Body of European Regulators for Electronic Communications

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Internet of Things indicators

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Contents

Executive Summary

The Internet of Things ('IoT') is an important worldwide phenomenon that will affect the lives of European citizens in many respects. BEREC has in the recent years started to consider the implications of IoT and in 2016 has published a report on "Enabling the Internet of Things"[1] which presented a good description of the phenomena and its characteristics and assessed whether IoT services require special treatment with regard to current and future.

As the number of internet-enabled devices, and consequently the requirements for network resources, increases, there is a need to reflect the importance of this sector in the work of BEREC. The work of this report assesses what type of measurement of IoT NRAs are already conducting on the supply-side, and assesses if there is, at this stage, any common set of IoT-related indicators which BEREC or National Regulatory Authorities ('NRA') could regularly collect in the coming years (possibly from 2019 onwards or later) in order to provide a realistic statistical overview of the IoT landscape.

The data collected should enable to inform BEREC's regulatory policy as to ensure the level of connectivity services in Europe so that the IoT can be successfully deployed, and also, secondarily to understand if and how this services may affect competition in the provision of electronic communication networks ('ECN') and services ('ECS').

In this document BEREC scopes the need for and the possibility of BEREC conducting a harmonised data gathering exercise so as to improve the current information on the IoT in Europe. To do so, the report conducts an assessment on the type(s) of data that its constituent NRAs are collecting and also reflects on their needs, as well as considering the views on this matter of stakeholders who participated in a public consultation that ran from 12 December 2018 to 23 January 2019.

BEREC elaborates on legal possibilities for NRAs to collect data from providers. Section 5 looks at IoT and machine-to-machine communications ('M2M') definitions. The ultimate objective of the report is to determine if there is any common set of IoT-related indicators which BEREC could regularly collect in the coming years (possibly from 2019 onwards or later) in order to provide a realistic statistical overview of the IoT landscape. Section 6 provides a set of indicators to collect, related to connectivity, in line with what is proportional and feasible.

Given the importance of IoT, and given the current limited power to NRAs to collect data on M2M and IoT, BEREC proposes, for a better understanding of these technologies, a third party study should be commissioned on the second half 2020 in the prior to the deadline for the Code transposition into national law.

[1] https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/5755-berec-report-on-enabling-the-internet-of-things

1. Introduction

The IoT is an important worldwide phenomena that will affect the lives of European citizens in many respects. The availability of IoT services will not only change the way individuals live and work but is also delivering an opportunity for the economic growth of European countries. This phenomena is expected to grow exponentially in a short span of time, and because of this, it may eventually place important demands on the deployment and capabilities of communication infrastructures and services and, possibly on complementary public resources such as spectrum and numbering.

Because of all of this, BEREC has in the recent years started to consider the implications of the IoT. In 2016, BEREC published a report on "Enabling the Internet of Things"[2] which presented a good description of the phenomena and its characteristics and assessed whether IoT services require special treatment with regard to current and future regulatory issues. In February 2017, BEREC held an expert "Workshop on the Internet of Things"[3], that brought together experts and stakeholders to discuss the regulatory implications and solutions required to "ensure a large-scale and sustainable IoT roll-out, in order to deliver significant benefits to citizens and consumers across different industries." Finally, in March 2018, BEREC held an internal workshop on 5G and the IoT to outline the related security issues and discuss 5G implications on the development of new services.

Currently, finding reliable data about the installed base of IoT devices and their market size is not easy, although some market reports provide some information based on forecasts and/or surveys. A non-exhaustive list of such reports can be found in Appendix 1. It is worth mentioning here the recent efforts and work undertaken by the Organisation for Economic Co-operation and Development ('OECD')[4], which has looked into the measurement of the IoT proposing a definition and a taxonomy of the concept.

In this document BEREC scopes the need for and the possibility of BEREC conducting a harmonised data gathering exercise so as to improve the current information on the IoT in Europe. To do so, the report conducts an assessment on the type(s) of data that its constituent NRAs are collecting and also reflects on their needs[5], as well as considering the views on this matter of stakeholders who participated in a public consultation that ran from 12 December 2018 to 23 January 2019. The ultimate objective of the report is to determine if there is any common set of IoT-related indicators which BEREC could regularly collect in the coming years (possibly from 2019 onwards or later) in order to provide a realistic statistical overview of the IoT landscape.

[2] https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/5755-berec-report-on-enabling-the-internet-of-things

[3] https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/6972-summary-report-on-the-outcomes-of-the-workshop-on-iot-technologies-and-their-impact-on-regulation

[4] 271 IoT measurement and applