the purpose of roaming.

3.56 As discussed in previous para, configuring provider's network to grant roaming access to subscribers of seeker's network requires allocation of network resources. Be it Radio Access Network (RAN), BSC, MSC, EPC, MME, HLR, VLR, Serving GPRS Support Node (SGSN), Gateway GPRS Support Node (GGSN), IN and billing systems in 2G/UMTS or LTE networks, all have to perform their functions to accomplish the task. Therefore, in order to allow roaming of customers of other TSP, network resources as discussed above have to be allocated and aligned in provider's network, this definitely add some cost to the roaming provider TSP.

3.57 In the present scenario, many TSPs are integrated operators having pan India presence of their network in various segments such as Access Networks, NLD, ILD etc., however, some of the TSPs are only providing access service in fewer LSAs. Hence, TSPs not having pan India presence are entering into commercial agreement for providing national roaming to serve their customers and provide access on pan India basis. Considering these facts, the operators having Pan India network coverage, network quality and overall market presence, appear better positioned to serve the customer in comparison to the TSPs having regional or fewer LSA based presence. Though based on the recent developments it is worth noting that the Indian telecom market is highly competitive and is rapidly witnessing consolidation. Spectrum sharing and trading has acted as an enabler for consolidation. In order to beat competition, TSPs having presence in fewer LSAs are in the process of making alliances or mergers with other operators to become an integrated operator. As per industry experts, there will be 4-5 integrated operators in the country in near future.

3.58 The entry of a new player in telecom market has intensified the competition and forced the incumbent operators to reduce the rates drastically. New bundled plans are being offered with minuscule charges for voice calls or completely unlimited voice calls. Also, data roaming in the country is not charged by many TSPs for their subscribers. In the competitive environment many TSPs has done away with national roaming charges to their subscribers. As such roaming in M2M will be required mostly by enterprise segment in M2M and possible tariff plans would be of bulk bundled nature rather than usage based as in today's environment. The Authority is aware of the fact that Average revenue per connection (ARPC) in M2M is comparatively very less as compared to the existing Average revenue per user (ARPU).

3.59 The Authority has noted that most of the stakeholders in their comments

have submitted that the tariff for roaming may be left to market forces to decide based on their commercial agreements similar to national roaming agreements in Telecom. Although some stakeholders have sought to mandate the TSPs to configure national roaming for M2M/IoT services and it should be free for M2M/IoT devices. Further some stakeholders have submitted that emergency services in M2M should not be charged for roaming and should be mandated to be allowed by all TSPs.

3.60 On the view of mandating free national roaming by all the operators, the Authority has evaluated various aspects and is of the view that all existing TSPs providing access services are having their commercial agreements already in place for providing services as per the license conditions. With the intense competition in the market several TSPs are not charging their subscribers for roaming charges at national level voluntarily.

3.61 On its part, the Authority through the Telecommunication Tariff (Sixtieth Amendment) Order, 2015 (3 of 2015) issued on 9th April, 2015 has inter-alia specified that “Every service provider shall offer a Special Roaming Tariff Plan to its pre-paid and post-paid subscribers.” The Authority has also reduced ceiling tariffs for national roaming calls and SMS and has mandated TSPs to offer a special roaming tariff plan. The revised tariffs are as shown in table 3.5 below.

Table 3.5 : Revised Tariffs

Item	Existing ceiling tariff	Revised ceiling Tariff
Outgoing local voice call while on national roaming	Rs. 1.00 per minute	Rs. 0.80 per minute
Outgoing long distance (inter-circle) voice call while on national roaming	Rs. 1.50 per minute	Rs. 1.15 per minute
Incoming voice call while on national roaming	Rs. 0.75 per minute	Rs. 0.45 per minute

Outgoing local Short Message Services (SMS) while on national roaming	Rs. 1.00 per SMS	Rs. 0.25 per SMS
Outgoing long distance (inter-circle) Short Message Services (SMS) while on national roaming	Rs.1.50 per SMS	Rs. 0.38 per SMS

3.62 Considering the national roaming issue in M2M, the positive side of mandating free roaming for M2M services throughout the country will be that M2M services requiring mobility will tend to proliferate the market rapidly. Also the user will get ubiquitous network coverage across the country. Whereas, the fallout of mandating the free national roaming could be that a TSP may not be ready to provide free roaming to the subscribers of another TSP in absence of commercial consideration since it has to align and allocate its network resources. The challenges before the TSP would be to cater to the needs of its own subscribers as well as roamers of other TSPs; therefore, the TSPs may not find it a viable arrangement to provide free national roaming for M2M/IoT at this stage.

3.63 The Authority has considered the fact that telecom tariffs have reduced drastically over the past few years. Typically M2M devices use very less data as compared to the data traditional consumers use for voice/data services. Since M2M/IoT deployment is in nascent stage and the potential of the market is substantial, the market based mechanism appears to be appropriate. No regulatory intervention on the issue of national roaming is felt suitable at this stage. However, the Authority is of the opinion that Regulatory forbearance may be permitted for roaming tariffs. It should be decided by the Service providers under the prevailing ceiling tariffs set by the Authority which is revised from time to time. Therefore, there should not be any mandate to enforce free roaming by any operators.

Roaming Access for Emergency Services

- 3.64 On the issue of providing roaming access for emergency services as suggested by some stakeholders, the Authority has come across one of the use cases in handling emergency services i.e. eCall in Europe. European Commission's recommendation was issued for mobile operators in 2011 which requires implementation of eCall in all networks. The recommendations also envisage routing eCalls to the Public Safety Answering Points (PSAPs) and handling of eCalls by PSAPs as any other 112/E112 emergency call. Among the required elements for deployment of eCall service -Vehicle and equipment manufacturers should include an in-vehicle system capable of bundling the 'Minimum Set of Data' and triggering the eCall and Mobile Network Operators should transmit the eCalls (voice and data) to the emergency call response centers (PSAPs). In order to manage the eCalls, the recommendations envisage Member States to upgrade their PSAPs. According to latest update on eCall regulation it requires that all new cars be equipped with eCall technology from April 2018.
- 3.65 The Authority in recent past has issued key recommendations on the issues associated with handling emergency services in the country. The Authority issued its recommendation on 'Single Number based Integrated Emergency Communication & Response System (IECRS) on 7th April, 2015. Through the recommendations it was proposed to have a single emergency number '112' throughout the country which could be used for all emergency phone calls across the country including for police, fire and ambulance. Accordingly, DoT while making amendment to the National Numbering Plan (NNP) -2003 on 4th May, 2016 issued guidelines on implementation of 'Single Number based Integrated Emergency Communication & Response System' to all Access Service Providers.
- 3.66 The Authority has noted that at this stage, the recommendations as

mentioned in preceding paragraph are in implementation phase. Implementation of single number '112' requires coordination and involvement of various government agencies in setting up PSAPs. The Authority is of the opinion that in order to garner advantage of the technology it would be fruitful to include the emergency service on the lines of eCall to bring down the number of casualties happening due to road accidents in the country. A prototype and proof of concept (PoC) can be initiated by the Central government in this regards and once based on its appropriateness same can be opted in emergency services framework mandatorily pre-fitted with vehicles.

3.67 In future, one of the use cases of M2M/IoT would be for emergency response and rescue. The broadband PPDR standards have been evolving and being adopted by various countries. Broadband PPDR provides better infrastructure and opportunity for handling the critical missions where heavy machines deployed in rescue missions can be operated remotely at the locations which are beyond the reach of human. Therefore, worldwide it is being realized to develop a scalable technical approach using different networks (commercial cellular, public safety land mobile, etc.) and concepts such as M2M/IoT to provide access and to improve communications for first responders. Thus role of M2M/IoT in emergency response system shall be crucial in future. The Authority is of the view that since standards are still in development phase, the concerned Authorities in the country must be aware and prepared to adopt the best practices using M2M for emergency purposes so that necessary guidelines/mechanism can be developed to implement. In India too a pilot testing can be done by integrating the emergency response service in line of eCall to make provisions for emergency communication in vehicles.

3.68 **In view of foregoing, the Authority recommends that:**

a) National roaming for M2M/ IoT shall be under forbearance and

ceiling as per prevailing Telecom Tariff Orders (TTOs) for access service.

- b) TSPs shall enter into commercial agreements to cater their roaming requirements for M2M subscribers.**
- c) The Authority shall review/issue separate TTO for M2M at an appropriate time in future, if deemed fit.**
- d) As a part of public safety initiative, the Government shall initiate a proof-of-concept (PoC)/ Pilot testing in integrating the emergency response service on the lines of eCall to make suitable mandatory provisions for emergency communication in vehicles.**

C. Roaming on permanent basis for foreign SIM/eUICC

3.69 Permanent roaming in M2M is provisioned to offer services globally for many vertical sectors particularly including automotive and consumer electronics. A large number of M2M devices are now roaming on a permanent basis. These include vehicles that are manufactured with built-in SIM cards and shipped to various countries around the globe. In fact, most M2M equipment, such as cameras, smart meters and health care equipment are manufactured in one country and distributed globally. Accordingly, devices requiring roaming facility are deployed in a mobile network using either SIM cards purchased by third-parties or other operator SIM cards.

3.70 M2M will continue to present many challenges for operators in near future. One of the main issues is with eUICC. An embedded SIM card (eUICC) cannot be manually replaced with a local SIM which implies that the M2M device will be connected to the visited mobile network as a roaming device. Taking control of M2M device activities and effectively detecting roaming devices in the network are among the list of challenges if operators want to optimize network performance and reduce operational and signaling costs.

- 3.71 In order to make a precise view on this issue, the Authority raised the issue in the CP for debate and comments of the stakeholders on whether roaming on permanent basis be allowed for foreign SIM/embedded Universal Integrated Circuit Card (eUICC).
- 3.72 In response, some stakeholders have supported to allow foreign SIMs as most of the devices imported to India may come with pre-fitted foreign eUICC at the factory with bootstrap profile. The stakeholders also submitted that foreign eUICC should also be allowed, with the possibility to download local subscription profiles for local regulatory requirements. Foreign eUICC needs to be registered with the local network to be able to swap the profile using subscription management technology as per GSMA global guidelines. And in the event, foreign eUICC is not allowed, there will be challenges to maintain separate eUICC Stock Keeping Units (SKUs) in production line and supply chain logistics for the devices manufactured to ship to India. It will add cost and delay the import of IoT devices to India.
- 3.73 One stakeholder has stated that in some M2M applications, international roaming will be inherent and will be factored into the design. Therefore, devices fitted with foreign SIMs should be allowed to freely roam internationally and contractual commercial arrangements to this aspect have to be left upon mutual agreement between the TSPs & M2M customers across geographies. Stakeholder has inter-alia suggested checks and balances as follows:
- a. The importer/Vendor/Automotive may be required to provide a declaration to Customs at the port containing details of IMEI, MSISDN, Make, Chassis No. of vehicle etc to identify the M2M fitted device and to know the ownership for Indian law compliances. This is similar to the practice currently being followed for example when handsets are imported in India.
 - b. The Importer/Vendor/Automotive should be mandated to cooperate with

Lawful Enforcement Agencies in India for traceability purposes, if required.

- 3.74 One stakeholder supporting permanent roaming, has further elaborated that restricting adoption to one or another SIM and business model could potentially hamper the uptake of M2M and IoT services in India. The M2M and IoT space is composed of a variety of verticals, with different justifiable needs. Also there is no embargo in India today on permanent roaming and the same should be continued. International Permanent Roaming enables scalable, well-tested and speedy deployment of M2M and IoT Services. Several automobile firms operate on the same model in other countries as well. It can facilitate a rapid deployment of M2M and IoT services in India by international and multinationals companies and, in reverse, provide an opportunity to Indian companies to export M2M and IoT services and devices. Stakeholder further stated that from the “Make in India” perspective, M2M/IoT devices will be manufactured in India with SIMs from local operators and exported world over. Any restrictions in international permanent roaming could be seen as a protectionist measure and may also encourage similar action by other nations.
- 3.75 One stakeholder has stated that roaming on a permanent basis is simply roaming which is permitted under existing license terms and conditions. Prohibiting the use of foreign SIMs/numbers for roaming will impede the growth of M2M applications/services. There are also technical challenges with respect to the technical feasibility of SIM replacement/ integration /refitting etc. and there is possibility that the M2M device could be compromised and potentially render the service inoperable.
- 3.76 Another stakeholder has mentioned that providing connectivity based on permanent roaming is the only option to fulfill the requirements, based on already existing international roaming agreements. To roll out these services based on local connectivity would require individual agreements

with local telecommunication providers in every country. The necessary effort would reduce the roll out speed of M2M platforms and local M2M applications in the countries that require local connectivity.

- 3.77 One stakeholder has suggested that roaming should be permitted for certain category of services/verticals or segments that are deemed as Permanent Roamers. It may be permitted by use of eUICC. While another stakeholder has suggested in case of M2M devices, permanent roaming should be allowed. The M2M device manufacturers should enter into commercial/ roaming agreements with the Indian TSPs. The service providers will get the SIMs issued after fulfilling KYC requisite in case of corporate connections and individual connections.
- 3.78 Some stakeholders have stated that they do not support international roaming on a permanent basis for foreign SIM/eUICC as only Indian licensed operators should be allowed to provide telecom services in India. The stakeholders in support of their argument have stated that they do not support to allow roaming on permanent basis for foreign SIMs, since it may be open to misuse and harm the security of the nation. The stakeholders have suggested replacing the foreign SIM to an Indian SIM, within a predefined time assigned by the authority. The replaced SIM of an Indian TSP/ MSP can be as per the commercial arrangements of M2MSP with Indian TSP.
- 3.79 One stakeholder while supporting not to allow permanent roaming of SIMs in the country has submitted that the SIMs that work on permanent roaming will not have KYC validity at the same level as local SIMs. For M2M services, ensuring security is of crucial importance owing to various applications in the present day. The stakeholder has further elaborated that Indian TSPs and companies would be helpless incase services are controlled from foreign countries using the foreign SIM/eUICC on permanent roaming, as the issue will fall outside their area of jurisdiction.

Also the traceability of foreign SIMs on permanent roaming would always be a matter of concern contrary to a domestic SIM.

3.80 One stakeholder has suggested that Roaming on International eUICC/ Inbuilt SIM should not be free. It should be ensured that import of eUICC based devices (M2M as well as mobiles/Tablets) will be done through proper channel, in India. It will discourage people to bring in international M2M devices just like that and will avoid uncontrollable situation in M2M devices. If we keep roaming charges on international SIMs/eUICCs, TRAI or any other agency can easily monitor these M2M devices, so that these M2M devices are not being used for illegal or terrorism related activities.

3.81 One stakeholder expressed that permanent roaming includes challenges such as National regulatory oversight, Customer protection, Lawful interception, Number portability and possible exhaustion of number ranges. However, if we allow permanent roaming, it will help the M2M ecosystem to develop in India at the same pace as in other countries. Thus the stakeholder suggests that permanent roaming should be allowed on the condition that the Indian TSP, on whose infrastructure, the SIM will be roaming in India, be the primary data owner. This will ensure that Indian law enforcement agencies will have a direct access on these data, as and when needed.

D. Timeline of foreign SIMs/eUICCs to be converted into Indian SIMs/eUICC

3.82 The Authority further sought inputs on whether there be a timeline/lifecycle of foreign SIMs to be converted into Indian SIMs/eUICC in case pre-fitted SIMs are permitted to be imported in the country.

3.83 In response, some stakeholders have suggested that the existing foreign SIMs should be converted to Indian SIMs within a reasonable time period. Supporting the argument, one stakeholder has suggested that the foreign

IMSI should be allowed for 30 days, within that time period a home IMSI should be activated or downloaded. Another stakeholder has appended that the embedded SIM is a new secure element designed to remotely manage multiple mobile network operator subscriptions and be compliant with GSMA specifications available in various form factors, either plugged-in or soldered, the eUICC is easy to integrate in any kind of device.

- 3.84 Supporting the conversion of foreign SIM into Indian SIM one stakeholder has submitted that there should be a timeline/lifecycle of foreign SIMs to be converted into Indian SIMs/eUICC due to the reasons viz. (a) The data will get outside India, (b) There shall be restrictions on the products that are coming from outside for usage in the M2M scenario, (c) This is a suitable option to retain the data generated in M2M devices in India.
- 3.85 Some stakeholders have pointed that the issue needs a balanced approach towards permitting foreign SIMs in M2M devices imported to India. The stakeholders suggests that if the M2M devices are to be used in India for more than 1 year's duration, the SIMs of foreign TSPs should be necessarily converted to domestic TSP SIMs within a period of 1 year from the date of activation of the device in India. Also, end to end M2M services setup, for provisioning M2M services in India, should mandatorily be hosted in India.
- 3.86 On the contrary, some stakeholders has put forth that it is not appropriate to have a timeline for conversion into domestic SIMs. As such both domestic SIM/eUICC and Permanent roaming foreign SIM/eUICC should be allowed. Some stakeholders have further submitted that the choice for use of global roaming embedded SIM or a local eUICC should be left with M2M Solution provider, based on market drivers, business cases, costs and Service Level Agreements.

- 3.87 One stakeholder has submitted that permanent M2M roaming with foreign numbering resources is one of the most effective methods to facilitate the development of M2M services and the IoT at large. Therefore, there is no need or, indeed no benefit, in mandating the eventual migration to Indian SIMs. Firstly, India's consumers and businesses risk exclusion from the benefits of the global M2M marketplace if rules prevent the delivery of M2M services in India that use foreign IMSIs and numbering resources. Likewise, Indian device manufacturers would be deprived of global export markets if prevented from the delivery of M2M services outside India using Indian IMSIs. Without a flexible policy in this area, India's efforts to develop a broad national M2M policy will be compromised because the proliferation of global M2M services in India as well the global prospects for M2M services developed and originated in India will be significantly impaired. Secondly, as the M2M and IoT market is evolving, it does not seem necessary to impose regulations on the timeframe within which a transition to an Indian SIM is required when a solution may be on a path toward obsolescence prior to the transition period's expiration. The stakeholder has urged to adopt the extra-territorial use of global numbering resources for M2M devices, without a mandatory transition to an Indian SIM, as a priority.
- 3.88 One stakeholder has stated that using an Indian or foreign SIM may not be an issue, as long as the data ownership is with an Indian TSP. Though, the MSP must be motivated to have the SIM/eUICC of an Indian TSP integrated at the OEM's end, in case the device will be permanently roaming in India. This will not be tough as Indian TSP's have provisions for all kind of SIM/eUICC as per the global standards. Services support for M2M should be adequately equipped to integrate SIM/eUICC of Indian TSP into the M2M Devices.
- 3.89 Suggesting an alternate option, one stakeholder has submitted that

programmable SIM solution (eUICC) is a better option to be used in case of permanent roaming. A eUICC has a minimum memory of 512 KB and has multiple profiles holding capacity. It can be easily programmed as a local SIM, by any Indian TSP. Second solution can be dynamic “IMSI swap”. This technology will allow download of a new mobile identity remotely into the devices. This will enable any M2M device to move from its home network and become a local device in its new roaming network, by downloading a local MNC. This technology is still in its development phase.

- 3.90 One stakeholder has proposed that another possible solution could be by having an International M2M Roaming Framework that enables use of home carrier's IMSI & MSISDN to provide services on global basis using Single SIM architecture.

Analysis

- 3.91 According to the study provided by Machina Research²⁷, the share of the countries explicitly prohibiting permanent roaming is only 2%, share of the countries permitting clearly is around 11% and rest of the countries have no clear cut regulations thus may be considered as probably permitted cases.
- 3.92 The issue under debate on allowing roaming on permanent basis or not has been a subject of debate in many countries across the world. There are number of arguments in favor of prohibition on permanent roaming. Some of the concerns are related to regulatory oversight as foreign operators are not directly licensed to operate in the domestic market. Other prominent reasons are exhaustion of network resources on permanent basis and applicability of extant KYC rules to roamer. Security and lawful interception also posed a challenge.

²⁷ <http://gsma.com/connectedliving/wp-content/uploads/2016/09/Machina-Webinar.pdf>

3.93 Some stakeholders are in favour of allowing permanent roaming for M2M devices. The stakeholders are broadly of the view that prohibiting the use of foreign SIMs/numbers for roaming will impede the growth of M2M applications/services. As most of the devices imported to India may come with pre-fitted foreign eUICC at the factory with bootstrap profile, the eUICC should be allowed, with the possibility to download local subscription profiles for local regulatory requirements. Foreign eUICC needs to be registered to the local network to be able to swap the profile using subscription management technology as per GSMA global guidelines.

3.94 TEC in its Technical report Release 2 on Intelligent Transport System has focused on two major work areas which were identified in Release 1 i.e. V2X communication and eUICC for connected cars. The report inter-alia has recommended that:

- a. Interface requirements of TEC for eUICC may be amended to incorporate the requirement of automotive sector including remote subscription management, multiple subscription and eUICC enabled location identifications.
- b. Regulatory policies/guidelines may be evolved on the following:
 - i. The issuance of Embedded SIMs by OEMs/M2M Service Providers, and the Identification of M2MSP/OEM by IMSI ranges
 - ii. Transfer of “Devices with Embedded SIMs” from one user to another using Aadhaar eKYC
 - iii. In conjunction with GSMA, development of Policy Guidelines for setting up Indian Certificate Issuers and local Certification Agencies for the new Network elements for the eUICC
 - iv. M2M Roaming
 - v. M2M/IoT privacy and security including the subjects of location of Application Servers hosting user data, use of MSISDN as an identity, IPV6 mandate such as to ensure a unique identity per connected SIM

- 3.95 Information such as IMEI, IMSI are important to be captured during import of the devices. Currently, there are certain prevailing guidelines/Directives to be followed by an importer during import of foreign made mobile handsets and equipment. Since SIMs in M2M are ancillary to some other equipment/goods such as vehicle, wearable devices, consumer durable goods etc, relevant information of main equipment / goods is necessary to be captured upfront. TEC in its Technical report Release 2 on Intelligent Transport System has comprehensively covered various aspects including the process of eUICC & Remote Subscription Management.
- 3.96 The Authority is aware of the fact that physical replacement of SIM in M2M environment is neither practical nor feasible once millions of devices are in operation. SIMs for the purposes of M2M communication are embedded (integrated/soldered) at the point of manufacturing in order to achieve the standard physical and environmental requirements and are deployed in domestic or international market. The Authority has taken note of the GSMA specifications issued on eUICC which provide a single, de-facto standard mechanism for the remote provisioning and management of M2M connections, allowing the “over the air” provisioning of an initial operator subscription, and the subsequent change of subscription from one operator to another.
- 3.97 As discussed in preceding para, the tools and specifications for remote provision of SIMs in M2M scenario are available. The technical challenge of remote provisioning or reconfiguration of SIMs can be addressed through adoption of prevailing GSMA specifications and standards. The Authority has taken note of the recommendations issued by TEC²⁸ on eUICC specifications and framework in the country. Once issues related to subscription management are addressed adequately, remote provisioning

²⁸ <http://tec.gov.in/pdf/M2M/V2V%20%20V2I%20Radio%20communication%20and%20Embedded%20SIM.pdf>

of SIMs on permanent roaming can be achieved in efficient manner.

- 3.98 On the issue of allowing permanent roaming, theoretically, there appear few issues in allowing permanent roaming of the foreign in-built SIMs/eUICCs. Present roaming arrangements are governed on the basis of mutually agreed commercial terms between two operators and accordingly services are used by roamer as subscribed in its home network. As already mentioned, in M2M scenario it is expected that large number of devices will be deployed for an average life span for 10-15 years with minimal or no requirement of human interventions. Long lifespan of the device in permanent roaming may not be suitable for overall interest of the nation as there are possibilities that goods/equipments/vehicles once imported by a person or a company are resold to another person in local market, thus creates an issue of authenticity and identity of the person. The issue is clearly linked with applicability of KYC rules and traceability of the person and device.
- 3.99 The Authority has also noted the security risks involved and possibility of hacking of entire network or system in intelligent and connected M2M/IoT networks. Recent attack of 'Ransomware' malware is just an example how it can affect the lives of citizens by attacking ATMs and banking system. As of now 100% Foreign Direct Investment (FDI) is allowed in many sectors and foreign companies are awarded turn-key contracts on long term basis. In view of the industrial automation at large scale, there are fair chances of vulnerability to hacking of the country's strategic sectors/networks such as power, telecom etc. For example- supervisory control and data acquisition (SCADA) systems being added to smarten up city grids. SCADA is a computer-based industrial automation control system that practically makes factories and utilities run on their own. In an electrical system, SCADA maintains balance between demand and supply in the grid. In the connected systems,

intelligent equipment talk to each other and exchange data and information, making the system more efficient but at the same time increasing the vulnerability if exposed to suspect individuals, companies and nations which may use such access to their advantage. In this regard the Authority is of the view that relaxation, if any, on the issue of permitting permanent roaming for foreign activated SIMs for strategic sector can be negotiated through Bi-lateral or Multi lateral Trade Agreements (MLTAs) on case to case basis and on the principle of reciprocity.

3.100 Some M2M verticals, mainly enterprise M2M customers; demand global M2M roaming solution to ensure multinational service delivery. To match enterprise customers' geographic needs, operators need to develop global M2M footprints by way of extending their commercial roaming agreements to include M2M roaming and charging. This depends on their roaming partners' capabilities and readiness to offer M2M services to roaming customers. Operators worldwide are actively entering into M2M alliances in order to expand their M2M roaming coverage and enable SIM provisioning for global connectivity of M2M devices.

3.101 One of the challenges identified in the international roaming of M2M SIMs is related to the compliance of the country specific process of the Know Your Customer (KYC). KYC norms for the M2M SIM used in Intelligent Transport System (ITS) Devices (GPS/GPRS etc.) may be different than the KYC norms for SIM being used for mobile phone. For example - there is no mechanism to ensure that vehicle ownership transfer is in sync with the device SIM connection.

3.102 The embedded SIM is a form factor that is physically integrated into the device, mostly by soldering to the device Printed Circuit Board (PCB). The embedded SIM cannot be easily removed in the field. As a result, the embedded SIM requires remote provisioning, which is the ability to

remotely select the SIM profile deployed on a SIM without physically changing the SIM card. This technology is standardized and can be implemented on a SIM card with any form factor. The term eUICC is used to represent a SIM card that can be remotely provisioned. It is pertinent to mention that eSIM and eUICC are one and the same. For ensuring uniformity of the term in the recommendations, the Authority has used the term eUICC.

3.103 At present there are 2 technical options being discussed for M2M services to allow remote provisioning of IMSIs i.e. Soft-SIM and Embedded SIM. The first approach termed as 'Soft-SIM' has not been widely accepted by the industry due to certain security concerns required to be addressed. The second approach termed as 'embedded UICC' (eUICC) has been adopted and approved by GSMA. The GSMA has approved the architecture and the technical specification documents for remote provisioning that could be deployed by the MNOs for M2M applications. Using this approach, the eUICC keeps all the security features of a regular UICC while adding the capability to securely provision a new 'profile' containing all the data required (including the IMSI) to represent a mobile subscription. The update of embedded UICC is made via over-the-air (OTA) technique. The GSMA documents describe the procedure for changing the eUICC profiles.

3.104 Many stakeholders in their submission have suggested converting foreign M2M SIM operating on permanent roaming to be converted into Indian SIM in a defined timeframe. Some stakeholders have requested the timeline of one year or less for such conversion. The Authority is of the view that various aspects of M2M are still evolving and it may take another couple of years for standardisation to complete. Therefore, timeline of three years to get the foreign SIM operating on permanent roaming converted into Indian SIM shall suffice for now, however, same

shall be reviewed/ revisited by the Authority/ Licensor at later stage, if deemed required.

3.105 The Authority is also aware of the fact that imported good/equipments such as automobiles, machines (like earth movers) and arms require mandatory registration/license at local authority such as Regional transport Office (RTO) for automobiles/ earth movers and State/District administration for arms. Reselling of such imported equipments/ machines are prominently in practice in India. Hence the chances are that reselling takes place in short span of time. The KYC of new owner/ buyer of such machinery and equipments imported with pre-fitted foreign SIM must be captured and compulsorily updated with concerned local authority. The Authority is of the view that at such instance the subscription of foreign SIM shall also be converted/ reconfigured into local subscription of Indian TSP's SIM instantly.

3.106 **In view of the foregoing, the Authority recommends that:**

- a) Devices with pre-fitted eUICC should be allowed to be imported only if it has the ability to get reconfigured 'Over the air' (OTA) with local subscription. GSMA approved guidelines shall be followed for provisioning of new profile remotely with 'Over-the-air' (OTA) mechanism.**
- b) Devices fitted with eUICC shall be allowed in operation in roaming for maximum three years from the date of activation of roaming in the network of Indian TSP and mandatorily converted/reconfigured into Indian TSP's SIM within the stipulated period or on change of ownership of the device, whichever is earlier. The Authority/Licensor shall review the condition later based on the developments and requirements.**
- c) Country specific relaxation on permanent roaming of foreign SIMs, if any, can be considered based on the strategic importance, Bi-**

lateral or Multi-lateral trade agreements and principle of reciprocity by the government.

- d) In case imported equipment to which the SIM/ device is fitted with such as automobile/ machines (like earth movers), arms etc. (requiring mandatory registration at local authorities such as RTO, State/ District administration) is transferred/ sold to another party before three years, the roaming device (eUICC) shall also be immediately configured with local subscription/eUICC of Indian TSP. The KYC details of the new owner/ buyer must be compulsorily updated in the database of concerned authorities.**

E. Whether only domestic manufactured SIM/eUICC be allowed in M2M communication?

- 3.107 TEC in its Technical report Release 2 on Intelligent Transport System has focused on two major work areas which were identified in Release 1 i.e. V2X communication and eUICC for connected cars. The report inter-alia has mentioned that:- *"There are concerns on non-availability of M2M services in North Eastern States and J&K in case of imported devices pre-fitted with foreign SIM cards. This is due to restrictions placed on international SIMs roaming to these areas. As government is considering only Indian SIM to be used in M2M devices, this may not remain an issue."*
- 3.108 Accordingly, a connected issue was raised in CP for comments of the stakeholders as to whether only domestic manufactured SIM/eUICC to be allowed in M2M. In response, most of the stakeholders are not in favour of allowing only domestic manufactured SIM/eUICCs.
- 3.109 In response, some stakeholder have stated that SIMs /eUICCs can be manufactured anywhere in the world, but should be activated within India, with a local service provider. Further one of the stakeholder has submitted that IMSIs issued by an Indian Company should be allowed,

eUICC carrying multiple IMSIs - home IMSI and foreign IMSIs - should be allowed. Home IMSIs should be allowed to be used at home country, foreign IMSIs should be allowed in the corresponding foreign land.

3.110 One stakeholder has taken a slight divergent view and has stated that many of the high end devices have preloaded foreign SIM where equipment warranty would be void in case of tampering, which may include changing SIM. Therefore, in some cases changing SIM may not be a possibility. The process to be followed in such cases should be clarified by the regulator. The stakeholder has suggested provision for regulatory oversight similar to Indian SIMs, in cases where the SIM cannot be changed within a specified time as notified by the regulator, the regulator may consider security verification and testing for SIM based devices.

3.111 One stakeholder has stated that from the economic point of view, it makes sense to mandate use of domestic SIMs for the device being used in India, but the fact that India is endeavoring to become a global manufacturing base, mandating use of only Indian TSP SIMs could have a reciprocal effect on the goods that are manufactured and exported from India.

3.112 Some stakeholders supporting allowing only domestic manufactured SIM/eUICC have suggested that only domestic manufactured SIM/eUICC should be allowed for the provision of M2M services. They have expressed that the remote SIM provisioning can take care of all practical challenges. Further, such a regime will facilitate MNP for M2M services as well, fostering more competition in the M2M market.

Analysis

3.113 As a major employment generator, GDP contributor and FDI earner, the automotive industry is instrumental in shaping the country's economy

and hence regarded as a 'Sunrise sector' under Make in India. Department of industrial Policy and Promotion (DIPP), Govt. of India, in its achievement report published on 24th November, 2016 has mentioned that in FY 2015-16, automobile exports grew by 1.91 percent (exports worth USD 8.8 billion)²⁹. The major growth drivers were Passenger Vehicles, Commercial Vehicles and Two Wheelers which registered a growth of 5.24%, 16.97% and 0.97% respectively in FY 2015-16 over the same period previous year. Exports in the auto-components sector is growing at a CAGR of 18% in the last 6 years. Exports in the last 2 years (2014-16) grew from USD 19.9 billion to USD 22 billion.

- 3.114 The report also mentioned that leading global players in car manufacturing companies like ISUZU Motors, Ford Motor, Tata Motors, and Suzuki Motor etc. have invested heavily in the manufacturing sector resulting in the setup of new assembly lines, manufacturing and green field units thus boosting the manufacturing ecosystem in India.
- 3.115 Some of the IT labs in India owned by the company viz. Bosch, Delphi and Mercedes are playing a critical role in the evolution of the Cloud Connected Car. Domestic carmakers³⁰ Tata Motors, Ashok Leyland and Mahindra Reva have their versions of Cloud Connected Cars and Fleet Management System ready. Thus it entails that companies having manufacturing base in India will install embedded M2M devices in the automobile at the production stage itself.
- 3.116 Consumer durables are another use case of huge potential for M2M/IoT where the product may remain in roaming for its entire life cycle. Consumer durables market which can be further differentiated by consumer electronics and consumer durables. According to India Brand

29 Reference: Department of industrial Policy and Promotion (DIPP), Govt. of India, website

³⁰ <https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-tele-tech-2013-noexp.pdf>

Equity Foundation (IBEF), India is set to become the 5th largest consumer durables market in the world. By 2025, India would rise from the 12th to the 5th largest position in the consumer durables market in the world. By 2020, the electronics market in India is expected to increase to USD400 billion from USD 94.2 billion in 2015. The production is expected to reach to USD 104 billion by 2020.

3.117 The Authority has carefully examined the comments of stakeholders and also noted the fact that 'Make in India' program of the government has significant impact on improving manufacturing profile of the country.

3.118 Draft IoT policy released by the government, envisages India to be global leader in manufacturing for M2M/IoT. Based on the comments of the stakeholders and overall ecosystem of M2M/IoT envisaged in the country, the Authority is of the view that it should not be mandated to have only Indian manufactured SIM to be operational in the country. The security concerns related to border area as mentioned in TEC report (para. 3.107 above) can be addressed by putting certain mechanism during import of such devices and SIMs.

3.119 **In view of the above, the Authority recommends that:**

- a) **It should not be mandatory to use only domestically manufactured SIMs in M2M. Embedded SIMs with standard specifications can be imported and relevant information shall be submitted by importer while import of the devices/SIMs.**
- b) **Suitable security mechanism similar to the existing mobile networks shall be put in place by the DoT for the Border States like J&K and NE areas, if deemed fit.**

F. International roaming charges

3.120 Mobility is rapidly becoming the primary concern of businesses globally.

M2M offers operators a choice, to build a value proposition around existing enterprise services and M2M connectivity. Telecom operators across the globe have begun planning and investing effectively to ensure that they are well-positioned for rapid growth in M2M services. This preparation includes partnering, revising price structures, realigning the organization and most importantly developing a working business model. Deploying an international solution has certain challenges both from a partnership perspective and also from a cost perspective, where roaming contracts can bloat traffic costs. It is a fact that operators with better network coverage, network quality and overall market presence and a wider multi-country footprint are better positioned to serve multinationals, leveraging existing roaming relationships with operator partners. Thus in order to make a fostering environment for M2M devices with in-built SIM requiring roaming at global basis, the Authority raised the issue for the comments of stakeholders on whether the international roaming charges be defined by the Regulator or it should be left to the mutual agreement between the roaming partners, in case permanent roaming of M2M devices having inbuilt foreign SIM is allowed.

3.121 In response, most of the stakeholders have pointed that international roaming charges should be market driven rather than prescriptive in nature. Given the availability of commercial roaming agreements in India, there is no need for any regulatory intervention on this matter. One stakeholder has further elaborated that it would, however, be wise for regulator to follow-up the development of the charges applied in these cases, so as to avoid having a party with significant power applying unreasonable commercial conditions which would in fact lock the market.

3.122 Some stakeholders have pointed that given the envisaged scales of service provisioning in India, the mutual agreements between the

roaming partners and the MSPs would be able to extract the best price for the roaming charges of the M2M devices. Therefore, it is ideal that the tariffs for international roaming be negotiated mutually between the roaming partners and the MSPs.

- 3.123 Some stakeholders have mentioned that M2M scenario is emerging and it would be prudent if we stick with the existing international P2P roaming policy. The commercial to be charged are anyway in TSPs domain and can be decided based on volumes and overall size/stake in the M2M. This can be re-visited/reviewed after some time.
- 3.124 One stakeholder has pointed out that generally, commercial considerations and not regulatory mandate drive adoption of innovative and efficient infrastructure sharing models such as network roaming. Typically, roaming arrangements are made at the discretion of the MNOs for their mutual benefits. Benefits include reducing operating costs, expanding network coverage into un-served geographic areas and provision of new services. Except any findings of anticompetitive behavior (e.g., collusion, abuse of dominance, margin squeeze), the rates for international roaming charges should be based on commercial agreement between the MNO partners.
- 3.125 One stakeholder has submitted that there is a possibility that for imported M2M devices, that may have SIM in-built, change or removal of SIM leads to nullification of the warranty and support as it amounts to device tampering. As standards are being driven for an interoperable and secure ecosystem, it is important for the Government and Industry, to address issues related to SIM. One stakeholder while expressing its view for not to consider permanent roaming of foreign SIMs stated that the same policy framework that is used in P2P mobile services should be maintained in the case of M2M mobile services as well.

Analysis

- 3.126 Present licensing regime allows licensees to enter into roaming agreements with other licensees as per their commercial arrangements for national roaming. For international roaming, licensees can enter into agreements with foreign Telecom Service Providers to provide roaming facility to its subscribers & vice versa. Roaming subscribers can only access those services to which they have subscribed in their home networks. The guidelines are applicable to voice as well as data services.
- 3.127 Multinational enterprises offering connected products to their global customer base are faced with a challenge to provide a seamless and user friendly localized M2M/IoT solution for end-users. The industry is evolving to overcome such challenges. For example- the Global M2M Association (GMA), an association of Deutsche Telekom, Orange, Telecom Italia, TeliaSonera, Swisscom, SoftBank and Bell has collaborated for Multi-Domestic Service platform which provides real-time connectivity management so that enterprises can effectively manage, monitor, troubleshoot and support their connected devices operated globally from a single source.
- 3.128 ITU-T Recommendation D.98³¹ on “Charging in International Mobile Roaming Service” provides many tools for lowering international mobile roaming rates including those for empowering consumers, offering market based solutions and making regulatory interventions. Another ITU Report, on ‘Regulatory analysis of international mobile roaming services’ published in March 2014 has undertaken in-depth analysis of roaming aspects and inter-alia concluded that: *Undertaking an investigation into international mobile roaming services is not easy. Operators will likely have significant resources to argue their case, and may claim to understand the market better than governments and*

³¹ <http://www.itu.int/rec/T-REC-D.98-201209-I>

regulators. More precisely, to the extent international mobile roaming prices remain a concern for governments and regulators, this report has been intended to provide the tools on how to undertake an analysis or investigation. Finally, it has canvassed the three main options open to a country that decides that some form of intervention is appropriate. These options are to treat the underlying competition problems, to treat the symptoms of those problems, or to harness the threat of regulation to provoke meaningful change amongst mobile operators.

3.129 The Authority is in agreement with the view that since M2M is at nascent stage therefore it is pre-mature to examine any issue of arbitrage or anti-competitive behavior in the market. The Authority also acknowledges the fact that international roaming tariffs could be better determined by market forces by bringing in innovations and improving network quality.

3.130 **In view of the above, the Authority recommends that:**

a) There is no case for regulatory intervention for setting ceiling for roaming charges for the devices imported with in-built SIM. The market forces shall address the issue based on commercial aspects.

G. International roaming policy for machines to communicate in the M2M ecosystem

3.131 International roaming policy can be broadly categorized into two aspects namely technical and commercial. Technical consistency in the form of adoption and implementation of standards commonly provides wider scope for businesses. Requirement of roaming becomes a mandatory aspect in certain cases due to the global nature of M2M business. Interoperability of devices in different networks become possible once globally accepted uniform standards are adopted for provisioning, information security, billing processes etc.

- 3.132 In relation to M2M roaming, it is important to distinguish M2M roaming from traditional consumer voice and data roaming, as the issues and implications in M2M are quite different. Looking at the types of roaming business model and regulatory innovations that could bring direct benefits to the end consumers, internationally harmonized standards are needed to foster innovative roaming solutions. Although relationship between operators and their bilateral commercial negotiations are key elements in this process. Accordingly, the Authority raised issue for the comments of stakeholders that what can be the International roaming policy for machines to communicate in the M2M ecosystem.
- 3.133 In response, most of the stakeholders have opined that they are not in favour of any regulatory framework related to international roaming for M2M. International roaming policy for M2M ought to be left to the mutual agreement between operators.
- 3.134 One stakeholder has stated that international roaming policy for machines should be based upon presently existing international roaming policy for voice and data services. Another stakeholder while supporting the view has stated that the Data ownership in such cases must be mandated to be with Indian TSP, on whose network the International SIM is roaming.
- 3.135 One stakeholder has submitted that the MSP shall utilize telecom resources operated by an authorized telecom licensee having valid license under Indian Telegraph Act, 1885, which may include international roaming under the international roaming arrangement or agreement with telecom operators worldwide. Further, the M2M roadmap released by DoT recognized the global nature of M2M services and underscore that a locally registered MSP in India may have commercial arrangements with MSPs in foreign markets. Therefore, it is important that resources being used to provide service can transit countries throughout a product's

lifetime. Additionally “international roaming” is an accepted concept, and is specifically mentioned under clause 4.3.4 of the National Telecom M2M Roadmap as well. The TRAI should follow the same recommendations in order to be consistent with the roadmap.

3.136 Some stakeholder have mentioned that for accommodating and facilitating the extra-territorial use of IMSIs and MSISDNs on a bilateral commercial basis, the ‘International M2M roaming framework’ addresses and makes transparent international roaming used explicitly for M2M services. This roaming framework enables the use of the home carrier’s IMSI and MSISDN to provide services on a global basis through a single SIM architecture.

3.137 The stakeholders has further submitted that in 2012, GSMA adopted an “M2M Annex” template for international roaming which mandates transparency in the provision of M2M services by requiring the parties to agree to identify their M2M traffic separately from other traffic and to exclude traditional wireless services. The stakeholders has also referred the BEREC report on Enabling the Internet of Things dated 12th February 2016, the Telecom Single Market (TSM) Regulation.

3.138 One stakeholder has further elaborated that allowing the extra-territorial use, in both directions of E.212 and E.164; numbers for M2M services is consistent with existing TRAI objectives and does not compromise the ability of the TRAI to perform its statutory functions. In the first place, all cases of permanent roaming in India, as elsewhere, involve an Indian MNO that is directly subject to the jurisdiction of the national regulator.

3.139 One stakeholder has submitted that M2M devices that are equipped with permanently roaming SIM cards are already fulfilling the regulatory requirements that are laid out in the international roaming agreements. For instance, lawful interception is possible at the SGSN, just like in the

case of international roaming by travelers. KYC may not always be required for every device, some M2M services require end user registration at least during initial set-up, for instance most telematics services for connected cars. In these cases, KYC is possible at least regarding the initial user of the service, and the M2M Service Provider will run a database which matches device numbers (for instance, vehicle identification numbers), IMSIs and personal data.

- 3.140 One stakeholder has opined that it is appropriate to have International roaming policy for machines which can communicate in the M2M ecosystem. This however requires further study and analysis. Another stakeholder while supporting the view has pointed that it should be clarified how the Privacy and Security Policy for managing data within India should be enforced for devices that roam out of India.

Analysis

- 3.141 On 15th December 2016 the European Commission adopted rules on the application of fair use policy on roaming at domestic price, as mandated by the co-legislator in 2015. The adoption was a result of intensive consultations with the European Parliament, Member States, stakeholders, consumer representatives, operators and the Body of European Regulators in Electronic Communications (BEREC). *The Regulations introduce that “a common approach to ensuring that users of public mobile communications networks, when travelling within the Union, do not pay excessive prices for Union-wide roaming services in comparison with competitive national prices (...).”*
- 3.142 The efforts of European Union (EU) are an example of international collaborations in making mobile services affordable so that customers are benefitted at large. Consequently, the EU has ended roaming charges for all people who travel periodically in the EU, while ensuring that operators

have the tools to deal with abuses of the rules. 'Roam like at home' is aimed for all people who travel in the EU, outside the country where they live, work or study. Although the provisions of 'Roam like at home' is not meant to be used for permanent roaming. Consumer-friendly safeguards are in place to avoid abuses. Operators can detect possible abuses based on the balance of roaming and domestic use over a 4-month period: if a customer spends the majority of time abroad and consumes more abroad than at home over the 4 months, the operator can ask the customer to clarify the situation within 14 days.

- 3.143 Majority of the stakeholders have indicated that existing framework of international roaming are adequate and workable. There is M2M specific GSMA adopted "M2M Annex" template for international roaming which mandates transparency in the provision of M2M services by requiring the parties to agree to identify their M2M traffic separately from other traffic and to exclude traditional wireless services.
- 3.144 ITU-T Rec. E.212 defines the extra-territorial use of E.212 resources as a situation where a MCC+MNC assigned to an operator in one country ("Country A") is used in another country ("Country B") through the network established in Country B. As per ITU recommendations the operators wishing to implement the extra-territorial use of an MCC+MNC, to seek approval of the relevant administrations of both Country A and Country B. The administrations should then confer together on the extra-territorial use of the MCC+ MNC and notify the applicant and all other PLMNs operating in Country A and Country B of their decision.
- 3.145 There is another business model in which SIM cards generated using the MCC+MNC in Country A are used in Country B. In this model there is no Country A network elements installed in Country B but it could still be regarded as extra-territorial use. Extra-territorial use of E.212 resources, as defined by the ITU, is not a widespread practice. Although some

reports of this were made to the ITU in 2012 and 2013 by Sweden, Switzerland and the Netherlands. In 2016, Federal Network Agency (BNetzA) of Germany ³² has set clear rules which allow use of extraterritorial IMSIs for M2M services provided in Germany as well as the use of German IMSIs for extraterritorial services.

3.146 In the broader context, the Authority is of the opinion that prevailing rules and provisions for the international roaming framework are able to address the requirement of the industry as such. As M2M standards and framework is evolving and new innovations at network level will take place during the course of time, the government in view of its IoT Policy and 'Make in India' initiative may consider studying the feasibility to allow extra-terrestrial use of IMSI by entering into country specific bilateral agreements. The import of devices from these countries shall also be considered for exemption from restriction on permanent roaming with adequate checks and balances.

3.147 **In view of the above, the Authority recommends that:**

- a) **International roaming in M2M shall be allowed under the well recognized framework of GSMA 'M2M Annex' to keep uniformity of the parameters and processes.**
- b) **In order to boost the M2M/IoT manufacturing in India, the government may consider feasibility of allowing extra-terrestrial usage of IMSI ranges with suitable framework on the basis of country specific bilateral agreements.**

H. Feasibility of allocating addressing resources

3.148 In normal cellular operations, if a customer intends to change connectivity service provider, it is currently necessary that the SIM is

³²https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/BNetzA/PressSection/PressReleases/2016/150615_IMSI.pdf;jsessionid=E5F0B1C360DA35FF0DF081B2EEC75059?__blob=publicationFile&v=2

replaced physically. However, in the M2M-context, physical replacement of SIM tends to be practically and technically impossible as most of the SIMs will be embedded or software driven. Also cost of changing of SIM and issues of proprietary standards might prevent (“lock-in”) switching the connectivity service provider. The idea to assign MNCs to MSPs is to make them independent on having a numbering series that could stimulate competition by enabling balanced negotiations that promote the growth of M2M. A large MSP holding its own MNC could have more leverage when entering negotiations with a potential TSP partner over its roaming and other rates. In order to explore the feasibility of assigning network codes to MSP, the Authority raised the issue for the comments of stakeholders on whether it would be feasible to allocate separate MNCs to MSPs, in order to provide operational and roaming flexibility to MSPs. The Authority further sought stakeholders view on the pros and cons of such arrangement.

3.149 In response, most stakeholders has submitted that Mobile Network Codes (MNCs) should continue to be given only to TSPs holding CMTS/UASL/UL (Access Service Authorization).

3.150 One stakeholder has highlighted that during the consultation process of VNOs, the issue of giving MNC to VNOs was also deliberated. However, even TRAI had recommended against the direct allocation of MNCs to VNOs despite the fact that VNOs already hold a Unified Licence. DoT accepted TRAI’s above mentioned recommendations and decided not to allocate a separate numbering series to VNOs. Since the same grounds also apply to TSPs/VNOs providing M2M mobile services, the stakeholder does not suggest any change in the allocation methodology.

3.151 Some stakeholders have further submitted that this is a similar situation to that of MVNO where underlying network numbering resources are being used for provisioning of service. Deployment of entire HLR

infrastructure will require substantial investments and extensive roaming arrangements with various TSPs. M2M service is part of the data service with fewer complexities. The stakeholders have suggested that instead of providing MNCs to MSP, provisioning of free roaming for M2M services would provide the operational and roaming flexibility for M2M services sans the complexity and cost of deploying the switch and the HLR. The stakeholders also stated that it is important that the numbering resources, for the M2M services too, are provisioned through the underlying NSOs only. The stakeholders have also submitted that TSPs should have the operational flexibility to choose and use MNCs for M2M services, as they deem fit, from the series of MNCs allotted to them.

3.152 One stakeholder has elaborated that M2M service using India SIMs can be offered only through an access/VNO authorization under UL. In case of VNO, license holders shall reach out to Access Service Providers for use of India MSC (M2M) Number series on the basis of mutual contractual agreement which inter-alia will contain compliances on numbering plan, routing plan, security conditions etc as are applicable to the parent NSO (Access Service Licensee).

3.153 One stakeholder has elaborated that Allocation of a separate Mobile Network Codes to MSPs, require detailed study of its technical and logistical complexities and implementation cost. While this solution will enable MSPs to select the connectivity provider depending upon their commercial arrangements and wide-spread coverage, leading towards rapid growth of this industry, but it also exposes to security, fraud risk and misuse of allocated numbering resources to MSPs, as this solution will allow private parties to procure and issue SIM cards. Moreover, since most of the M2M solutions are likely to work on data technology, a separate number series may not hold significance.

3.154 Some stakeholders have stated that while there may be potential benefits

of liberalizing some numbering assignment policies to extend the direct allocation of MNCs to MSPs, there are concerns in granting MNCs to parties other than telecom operators (i.e., to M2M users or MSPs, rather than MNOs or virtual MNO (MVNOs)). Changes in Mobile network codes (MNC) numbering allocation policies should be carefully assessed in light of their implementation costs, and their technical and logistical complexities. Some stakeholders have mentioned that according to the Body of European Regulators of Electronic Communications (BEREC), allowing IoT users to be assigned MNCs raises questions of the technical and economic conditions of MNC assignees. The stakeholders therefore requested to observe what countries with more open MNC assignment policies have experienced before making a policy decision.

- 3.155 One stakeholder has further elaborated that Technical solutions for changing connectivity provider are available today that eliminates the need to physically replace the SIM or to change MNC allocation policy. The GSMA Embedded SIM specifications were developed specifically for M2M market where it can be challenging to provision connectivity from the outset, or when deployed devices have a long lifetime and/or are deployed in locations where physical SIM replacement is not practical.
- 3.156 One stakeholder has submitted that it does not believe the benefit justify having MNCs allocated to MSPs. Today, there are different solutions (proprietary and GSMA) in the market to allow a SIM Card to be re - provisioned over the air with a new Service Provider, avoiding the MSP lock-in. There are potential benefits viz. easier for MSP to switch Service Providers of connectivity, avoiding lock-in, as the costs of swapping SIMs deployed in field are usually prohibitive. On the other side there are disadvantages in the form of increased complexity for the MSP. It could be argued that security could be compromised by having an inexperienced private third party handling identifiers.

- 3.157 One stakeholder has detailed that traffic separation could be done not only with operator resources and local resources (e.g. MCC 404 MNC 999) but also with ITU resources (e.g. Shared Country Code; MCC 901 MNC04). The stakeholder has submitted that the so-called non-geo SIM (MCC 901) act as a proper instrument to fulfill M2M/ IoT needs. Separation of traffic is advantageous to be able to set specific technical parameters as well as for negotiation of roaming rates. Usage of a non-geo SIM compared to any other foreign SIM in India is just dependent on the roaming agreements in place for the respective resources. “National Roaming” would be possible for both options / resources. Given that a Global SIM does not have any home country, it roams everywhere and could make use of any roaming network in the world, providing “Best Coverage”.
- 3.158 The stakeholder has also stated that currently used solution which is based on GSMA/ITU standards (the extra-territorial use of a numbering resource (normal E.212 MNC code / E.164 MSISDN and MCC 901 types) for M2M services in both directions) is much more effective. Indian regulators should allow the permanent use of E.212/E.164/MCC901 type numbering codes outside Indian territories as well as the use of foreign IMSI/MSISDN within Indian Territory.
- 3.159 One stakeholder has stated that the MSPs will need to take subscriptions from several TSPs and other wireless network providers. The MSP must get a separate series. In the example of the embedded UICC the Operational subscription will not be allocated till the card is sold after manufacturing, so the ICCID on the card for identification should belong to the MSP.
- 3.160 Some stakeholders have opined that opening up access to Mobile Numbering Codes (MNCs) could stimulate competition by enabling balanced negotiations that promote growth of M2M. Large MSP holding

its own MNC could have more leverage when entering into negotiation with potential TSP partner over its roaming and other rates. This would enable the user to be no longer dependent on a specific TSP. This will provide him the freedom/choice to change the SIM and other settings independently, thereby enhancing competition in the market for M2M. Switching to new TSP at any stage would be much simpler & less expensive for an MSP because SIM cards that are installed in the M2M devices would not need physical replacement. Another stakeholder while supporting the idea has stated that by allocating Mobile Network Code to MSP, one will be able to have a differential treatment, but it would be a complex system.

- 3.161 One stakeholder has submitted that MSP latches to its primary TSP (UL Access). Numbers should only be assigned to the TSP and it should have an option of sub-assigning them to the MSP. The primary responsibility of complying with interconnection, roaming etc., should be with the TSP. M2M devices work on the SIM cards issued by the TSPs and is assigned numbers accordingly. A separate numbering scheme (such as 11 digit or more) should be prescribed for M2M Services so that these services can be easily identified, if it doesn't add to the complexity of the TSPs. There may be shortage of MNC in the future keeping in mind the fast paced growth of devices across the globe. However, TSPs are eventually moving to Packet Switching based 4G / LTE network and M2M is a data based service. So they recommend M2M services must be based on IPv6 platform. Building M2M services on the advanced and upcoming technology (IPv6) will be economically feasible in the long run. This will also eliminate the problems of switchover from IPv4 to IPv6 in the future.
- 3.162 One stakeholder has suggested the Authority to consider the work carried out by TEC on numbering plan for M2M services. In this regard the stakeholder has elaborated that as per the proposed plan by TEC

having two options; DoT has provided 5 codes of 3-digit length – 559, 575, 576, 579, and 597. The stakeholder has requested the Authority to consider a two digit M2M identifier instead of three, which could also provide very large scalability. The scheme under both options of TEC mail may scale up to 50 billion count (each series 1000*10 million = 10 billion), provided there is no dedicated identifier for MSP/MNO, M2M operation is operated at national level with no PLMN demarcation at circle level. However, such a scenario needs deeper analysis from feasibility and operability aspects.

Analysis

3.163 IMSIs are unique identification numbers that allow device recognition and network routing. The IMSI consists of a mobile country code (MCC), to identify the country; a mobile network operator code (MNC), to identify a specific network within that country; and a Mobile Subscriber Identity Number (MSIN), which identifies a specific customer within the mobile network operator's customer base. Globally, network codes such as MNCs are allocated mainly to MNOs. However, in some countries MNCs are allocated to MVNOs also.

3.164 Few countries in European Union including Germany have liberalized policies with regard to allocation of IMSI ranges. As mentioned earlier in para. 3.145 above, in order to promote its Industrial Revolution 4.0; BNetzA's (German Regulator) new rules allow foreign IMSIs (i.e., IMSIs with non-German country codes) to be used in Germany, as well as for IMSIs with a German country code to be used outside of Germany. BNetzA initially considered a notification requirement in the context of public safety, capacity planning relative to number management and clarity into the use of German IMSI numbers used abroad but determined that none of these objectives superseded the need for a streamlined approach to the extra-territorial use of IMSIs for M2M

applications.

- 3.165 ITU-assigned numbering resources (from the E.212 shared 901 Mobile Country Code (MCC) and/or E.164 +882/+883 ranges) provide another potential numbering solution for M2M services that are to be deployed in multiple countries. MCC 901/882/883 has been traditionally adopted by telecom operators as well as companies like Iridium, Inmarsat and Thuraya etc, those are providing services of global nature such as maritime and satellite communications. As per the information available at ITU website³³ recently the MCC 901 having been assigned to the companies associated with M2M/IoT. These assignments indicate that shared MCC 901 could be a better option to address the M2M market in future.
- 3.166 There are certain advantages of using MCC 901 for M2M in the long run. The foremost advantage is that SIM under such configuration becomes global and there is no requirement of procurement or reconfiguration of country specific SIM. Another advantage is that faster rollout of the services is possible and traffic of M2M can also be distinguished from traditional traffic of voice and data. However implementation of MCC 901 has been on voluntary and mutual agreement basis by some operators in the world. This is because of the fact that each operator will have to change the configuration for MCC 901 in their networks in case it is mandated to be configured.
- 3.167 Majority of the stakeholder are of the view that network codes such as MNCs shall only be allocated to CMTS, UAS, and UL-Access license holders. The reasons mentioned by stakeholders for not allocating the MNCs to MSPs are lack of technical expertise, requirement of huge investment in network infrastructure, security issues, mishandling of

³³ http://www.itu.int/net/ITU-T/inrdb/e212_901.aspx

resources etc.

3.168 The Authority has noted that numbering issue for the M2M cellular connections has been adequately addressed by DoT. A 13-digit numbering scheme for M2M has been finalized and accordingly identifiers 559, 575, 576, 579, and 597 have been issued for implementation by the TSPs in their networks. The Authority is also optimistic about the fact that dependency on numbering system will get reduced in future as adoption of IPv6 across the networks and devices increases.

3.169 **In view of the above, the Authority recommends that:**

- a) Allocation of various network codes including MNCs shall be to licensed TSPs only.**
- b) There is no need to allocate MNCs or any other network codes to MSPs.**

I. Quality of Service (QoS)

3.170 Sub-Clause (v) of clause (b) of sub-section (1) of section 11 of Telecom Regulatory Authority of India Act, 1997 (24 of 1997) mandates the Authority to “lay down the standards of quality of service to be provided by the service providers and ensure the quality of service and conduct the periodical survey of such service provided by the service providers so as to protect interest of the consumers of telecommunication services”. In the discharge of these functions the following are incumbent on the Authority:

- (i) create conditions for customer satisfaction by making known the quality of service which the service provider is required to provide and the user has a right to expect;

- (ii) measure the Quality of Service provided by the Service Providers from time to time and to compare them with the benchmarks so as to assess the level of performance; and
 - (iii) to generally protect the interests of consumers of telecommunication services,
- 3.171 In M2M environment there will be billions of devices interconnected and exchanging information. Such complex and heterogeneous resources and networks will pose a new challenge of setting benchmarks and meeting requirements in order to provide guaranteed QoS to M2M consumers.
- 3.172 Role of the network is to manage nodes (discovery, join, leave, etc.) and relay data packets from the source to the destination node in the network. From the QoS perspective, M2M Architecture broadly consists of three interlinked domains -M2M Device Domain, Network Domain and Application Domain.
- 3.173 In M2M Device domain, short ranges Personal Area Networks (PAN) communication takes place between devices such as sensors, actuators, aggregators and gateway using the protocols such as Bluetooth, Zigbee, WiFi etc. The information can further be transmitted to the internet through gateway device or to local user/control. Since short range communication is generally based on standard protocols, there is no role of public telecom network in such scenario.
- 3.174 The role of public telecom network becomes prominent for establishing a reliable communication between M2M data aggregator and application server/cloud for exchanging the information collected from M2M devices.
- 3.175 The heterogeneous networks (HetNets) are composed of wireless networks with diverse access technologies, e.g. 2G, 3G, 4G, WLAN, WiFi, and Bluetooth. The HetNets are already standardized in 4G; Existing cellular

networks are not substantial enough to support massively connected devices with low latency and significant spectral efficiency, which will be crucial in the future communication and computing.

3.176 Well defined QoS parameters are important for evaluating whether technologies, services, and applications meet customer expectations for quality, availability and reliability. Each new product faces a challenge of delivering a QoS equal to or better than existing products. Therefore, service providers have to find new ways of improving their services, even in heterogeneous environments. As brought out in the CP, QoS can be looked at from two major perspectives- network perspective and application/user perspective. In view of the heterogeneity of the networks in M2M/IoT environment, as discussed above, the Authority raised an issue for comments of the stakeholder on whether there is a need to define different types of SLAs at point of interconnects at various layers of Heterogeneous Networks (HetNets). The opinion was also sought on the parameters that must be considered for defining such SLAs.

3.177 In response, some stakeholders have pointed that TRAI has already prescribed QoS norms for bearer services, both wireless and wireline (voice and data) and the same should also apply to M2M communication services. The QoS/SLAs of M2M should be flexible, left to mutual agreement between customers and TSPs and based on the use case (instead of on bandwidth). Another set of stakeholders having similar view further mentioned that since SLAs may require different measurements depending on the M2M service provided, any attempt by government to set those parameters could result in impeding the deployment of new and innovative services. The best approach is not to mandate any QoS as every M2M application may have its own unique requirements.

3.178 Some stakeholders have submitted that presently M2M business cases

are in B2B segment and at very nascent stage. So, at this stage fixing benchmarks/ SLA is not advisable. Once, there are enough identified issues pertaining to quality of service, TRAI may come up with SLA/ QoS Regulation as done in the case of Mobile Banking.

- 3.179 Some stakeholders have stated that the Authority should allow the SLAs to be defined and followed mutually by the M2MSP/M2MAP with TSP/ ISP/ VNO, in the context of M2M services for that specific segment; since such services are evolving and require maturity and adoption.
- 3.180 One stakeholder has suggested that the existing UASL already covers QoS very comprehensively and keeping in view the evolving nature of various communications technologies and standards to support M2M use cases, it may be premature to make amendments to the existing license to address the requirements of M2M.
- 3.181 One stakeholder has stated that Point of Interconnect (POI) norms are applicable where interconnectivity is provided between two networks and the rules for the same are elaborately laid down under the Access services authorization under UL and the same would be applicable in case of M2M services offered under UL access services authorization. In case of UL (VNO), once the entity intending to provide M2M service obtains VNO authorization, the prevalent norms on POIs applicable to the parent NSO will be automatically applied/ extended to it as well. Regarding QoS benchmarks for M2M networks, being different in characteristics insofar as it involves cross industry partnerships, should not be defined only from the communication/connectivity point of view.
- 3.182 One stakeholder has elaborated that QoS requirements will vary with the type of M2M application. Hence, diverse QoS requirements will have to be incorporated in the application design on a case to case basis. Also, technical specifications are still evolving to meet the requirements of

M2M/IoT communication, as M2M is still at a very nascent stage in its evolution. Thus, it is critical to allow the standards to become sufficiently mature and stable before any regulation on QoS is notified.

- 3.183 One stakeholder has stated that Internet of Things (IoT) is a technological paradigm which is an extension of existing heterogeneous networks with capabilities of sensing, actuation, communication, computation, networking and storage, to get the real world data to the end user applications and systems. Quality of Service (QoS) in IoT is one of the critical factors for implementation, management and optimizations. Licensed spectrum can reliably deliver high quality of M2M services over wide areas, as operators are not at risk of interference and can control usage levels. QoS parameters are covered in the license of the TSP's, and the same can be extended to M2M services as well.
- 3.184 One stakeholder has stated that in terms of networks, the M2M SLA for mission critical use cases must mandate access to more than one mobile network. The eUICC can enable this requirement. Apart from emergency services and Military services, which both uses dedicated networks, all attempts to define QoS and reserve bandwidth have failed. QoS is handled by each ISP as per their agreements with interconnecting networks. M2M services should not require anything in addition.
- 3.185 One stakeholder has elaborated that the M2M system should be able to make use of the Quality of Service (QoS) supported by underlying networks. M2M applications or service capabilities may use QoS capabilities of the underlying networks when implemented by the system. There is no need to define different types of SLAs at point of interconnects at various layers of Heterogeneous Networks as well as any distributed optimal duty cycle to optimise the energy efficiency, end-to-end delay and transmission reliability in a M2M network.
- 3.186 Among the stakeholders supporting SLAs to be defined has suggested

that there may be guidelines defined by TRAI, to pre-empt a call drop like situation at points of interconnections, however, the SLAs should be as per contractual T&C of the MSP and TRAI may offer guidance on minimum performance levels. Another stakeholder supporting the requirement has stated that there is a need to define SLAs at point of interconnects, however the definitions of parameters for SLAs need further study.

- 3.187 One stakeholder has suggested that there is a need to define different types of SLAs at point of interconnects at various layers of Heterogeneous Networks (HetNets) as this would ensure that Open Access network, third party Application platform, TSP network infrastructure are interconnected and shall adhere to SLA to provide required quality of service. Depending on the type of application & type of service, SLAs shall be designed at point of Interconnects at various layers. Further, a few applications may require lowest latency while some applications might require highest availability (always ON), while a few others may require burst data periodically. Latency, Guaranteed Bandwidth, Availability, zero error communication, etc. are some of the realities of network management, and they need to be acknowledged and catered to.
- 3.188 One stakeholder has submitted that the challenge lies in providing end-to-end communication with guaranteed QoS. A common QoS framework is required to be adopted from Network perspective. Some of the parameters that may be taken into account while defining the SLAs would include latency, packet delays, reliability of packet transmission, packet loss, data rate, etc. QoS parameters can also be defined separately for different types of services.
- 3.189 One stakeholder has mentioned that it has 3 different types of SLAs with their customers, which are namely (i) IoT communication service availability; (ii) uplink delivery time; and (iii) availability of cloud access.

- 3.190 One stakeholder has submitted that the QoS and SLAs for M2M services are purely dependent upon the type of service offered and connectivity structure deployed by M2M service provider. Therefore, the standard SLAs for each M2M service will not be applicable and should be mutually agreed between the M2M service provider and connectivity provider. Further, licensed and unlicensed spectrum will have different QoS for M2M services. The licensed spectrum can provide high quality of service guarantees over wide areas without any interference and can control usage levels as they have exclusive access to their spectrum bands. The licensed spectrum will have higher assurance level for crucial M2M services such as security, transportation and medical applications. Whereas, unlicensed spectrum having low power and high risk of interference, may not always support such critical applications which demands higher QoS levels.
- 3.191 Some stakeholders have submitted that the differences between fixed and mobile networks should be recognized, including technology differences and the impact of radio frequency characteristics. Consumers should have the ability to choose between competing service providers on the basis of being able to compare performance differences in a transparent way. The high degree of competition in the mobile market provides ample incentives to ensure customers enjoy the benefits of an open internet.
- 3.192 One stakeholder has opined that QoS norms for M2M cannot be static, as different M2M mobile services will have different QoS requirements. Although many M2M services have no stringent QoS requirements and can deal perfectly with best-effort QoS, but some M2M services will have higher QoS or priority requirements than normal data services. The stakeholder has stated that QoS/SLAs of M2M should be flexible, left to mutual agreement between customers and TSPs and based on the use case (instead of on bandwidth), as prescribing standard QoS norms for

M2M will be very complex and difficult to monitor. TRAI should follow a light touch approach to QoS with respect to M2M/IoT and allow the customers and TSPs to come to a mutual decision (as is being done for enterprise services).

3.193 One stakeholder in its detailed submission has stated that there are currently three perspectives on quality-of-service:

- a. Network perspective - Network Service Parameters: represents the quality that is offered internally by a service management team in the national as well as in the roaming case. This includes for example “incident resolving time” or “availability of service node”.
- b. Network perspective – Technical Parameters: refers to the service quality that networks offer to applications or users. Network QoS parameters are latency or delay of packets, reliability of packet transmission etc.
- c. User perspective: parameters describing the quality which is recognized by the user of the M2M service. User QoS parameters can be e.g. quality of the video from a surveillance camera, refresh period of sensor data or SMS delivery time.

3.194 The stakeholder has further elaborated that in the current implementation of GSM/LTE networks vis-à-vis issue of technical QoS parameters in M2M, there are use cases which need high-bandwidth and transmission priority and also on the other hand use cases with low-bandwidth and low priority. The stakeholder states that currently there is no way to implement proper solutions in the present mobile network environment and therefore the industry is very active in defining the next generation of mobile communications (5G). This standard is explicitly addressing the needs of M2M quality (mMTC).

Analysis

- 3.195 Generally, QoS is defined as the performance level of a service offered by the network to the user. QoS has a stringent requirement for real-time applications and enables more efficient sharing of network resources. It manages time-sensitive multimedia and voice application traffic to ensure that it gets a higher priority, since greater delays cause serious deterioration in the provided service.
- 3.196 The requirement of QoS can be broadly categorized as low, medium and high. For the narrowband operations, the grouping of application for M2M can be done based on range, bandwidth and QoS, reflecting the predominantly narrow band nature of most M2M applications.
- 3.197 Licensed cellular networks viz. CDMA, 2G, 3G and 4G/LTE are inherently designed to provide standardised QoS. By tweaking certain parameters these networks can provide optimal results to certain extent. Security and privacy of the networks & information in licensed cellular network is an integral aspect and thus provides a clear advantage to cellular networks using licensed spectrum over network using unlicensed spectrum. The operation based on the unlicensed spectrum such as WiFi and LPWAN cannot be enforced or configured for guaranteed QoS. From user's point of view M2M/IoT operations can be categorised as normal, business critical, mission critical.
- 3.198 Network is a distributed system. All nodes need to perform networking related tasks. RF-based Network in M2M/IoT is usually a Wireless Multi-hop Network. There are challenges of reliability and performance in such networks. Some examples are:
- Wireless Sensor Networks (WSNs)
 - Mobile Wireless Ad hoc Networks (MANETs)
 - Wireless Mesh Networks (WMNs)

- Vehicular Ad Hoc Networks (VANETs)

3.199 The prevailing mechanisms and defined parameters have been adequately addressing QoS requirements for voice, data and messaging in P2P communication. Some of the M2M services such as vehicle tracking etc. are already being provided by TSPs for long but due to gaps of coverage and capacity, the QoS is often below benchmark in general. In near future, the challenge lies to address QoS issues for billions of connected devices or things meant for critical communications having ultra reliable and near real time requirements. These requirements cannot be fulfilled unless the capability and capacity of the underlying network are not enhanced. Moving forward a few years, a major component of fifth generation (5G) network is likely to be ultra-dense network configurations, particularly in metro areas.

3.200 The fifth generation (5G) of the cellular networks are not only natural progression of 4G networks but also will be focussed on various aspects those are not addressed so far through prevailing networks. Certain identified prospects of 5G networks are user-centric (by providing 24x7 device connectivity, uninterrupted communication services, and a smooth consumer experience), service provider centric (by providing a connected intelligent transportation systems, sensors, and mission critical monitoring/tracking services), and network operator centric (by providing an energy-efficient, scalable, low-cost, uniformly-monitored, programmable, and secure communication infrastructure).

3.201 In its progression, the development of 5G networks are perceived to realize the main features mentioned below:

Ubiquitous connectivity: In future, many types of devices will connect ubiquitously and provide an uninterrupted user experience.

Near Zero latency: The 5G networks will support life-critical systems, real-time applications, and services with zero delay tolerance (extremely low latency of the order of 1 millisecond).

High-speed Gigabit connection: The zero latency property could be achieved using a high-speed connection for fast data transmission and reception, which will be of the order of Gigabits per second to users and machines.

- 3.202 Communication in M2M / IoT is generally based on internet, this implies that devices and underlying network must also support TCP/IP. For relaying the packet into Internet for a practical deployment, a gateway is often needed in a network. It offers relaying packets between the network and the Internet. Besides the networks based on TCP/IP, there are numerous evolving technologies in M2M those do not use TCP/IP at all. Sigfox which operates in unlicensed spectrum is one of such protocol which have very low payload and is not based on TCP/IP protocol suite.
- 3.203 The Authority is of the view that M2M is at a nascent stage of development and standardization are still taking shape worldwide. The role of HetNets will be prominent during development and deployment of 5G networks. The Authority is in agreement with the views of stakeholders that there will be requirement of application based QoS that has direct relation with allocation and aligning network resources. The Authority is also aware of the fact that core functions of present networks are gradually moving towards Network Function Virtualization (NFV) and radio part will be managed through Software Defined Network (SDN) where licensed and unlicensed spectrum can be used efficiently. Entire M2M/ IoT is required to be seen as a separate domain of device, network and application and accordingly, QoS requirements should be addressed. For example - criticality of the service has to be decided at device level to opt the best network/ medium to reach the destination. This implies that

critical services shall be running only on licensed spectrum and unlicensed spectrum will be utilized for non-critical or normal M2M /IoT services.

3.204 The Authority believes that at this juncture existing parameters/norms of interconnection suffice the requirement. Heterogeneity of networks and their associated issues are likely to be addressed through technological development especially in 5G deployments in near future. Accordingly, market forces and M2M/IoT ecosystem will adequately address such issues once there is enough proliferation of M2M /IoT ecosystem.

3.205 **QoS is in the exclusive domain of TRAI. Therefore, the Authority recommends that:**

a) Once the M2M sector develops, the Authority will put in place comprehensive regulations on QoS parameters in M2M communication, as per service requirements.

J. Distributed optimal duty cycle to optimise the energy efficiency

3.206 In an M2M environment, concurrent and massive access of devices may cause performance degradation, such as intolerable delay, packet loss, and unfairness due to possible congestion and interference. To fulfill the requirements of IoT, the main design challenge for M2M communications is to effectively manage the massive access of energy constrained devices while satisfying different QoS requirements. To resolve this issue one option could be to have duty cycle control to improve the end-to-end network performance by optimisation of energy efficiency, delay and reliability. In M2M ecosystem, due to the coexistence of cellular and capillary networks, it is crucial to optimise the overall network performance by simultaneous optimisation of access control and duty cycle control.

3.207 In view of the forgoing, the Authority raised an issue in the CP to seek

stakeholders view on the distributed optimal duty cycle to optimise the energy efficiency, end-to-end delay and transmission reliability in a M2M network.

3.208 In response, one stakeholder has submitted that while any policy should be technology neutral; guidance on energy efficiency, delays etc. are important for optimisation of performance and to ensure service levels. The major benefit of supporting M2M applications in cellular networks is the ubiquitous wireless access in both urban and rural environments on the existing wireless cellular infrastructure, which means there is no need to build alternate infrastructures. However, the low mobility, stringent cost and energy efficiency requirements of M2M devices make the design criteria of M2M communication very different from that of cellular networks. The stakeholder has proposed to allow for higher device density, a lower power level ~0.5 – 1 Watt with a 5-10% duty cycle. It is essential to support a large number of M2M devices, and suitable specifications and standards may be adopted, keeping local requirements and global trends in mind, after a thorough technical analysis.

3.209 One stakeholder has suggested that for co-existence of multiple operators on same unlicensed M2M band, standards mentioned in table 3.6 should be followed. This will ensure efficient usage of M2M unlicensed spectrum and avoid spectrum hogging by any single MSP.

Table 3.6

Device duty cycle of 5%	with Channel BW of 200 KHz and max Device
Transmit power-	30dBm. (EIRP)
Network duty cycle of 10%	with Channel BW of 200 KHz and max transmit power- 36dBm (EIRP)
Allow	Transmit power of 36dBm EIRP and 250 KHz channel in a specific frequency.

- 3.210 Some stakeholders were of the view that the energy efficiency, end-to-end delay and transmission reliability etc., are specific to a particular use case and are technology specific and therefore may be left to M2MAP/M2MSP and MNO/TSP/ISP/VNO.
- 3.211 One stakeholder has suggested that M2M Networks should be encouraged to package data in 140 byte packets so that the SMS fallback from GSM Data and LPWAN networks can co-exist. Another stakeholder has submitted that Duty Cycle used in Europe and other countries who adopted European standard ETSI EN 300 220 for non-specific SRD and the related recommendation from Electronic Communications Committee (“ECC”) ERC 70-035, can also be used in India. The stakeholder proposes the Duty Cycle limit of 1% to 10%, depending on the application, and to allow TSPs and MSPs to determine the end-to-end delay and transmission reliability in M2M network, as a commercial decision based on the positioning of its service proposition.
- 3.212 One stakeholder has submitted that the energy efficiency of the M2M devices is solely dependent on the frequency of feedback from the end devices. Therefore, the optimization of the services shall largely depend on the application that is deployed for provisioning the M2M services.
- 3.213 One stakeholder has stated that the contemporary reports from NGMN, 5G Americas and like organizations have revealed that the various parameters of determining network performance include optimal duty cycle for energy efficiency, end-to-end delays and transmission reliability. However, the evolution of M2M space is in the early phases of inception and it requires further study to determine the specific parameters (with respective values) that can be used for deployment purpose.

Analysis

- 3.214 Generally in many use cases of M2M like the ‘wearable devices domain’

or low sampling rate applications, the devices working in ultra-low power environment typically operate on battery power and are characterized by short, occasional periods of activity combined with long periods of inactivity. In most cases like these there will be infrequent or zero human interventions. Energy efficiency is a key performance criterion for such devices, and this emphasizes requirement of prolonged battery life of years and even decades. Energy efficiency is directly associated with duty cycle. In a nutshell, a well defined duty cycle can result into providing better QoS at network side. Setting appropriate duty cycle will be of great relevance when large number of devices will be sharing limited resources like spectrum (especially spectrum in the delicensed bands).

3.215 The duty cycle of radio devices is often regulated by many governments. Every radio device must be compliant with the regulated duty cycle limits. This applies to both nodes and gateways. This implies that nodes should be programmed such that they stay within the set limits. For example - in Europe, duty cycles are regulated by section 7.2.3 of the ETSI EN300.220 standard³⁴. The duty cycle applies to all transmitters excluding those with a listen before talk facility with Adaptive Frequency Agility (AFA) or an equivalent mitigation method. ETSI in the document has defined the duty cycle as the ratio, expressed as a percentage, of the maximum transmitter "on" time monitored over one hour, relative to a one hour period. The device may be triggered either automatically or manually. Depending on how the device is triggered the duty cycle can be fixed or random.

3.216 The Authority has carefully examined the comments of the stakeholders. The Authority is generally in agreement with the views submitted by many stakeholders that the energy efficiency, end-to-end delay and transmission reliability etc., are specific to a particular use-case and

³⁴ http://www.etsi.org/deliver/etsi_en/300200_300299/30022001/02.04.01_40/en_30022001v020401o.pdf

technology. Thus market requirements are to drive the innovations and enhancements at application level, device level and network level. As of now there is no duty-cycle limitation for the low power devices operating in 865-867 MHz and other unlicensed frequency bands in India.

3.217 The Authority has considered various aspects of the optimum duty cycle defined by various countries/regions. The Authority is of the opinion that there is huge market potential for deployments of M2M/IoT in unlicensed bands in India and there could be a need to implement a light regulation around Duty Cycle to enable eco-system evolution in an orderly manner. It will ensure optimum utilization of resource, i.e. spectrum, and will restrict spectrum hogging. Authority is aware that fixing of one duty cycle will not meet the requirement of various use cases in the M2M ecosystem. Some applications will require higher duty cycle than others based on the quantum of information generated by the device. For e.g.: smart electricity meters which transmits 4 or 5 packets of information in a day can have very low duty cycle but a driverless car will have to have a different and very high duty cycle. However, in the present stage of deployment of M2M devices and services a duty cycle of 10% both at device level and network level would suffice to meet the requirements. These parameters can be reviewed once there is substantial deployment of M2M ecosystem in the country and sufficient data being made available for analysis of use cases.

3.218 **Accordingly, the Authority recommends that:**

- a) In the present stage of deployment of M2M devices and services, a duty cycle of 10% both at device level and network level would suffice to meet the requirements. These parameters can be reviewed once there is substantial deployment of M2M ecosystem in the country and sufficient data being made available for analysis of use cases.**

CHAPTER IV: DATA SECURITY AND PRIVACY CHALLENGES

- 4.1 M2M will create a wealth of information covering various aspects of economy which will have immense potential use for public welfare. At the same time, the predicted pervasive introduction of sensors and devices into currently intimate spaces – such as home, car, wearable and ingestible, can give rise to privacy concerns of individuals.
- 4.2 Moreover, many of the future benefits from the M2M are likely to be delivered by new services based on the analysis of data from a wide range of sources. Some of this data may be personal or commercially sensitive, so it will be important to ensure that it is collected, stored and processed securely.
- 4.3 With the development and proliferation of M2M services, it becomes increasingly important to secure such data from unauthorized use and attacks. Globally, it is being acknowledged that secure and reliable communication among connected M2M devices is an important issue for deliberation. The perceived risks to privacy and security, if not realized, could undermine the consumer confidence necessary for the technologies to meet their full potential, leading to less widespread adoption and hence hamper the growth of M2M communications.
- 4.4 Further, most of the data generated by the M2M ecosystem will reside in clouds which can either be located in India or abroad. Security of the data thus stored falls under the jurisdiction of the country where the cloud is hosted. Lawful Interception of such data can also throw up many challenges to law enforcement agencies, especially when the cloud is hosted outside the geographical boundaries.

- 4.5 Also, service provision through M2M communications involving big data may warrant modification of some provisions of the rules in the Information Technology (IT) Act 2000. Rules related to the purpose limitation, security, data breach, opt in and out and ability to withdraw consent, disclosure of information, privacy policy, form of consent, consent by minors, applicability of the rules, level of encryption, etc. may need to be deliberated upon and factored into the law in the context of M2M communication.
- 4.6 Considering the complexities involved in M2M environment regarding Data Privacy, Data Security and Cross Border Data Flow, the Authority raised the following issues, in the CP, for comments of stakeholders-
- How M2M Service Providers should ensure protection of consumer interest and Data Privacy of the consumer
 - Whether the existing measures taken for security of networks and data are adequate for security in M2M context too
 - Whether any amendment is required in IT Act 2000 in order to protect the security and privacy of an individual in M2M environment
 - Whether cross border data flow should be permitted
- 4.7 A large no. of response was received from the stakeholders on all the issues. All the stakeholders were of the view that data privacy and security is very critical for the growth of M2M industry. These issues need detailed deliberation.
- 4.8 A nine-judge bench was set up by the Hon'ble Supreme Court to decide whether right to privacy can be declared as a fundamental right under the Indian Constitution. The bench of nine-judge was set up as a result of a batch of petitions that challenged the constitutional validity of the Aadhaar scheme, with a number of petitioners alleging that the biometric authentication system violated the privacy of Indians. The Hon'ble

Supreme Court has given its verdict on privacy. However, certain other issues pertaining to data security and privacy are still under the deliberations of the Apex court.

- 4.9 Regarding the IT Act 2000, it is learnt that the Act is under review. A closed group, under IT Secretary, has been set up to look into various aspects of the IT Act in line with the changing times.
- 4.10 The Authority has issued a consultation paper on 9th August, 2017, on "Privacy, Security and ownership of Data in telecom sector" with the following objectives:
- a. To identify the scope and definition of Personal data, Ownership and Control of data of users of telecom services.
 - b. Understand and Identify the Rights and Responsibilities of Data Controllers.
 - c. To assess the adequacy and efficiency of data protection measures currently in place in the telecom sector.
 - d. Identify the key issues pertaining to data protection in relation to the delivery of digital services. This includes the provision of telecom and Internet services by telecom and Internet service providers (TSPs) as well the other devices, networks and applications that connect with users through the services offered by TSPs and collect and control user data in that process.
- 4.11 **The Authority understands that in order to promote investment and innovation concurrently in the emerging sector of M2M communications, India needs to have in place balanced and clear rules for data security and privacy. After due deliberation, the Authority will issue comprehensive recommendations on Data Protection.**

CHAPTER V: SUMMARY OF RECOMMENDATIONS

5.1 The Authority recommends that:

- a) All access service providers' viz. CMTS, UASL, UL (AS) and UL holders using licensed access spectrum shall be allowed to provide M2M connectivity within the area of their existing authorizations. DoT may suitably amend the license conditions in respective licenses.**
- b) All Basic Services licensees and ISP licensees shall be allowed to provide M2M connectivity, including on unlicensed band, within the area of their existing authorizations, barring M2M cellular services. DoT may suitably amend the license conditions under Basic Service Operators (BSOs) and respective ISP categories.**
- c) All UL (VNO) holders shall also accordingly be allowed to provide M2M connectivity as authorized in their existing authorizations. DoT may suitably amend the license conditions of UL (VNO).**
- d) Connectivity provider using WPAN/WLAN technologies for providing M2M connectivity for commercial purposes, operating in unlicensed spectrum, should register with DoT.**
- e) Connectivity provider using LPWAN technologies operating in unlicensed spectrum should be covered under licensing through a new authorization under UL namely UL (M2M). Such licensees should be allowed to bid for licensed spectrum to provide exclusively M2M services, if they desire to provide M2M services in the licensed band.**
- f) UL (M2M) authorization shall comprise of three categories i.e. UL (M2M) Category-A-National area, UL (M2M) Category-B -Telecom Circle/Metro area, UL (M2M) Category -C- SSA/ District area.**
- g) Government, through DoT, should identify critical services in M2M sector and these services should be mandated to be provided only by connectivity providers using licensed spectrum.**

h) Since M2M is in its nascent stage and needs an integrated national approach on various issues, regulatory authorities whose sectors will get impacted by M2M communications like TRAI, Central Drug Standards Control Organization, National Highways Authority of India, Inland Waterways Authority of India, Central Electricity Regulatory Commission, etc. and Ministry of Law & Justice should also be members in M2M apex body formed by DoT.

[Para 2.61]

5.2 Accordingly, the Authority recommends that:

a) M2M Service Providers (MSPs) should register as M2M service provider as envisaged by DoT. This registration will be exclusive for the MSP and not part of existing OSP registration. Exclusive guidelines for MSP Registration should be issued. MSPs to provide details of the connectivity provider who would be providing connectivity in their M2M application.

[Para 2.70]

5.3 The Authority recommends that:

- a) Device manufacturers should be mandated to implement “Security by design” principle in M2M device manufacturing so that end-to-end encryption can be achieved.**
- b) The government should provide comprehensive guidelines for manufacturing/ importing of M2M devices in India.**
- c) A National Trust Centre (NTC), under the aegis of TEC, should be created for the certification of M2M devices and applications (hardware and software).**

[Para 2.82]

5.4 The Authority recommends that:

a) For connectivity provider using technologies in WPAN/WLAN operating in unlicensed band, there should not be any Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG). A nominal

fee maybe charged to cover administrative cost.

- b) For obtaining authorizations under UL (M2M) Category ‘A’ for National area, UL (M2M) Category ‘B’ for Telecom circle/ Metro area and UL (M2M) Category ‘C’ for SSA area, the amount payable in the form of Entry Fee, PBG, FBG shall be as per the table below.

Table: Entry Fee, PBG or FBG, Networth, equity for UL (M2M)

Sl. No.	Service Authorization	Minimum Equity (Rs. Cr.)	Minimum Networth (Rs. Cr.)	Entry Fee (Rs. Cr.)	PBG (Rs. Cr.)	FBG (RS. Cr)
1	UL (M2M) "A" (National Area)	Not prescribed	Not prescribed	0.30	2.00	0.100
2	UL (M2M) "B" (Telecom circle/Metro Area)	Not prescribed	Not prescribed	0.020	0.100	0.010
3	UL (M2M) "C" (SSA)	Not prescribed	Not prescribed	0.002	0.005	0.001

- c) As regard to the case of MSP, the Entry Fee, Performance Bank Guarantee (PBG) or Financial Bank Guarantee (FBG) should be same as envisaged by DoT in “M2M Service Providers Registration –Draft Guidelines May 2016”

[Para 2.93]

5.5 The Authority recommends that:

- a) Spectrum allocation should be technology and service neutral. No separate spectrum band is to be allocated exclusively for M2M services.
- b) Requirement of additional licensed spectrum for access services to meet the projected influx of connected devices due to M2M communication will be revisited by the Authority after WRC-19.
- c) In order to facilitate smooth roll out of M2M services utilizing the license exempt spectrum, 1 MHz of spectrum from 867-868 MHz and a chunk of 6 MHz of spectrum at 915-935 MHz is recommended to

be delicensed.

- d) The Authority on various occasions has recommended to the Government for delicensing the V-band (57-64 GHz). This may be done on priority.

[Para 3.45]

5.6 The Authority recommends that:

- a) National roaming for M2M/ IoT shall be under forbearance and ceiling as per prevailing Telecom Tariff Orders (TTOs) for access service.
- b) TSPs shall enter into commercial agreements to cater their roaming requirements for M2M subscribers.
- c) The Authority shall review/issue separate TTO for M2M at an appropriate time in future, if deemed fit.
- d) As a part of public safety initiative, the Government shall initiate a proof-of-concept (PoC)/ Pilot testing in integrating the emergency response service on the lines of eCall to make suitable mandatory provisions for emergency communication in vehicles.

[Para 3.68]

5.7 The Authority recommends that:

- a) Devices with pre-fitted eUICC should be allowed to be imported only if it has the ability to get reconfigured 'Over the air' (OTA) with local subscription. GSMA approved guidelines shall be followed for provisioning of new profile remotely with 'Over-the-air' (OTA) mechanism.
- b) Devices fitted with eUICC shall be allowed in operation in roaming for maximum three years from the date of activation of roaming in the network of Indian TSP and mandatorily converted/ reconfigured into Indian TSP's SIM within the stipulated period or on change of ownership of the device, whichever is earlier. The Authority/ Licensor shall review the condition later based on the developments and requirements.

- c) **Country specific relaxation on permanent roaming of foreign SIMs, if any, can be considered based on the strategic importance, Bi-lateral or Multi-lateral trade agreements and principle of reciprocity by the government.**
- d) **In case imported equipment to which the SIM/ device is fitted with such as automobile/ machines (like earth movers), arms etc. (requiring mandatory registration at local authorities such as RTO, State/ District administration) is transferred/ sold to another party before three years, the roaming device (eUICC) shall also be immediately configured with local subscription/eUICC of Indian TSP. The KYC details of the new owner/ buyer must be compulsorily updated in the database of concerned authorities.**

[Para 3.106]

5.8 The Authority recommends that:

- a) **It should not be mandatory to use only domestically manufactured SIMs in M2M. Embedded SIMs with standard specifications can be imported and relevant information shall be submitted by importer while import of the devices/SIMs.**
- b) **Suitable security mechanism similar to the existing mobile networks shall be put in place by the DoT for the Border States like J&K and NE areas, if deemed fit.**

[Para 3.119]

5.9 The Authority recommends that:

- a) **There is no case for regulatory intervention for setting ceiling for roaming charges for the devices imported with in-built SIM. The market forces shall address the issue based on commercial aspects.**

[Para 3.130]

5.10 The Authority recommends that:

- a) **International roaming in M2M shall be allowed under the well recognized framework of GSMA 'M2M Annex' to keep uniformity of**

the parameters and processes.

- b) In order to boost the M2M/IoT manufacturing in India, the government may consider feasibility of allowing extra-terrestrial usage of IMSI ranges with suitable framework on the basis of country specific bilateral agreements.

[Para 3.147]

5.11 The Authority recommends that:

- a) Allocation of various network codes including MNCs shall be to licensed TSPs only.
- b) There is no need to allocate MNCs or any other network codes to MSPs.

[Para 3.169]

5.12 QoS is in the exclusive domain of TRAI. Therefore, the Authority recommends that:

- a) Once the M2M sector develops, the Authority will put in place comprehensive regulations on QoS parameters in M2M communication, as per service requirements.

[Para 3.205]

5.13 The Authority recommends that:

- a) In the present stage of deployment of M2M devices and services, a duty cycle of 10% both at device level and network level would suffice to meet the requirements. These parameters can be reviewed once there is substantial deployment of M2M ecosystem in the country and sufficient data being made available for analysis of use cases.

[Para 3.218]

5.14 The Authority understands that in order to promote investment and innovation concurrently in the emerging sector of M2M communications, India needs to have in place balanced and clear rules for data security and privacy. After due deliberation, the

Authority will issue comprehensive recommendations on Data Protection.

[Para 4.11]

LIST OF ACRONYMS

Acronyms	Description
3GPP	3rd Generation Partnership Project
ACI	Adjacent Channel Interference
ACLR	Adjacent Channel Leakage Ratio
AMRUT	Atal Mission For Rejuvenation And Urban Transformation
APT	Asia-Pacific Telecommunity
ARPC	Average Revenue Per Connection
ARPU	Average Revenue Per User
ATM	Automated Teller Machine
B2B	Business To Business
B2C	Business To Consumer
BEREC	Body of European Regulators For Electronic Communications
BIS	Bureau of Indian Standards
BLE	Bluetooth Low Energy
BSC	Base Station Controller
BSOs	Basic Service Operators
BTS	Base Transceiver Station
CAGR	Compound Annual Growth
CDMA	Code Division Multiple Access
CEPT	Conference of European Postal and Telecommunications
CMRTS	Captive Mobile Radio Trunked Systems
CMTS	Cable Modem Termination System
CP	Consultation Paper
CPM	Conference Preparatory Meeting
DeitY	Department of Electronics and Information Technology
DoT	Department of Telecom
eCall	Emergency Call
ECC	Electronic Communication Committee
E MLPP	Enhanced Multi-Level Precedence & Pre-Emption
EPC	Evolved Packet Core
ESN	Electronic Serial Number
ETSI	European Telecommunication Standards Institute
EU	European Union
eUICC	Embedded Universal Integrated Circuit Card
EVDO	Evolution-Data Optimized
FBG	Financial Bank Guarantee
FDD	Frequency Division Duplexing
FDI	Foreign Direct Investment
FD-LTE	Frequency Division Duplex-LTE
FPOs	Free Ports
Gbps	Giga Bits Per Second
GDP	Gross Domestic Product

GDPR	General Data Protection Regulation
GGSN	Gateway GPRS Support Node
GHz	Giga Hertz
GMA	Global M2M Association
GMLC	Gateway Mobile Location Centre
GoI	Government of India
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System For Mobile
GSMA	Groupe Speciale Mobile Association
HAN	Home Area Network
HetNets	Heterogeneous Networks
HLR	Home Location Register
HPP	HLR Proxy Provider
HSPA	High Speed Packet Access
IBEF	India Brand Equity Foundation
ICCID	Integrated Circuit Card Identifier
ICR	Intra- Circle Roaming
ICT	Information And Communication Technologies
IECRS	Integrated Emergency Communication & Response System
ILD	International Long Distance
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
IMT	International Mobile Telecommunications
IN	Intelligent Network
IoT	Internet of Things
IP	Internet Protocol
IPv4	Internet Protocol Version4
IPv6	Internet Protocol Version6
ISM	Industrial, Scientific and Medical
ISP	Internet Service Provider
IT	Information Technology
ITS	Intelligent Transport System
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union's Radio Communication Sector
ITU-T	International Telecommunication Union's Telecommunication Standardization Sector
J&K	Jammu & Kashmir
KB	Kilo Bytes
KHz	Kilo Hertz
KYC	Know Your Customer
LAN	Local Area Network
LEA	Law Enforcement Agencies

LF	License Fee
LI	Lawful Interception
LIPD	Low Interference Potential Devices
LoRa	Long Range
LPWA	Low Power Wide Area
LPWA UNB IoT	Low Power Wide Area Ultra Narrow Band IoT
LPWAN	Low Power Wide Area Network
LSA	Licensed Service Area
LTE	Long-Term Evolution
LTE-A	Long-Term Evolution Advanced
M2M	Machine To Machine
M2MAP	M2M Application Provider
M2MSP	M2M Service Provider
MAC	Media Access Control
MANET	Mobile Wireless Ad-Hoc Networks
MBB	Mobile Broadband
MCC	Mobile Country Code
Meity	Ministry of Electronics and Information Technology
MHz	Mega Hertz
MLAT	Mutual Legal Assistance Treaties
MLTA	Multi-Lateral Trade Agreements
MME	Mobility Management Entity
mMTC	Massive Machine Type Communication
MNC	Mobile Network Codes
MNOs	Mobile Network Operators
MoHFW	Ministry of Health And Family Welfare
MoUD	Ministry of Urban Development
MSC	Mobile Switching Centre
MSISDN	Mobile Station International Subscriber Directory Number
MSP	M2M Service Providers
MTC	Machine Type Communication
MVNO	Mobile Virtual Network Operator
NB-IoT	Narrowband IoT
NE	North East
NFAP	National Frequency Allocation Plan
NFV	Network Function Virtualization
NGMN	Next Generation Mobile Networks
NLD	National Long Distance
NNP	National Numbering Plan
NSO	Network Service Operator
NTP	National Telecom Policy
OEMs	Original Equipment Manufacturer
OHD	Open House Discussion
OSP	Other Service Providers

OTA	Over The Air
P2P	Point To Point
PAN	Personal Area Network
PBG	Performance Bank Guarantee
PCB	Printed Circuit Board
PCR	Priority Call Routing
PDA's	Personal Digital Assistant
PLMN	Public Land Mobile Network
PMRTS	Public Mobile Radio Trunked Systems
PoC	Proof of Concept
POI	Point of Interconnect
POS	Point of Sale
PPDR	Public Protection & Disaster Relief Network
PSAPs	Public Safety Answering Points
QoS	Quality of Service
RAN	Radio Access Network
RF	Radio Frequency
RFID	Radio Frequency Identification Devices
RTO	Regional Transport Office
SBO	Service Based Operators
SCADA	Supervisory Control And Data Acquisition
SDN	Software Defined Network
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module
Sis	System Integrator
SKUs	Stock Keeping Unit
SLA	Service Level Agreement
SMEs	Small And Medium-Sized Enterprises
SMS	Short Message Service
SRD	Short Range Devices
SUC	Spectrum Usage Charge
T&C	Terms & Conditions
TCP	Transmission Control Protocol
TDD	Time Division Duplexing
TD-LTE	Time Division Duplex-LTE
TEC	Telecommunication Engineering Center
TG	Task Group
TRAI	Telecom Regulatory Authority of India
TSDSI	Telecommunications Standards Development Society of India
TSM	Telecom Single Market
TSPs	Telecom Service Providers
TTO	Telecom Tariff Order
UASL	Unified Access Service Licence
UHF	Ultra High Frequency

UICC	Universal Integrated Circuit Card
UL	Unified License
UL (AS)	Unified License (Access Service)
UL(VNO)	Unified License (Virtual Network Operators)
UMTS	Universal Mobile Telecommunications System
URLLC	Ultra-Reliable and Low-Latency Communications
USD	United States Dollar
UTs	Union Territories
V2I	Vehicle To Infrastructure
V2V	Vehicle To Vehicle
V2X	Vehicle To Everything
VANET	Vehicular Ad-Hoc Networks
VHF	Very High Frequency
VLR	Visitor Location Register
VNO	Virtual Network Operators
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless-Local Area Network
WMN	Wireless Mesh Networks
WP5D	Working Party 5D
WPAN	Wireless-Personal Area Network
WRC	World Radiocommunication Conferences
WSN	Wireless Sensor Networks

ANNEXURE -I

F.No. 4-16/ 2015-NT
Government of India
DoT, Networks and Technologies Cell

Dated: 5th Jan, 2016

To,
The Secretary,
Telecom Regulatory Authority of India,
N. Delhi

Sub: - Reference to TRAI seeking recommendation on Quality of Service (QoS), Spectrum and Roaming related requirements in M2M Communications.

'National Telecom M2M Roadmap' has been released by DoT in May 2015 with the objective of proliferating the growth of M2M ecosystem and to bring tangible social and economic benefits to consumers, businesses, citizens and government.

2. Certain actionable points have evolved from the Roadmap document which needs to be taken up to further the M2M ecosystem growth. Addressal of M2M Quality of Service (QoS), Spectrum and Roaming aspects are such actionable points emerged from M2M Roadmap. These items have been deliberated in various sections of the M2M Roadmap. Softcopy of the document is available on the DoT website.

3. TEC has also come up with 9 technical reports on M2M detailing sector specific requirements/ use cases to carry out gap analysis and future action plans with possible models of service delivery. Some of these reports have also touched upon requirements related to Spectrum, Roaming and QoS and are available at website <http://www.tec.gov.in/technical-reports/>

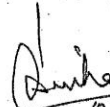
4. Accordingly TRAI recommendations are sought for following points related to M2M communications:

- A. QoS in M2M Services
- B. M2M Roaming Requirements
- C. M2M Spectrum Requirements

The relevant information on the above points is extracted from the DoT M2M roadmap, compiled for easy reference and is attached as Annexure-I to this letter.

5. Accordingly, TRAI is requested to provide its recommendations under section 11 (1) (a) of TRAI Act, 1997 as amended in TRAI (amendment) Act, 2000, for recommendation on Quality of Service (QoS), Spectrum and Roaming related aspects of M2M communications in a holistic manner.

Encl: Annexure-I


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Background Note

(For Seeking TRAI recommendations on QoS, Spectrum and Roaming related aspects of M2M communications)

Quality of Service (QoS):

The notion of QoS has been introduced to capture the qualitatively and/ or quantitatively defined performance contract between user applications and the service provider. Different machines (e.g., sensors, meters) in an M2M system capture “events” (e.g., temperature, inventory level), which are transmitted through a network (e.g., wireless, wired or hybrid) to an application that translates them into meaningful information. Thus in Machine to Machine (M2M) systems, different communication networks converged into one large heterogeneous network thereby making the fulfillment of QoS requirement more complex. From the QoS perspective, in the service provisioning process, networks of different characteristics can be used. According to that, the challenge is how to provide end-to-end QoS guarantees despite the limitations of different means of communication.

M2M communication show quite different characteristics compared with the traditional Human-to-Human (H2H) communications. QoS categorization of H2H communications is mainly based on delay, because voice is the main service in H2H communication. However, providing M2M data communications to large numbers of M2M devices and providing services to M2M application owners rather than end-users implies a different optimization of the network. Although many M2M applications have no stringent QoS requirements and can deal perfectly well with best-effort QoS, some M2M applications have higher QoS or priority requirements than normal data services. TSP's and ISP's are increasingly providing QoS differentiation in their packet-based networks. This will represent an added value for many M2M applications.

QoS has become a stringent requirement for real time applications and enables more efficient sharing of network resources. It manages time-sensitive multimedia and voice application traffic to ensure it gets a higher priority, since greater delays cause serious deterioration in the provided service. QoS parameters differ from application to application. For instance, in multimedia applications bandwidth and delay are most common parameters. In military services, these parameters rely mostly on security and reliability aspects. In routing protocols, besides delay and packet delivery ratio, the routing overhead is also taken into account (i.e., the number of routing packets transmitted per data packet). However, the common metric includes only following parameters: delay, delay variance (jitter), packet loss ratio, and data rate.

M2M systems have their own QoS requirements. Since there are a large number of M2M services, like mobile streaming, smart metering, regular monitoring, emergency alerting, or mobile payment, it is suggested that these services are described according to the high or low need for a real-time transmission, accuracy, and priority. For instance, service that includes emergency alerting has a high delay variety and high real-time requirements, while a regular metering service does not have such strict requirements.

M2M Roaming Requirements:

In M2M domain, there are scenarios, wherein M2M Service provider or manufacturer may be an entity located in foreign country and it may prefer to fit the foreign telecom service provider's SIM in the machine to be used in India always. Like, a car may be manufactured in a foreign country with a foreign telecom operator's SIM in it. In such cases, SIM shall be always in roaming state outside its home network (permanent roaming).

Present licensing regime allows licensees to enter into roaming agreements with other licensees as per their commercial arrangements for national roaming. For International Roaming, licensees can enter into agreements with foreign telecom Service Providers to provide roaming facility to its subscribers & vice versa. Roaming subscribers can only access services to which they have subscribed in their home networks. The guidelines are applicable to voice as well data services. There are concerns on non-availability of M2M services in North Eastern States and J&K in case of imported devices pre-fitted with foreign SIM cards. This is due to restrictions placed on international SIMs roaming to these areas.

As per stakeholders, in general, quantum of M2M traffic and correspondingly ARPU is very less and therefore it may require separate roaming arrangements/ interconnect charges among TSPs. GSMA has also finalized separate template for roaming of M2M subscribers. In long run, separate identifier like IMSI or MSISDN may be allocated to M2M services, which is different from voice or data SIMs to enforce and regulate M2M specific roaming.

In line with declared policy objective of One Nation - Free Roaming and no roaming charge across the nation in NTP - 12, there should not be any inter-circle roaming charges for M2M services. This may give a boost to M2M services, as machines i.e. automobiles are more often likely to roam in different circles. The volume of data exchanged for mobile machines is small and this provision is not likely to have much revenue impact for operators. TRAI may look into M2M specific roaming charges in case of M2M services for both intra-operator and inter-operator roaming scenarios in view of low data volume, objectives of NTP - 12 and with an aim of providing a boost to M2M services.

M2M Spectrum Requirements:

M2M covers various Industry verticals and use different frequencies for various kinds of service offerings covering short range communication on high frequencies like Bluetooth, ZigBee, and 6LoWPAN to low frequency range for RF mesh etc. in neighborhood network connectivity requirements. Technological developments enabling utilization of White Space in different licensed bands have thrown new possibilities for efficient spectrum utilization benefitting M2M services as well. Globally, the trend is to use telecom network of TSP and/ or free wireless bands for M2M communications. In line with the requirement, there may be a need to fine-tune free spectrum bands. Also detailed planning and guidelines are required for effective and efficient use of white spaces protecting interest of primary spectrum usages. TRAI may take up the M2M Spectrum requirements in totality covering relevant aspects as detailed above.

M2M ECOSYSTEM

oneM2M (Technical Specification - Common Terminology)³⁵

M2M Application Service: realized through the service logic of an M2M Application and is operated by the User or an M2M Application Service Provider

M2M Application Service Provider: entity (e.g. a company) that provides M2M Application Services to the User

M2M Common Services: set of oneM2M specified functionalities that are widely applicable to different application domains made available through the set of oneM2M specified interfaces

Common Service Functions



M2M Common Service Functions³⁶

³⁵ http://www.onem2m.org/images/files/deliverables/Release2/TS-0011-Common_Terminology-V2_4_1.pdf

³⁶ https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwit7s_e6_fPAhVLp48KHQvIAiQQFggdMAA&url=http%3A%2F%2Fwww.onem2m.org%2Fcomponent%2Ffiles%2Fdownload-file%2Ffiles%3Fpath%3DoneM2M_Showcase%25255ConeM2M_Service_Layer_Platform.pdf%26Itemid%3D122&sg=AFQjCNFDvn4E6z-Y5Gx4yvDPC7ECAtXjLw&sig2=cdBHcljxkkjGSOuYMfv0yg

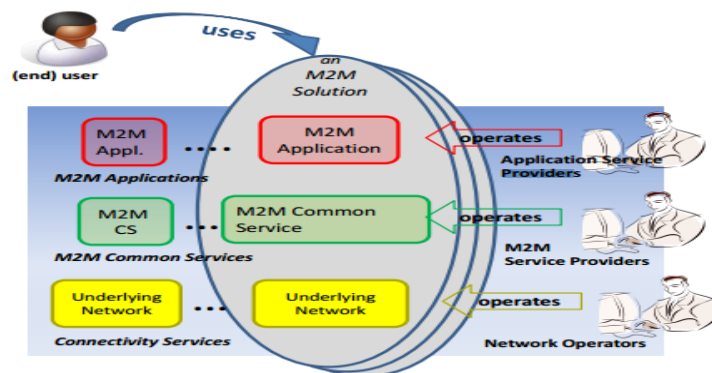
M2M Service Provider: entity (e.g. a company) that provides M2M Common Services to a M2M Application Service Provider or to the User

oneM2M (Technical Specification - Requirements)³⁷

The M2M ecosystem:

1. The User (individual or company – aka, end-user):
 - ◆ Uses an M2M solution
2. The Application Service Provider:
 - ◆ Provides an M2M application service
 - ◆ Operates M2M applications
3. The M2M Service Provider:
 - ◆ Provides M2M services to Application Service Providers
 - ◆ Operates M2M common services
4. The Network Operator:
 - ◆ Provides connectivity and related services for M2M Service Providers
 - ◆ Operates an underlying network. Such an underlying network could, e.g., be a telecom network.

Any of the above functional roles may coincide with any of the other roles.



Functional Roles in the M2M Ecosystem

³⁷ http://www.onem2m.org/images/files/deliverables/Release2/TS-0002-Requirements-V2_7_1.pdf

ETSI (Technical Report –M2M Definitions)³⁸

M2M Service: is the set of functionalities that a M2M Service Capability Layer makes available through the standardized interfaces.

M2M Service Provider: is an entity (e.g. a company) that provides M2M Services of the M2M System to a M2M Application Service Provider or to the end user.

M2M Application Service: an M2M Application Service is realized through the service logic of an M2M Application and is operated by the end user or an M2M Application Service Provider.

M2M Application Service Provider: is an entity (e.g. a company) that provides M2M Application Services in the M2M System to the end user.

ITU-T (REC Y.2060 Overview of the Internet of things)³⁹

The IoT ecosystem is composed of a variety of players:

Device provider: The device provider is responsible for devices providing raw data and/or content to the network provider and application provider according to the service logic.

Network provider: The network provider plays a central role in the IoT ecosystem. In particular, the network provider performs the following main functions:

- ♦ access and integration of resources provided by other providers;
- ♦ support and control of the IoT capabilities infrastructure;
- ♦ Offering of IoT capabilities, including network capabilities and resource exposure to other providers.

Platform provider: The platform provider provides integration capabilities and open interfaces. Different platforms can provide different capabilities to

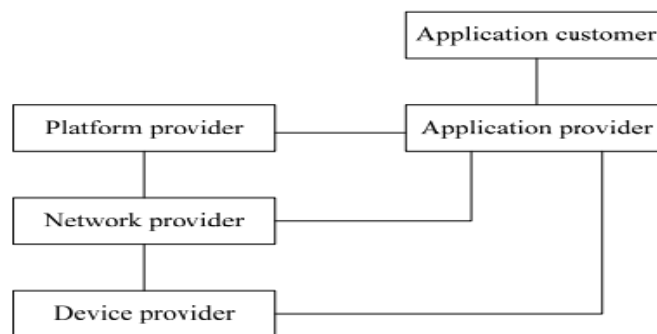
³⁸ http://www.etsi.org/deliver/etsi_tr/102700_102799/102725/01.01.01_60/tr_102725v010101p.pdf

³⁹ <https://www.itu.int/rec/T-REC-Y.2060-201206-l>

application providers. Platform capabilities include typical integration capabilities, as well as data storage, data processing or device management. Support for different types of IoT applications is also possible.

Application provider: The application provider utilizes capabilities or resources provided by the network provider, device provider and platform provider, in order to provide IoT applications to application customers.

Application customer: The application customer is the user of IoT application(s) provided by the application provider.



IoT ecosystem

BEREC (Report – Enabling the Internet of Things)⁴⁰

The market players in the IoT value chain are understood as follows:

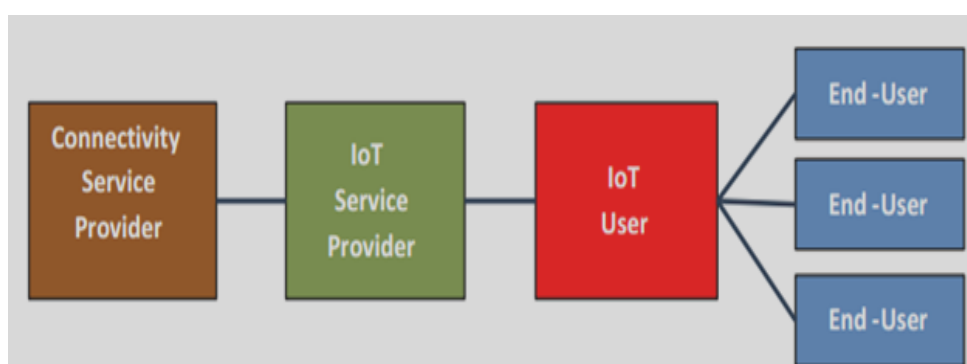
Connectivity service provider: Provider of an electronic communication service pursuant to Art. 2 lit. c Framework Directive, i.e. basically a service normally provided for remuneration which consists wholly or mainly in the conveyance of signals on electronic communications networks.

IoT service provider: Provider of an IoT service, which can comprise the provision of an IoT platform and/or other IoT-related IT services/solutions.

⁴⁰ http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/5755-berec-report-on-enabling-the-internet-of-things

IoT user: Purchaser of an IoT service who incorporates the IoT service as one component in his own products (i.e. connected devices) and/or services (e.g. a car manufacturer, an electricity provider which also includes the provision of a smart meter in its service).

End-user: Customer at the end of the value chain who purchases a connected device and/or utilises a service (including an IoT service and/or IoT device) (e.g. car owner, electricity customer). An end-user may be a private person or a company (e.g. private car owner and/or company with a car fleet).



IoT value chain

Usually, the connectivity service providers' customers are the IoT device makers, the IoT service providers or the IoT users, not the end-users (in the sense of this report). Often the connectivity service providers have no relationship with the IoT service providers, and run their business with the hardware manufacturers. The end-user, on the other hand, buys an interconnected device and is not necessarily interested in the communication service as such. The service of the connectivity service provider to the IoT device maker, IoT service provider or IoT user is a wholesale-type of arrangement.

DoT (National Telecom Roadmap)⁴¹

⁴¹ <http://www.dot.gov.in/sites/default/files/National%20Telecom%20M2M%20Roadmap.pdf>

M2M Service Provider: Data collection and analysis from M2M device and platform are controlled by same entity/ organization. This entity has been termed as “M2M service provider” in this document.

Following type of business models can be built by a M2M service provider (MSP):

1. MSP focuses on its own services, leaves choice of connectivity/ network on end customer allowing him/ her to choose TSP of their choice.
2. MSP becomes bulk customer of a TSP and provides end to end service along with SIM and connectivity to end customer. He settle bills of TSP directly as bulk customer and raises single bill to his customer for overall service offering including telecom services provided.
3. A TSP is also MSP and sells services to customer similar to value added services.
4. MSP becomes an MVNO and accordingly offers services to its end customers.

TEC (Technical Report M2M Gateway and Architecture)⁴²

There can be various types of service providers in M2M implementation like:

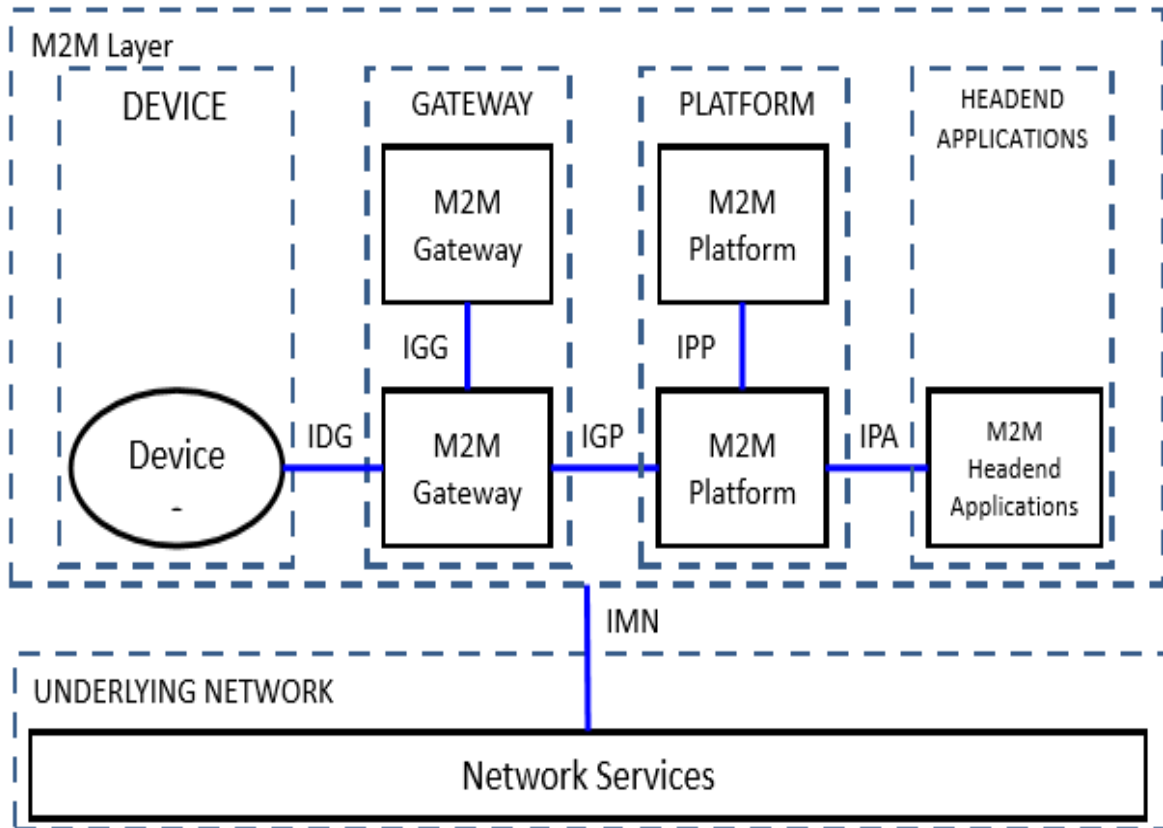
- ◆ Field Providers (provisioning of devices & LAN / FAN)
- ◆ M2M service providers (M2M SPs)
- ◆ Application Service providers
- ◆ Network Service Providers

The M2M ecosystem is considered to be organized in a 3-Layer model:

- ◆ Network Services Layer
- ◆ M2M Services Layer: Based on Internet Protocol (IP) and provided by the M2M Service Provider. (The development of this layer is the key focus area towards standardization of M2M communications)

⁴² <http://tec.gov.in/pdf/M2M/M2M%20Number%20resource%20requirement%20&%20options.pdf>

- ◆ Application Layer: Provided by the Application Service Provider catering to End User Applications.



General M2M Network Architecture

GSMA (IoT Security Guidelines for Network Operators)⁴³

IoT Service Provider: Enterprises or organisations who are looking to develop new and innovative connected IoT products and services. The provider could be a Network Operator.

ERICSSON (White paper –Machine to Machine)⁴⁴

M2M Service Provider: M2M service providers do not own any network infrastructure. They are specialized in building and managing M2M solutions,

⁴³ <http://www.gsma.com/connectedliving/wp-content/uploads/2016/02/CLP.14-v1.0.pdf>

⁴⁴ <https://www.ericsson.com/res/docs/whitepapers/wp-m2m.pdf>

they are in need of well-managed connectivity from operators. In such a case, the M2M service provider would serve as a channel partner for the operator.

PricewaterhouseCoopers (PwC) (White paper on M2M technologies)⁴⁵

The four key categories in the M2M ecosystem are as follows:

Hardware and Semiconductor Company: These provide the end-point devices from where data is acquired (sensors, GPS units, smart meters, RFID tags, video cameras, and smartcards).

Communication service provider: These enable the transmission of data between machines.

M2M service provider: These are vertical niche players providing specific M2M application solutions for data analysis for decision-making.

System integrator: This is the technical domain expertise to bind all systems together.

The roles of these players may overlap in various business models that will evolve depending on the positioning created by each individual player and specific market opportunities.

⁴⁵ <https://www.pwc.in/assets/pdfs/publications/2013/m2m-technologies.pdf>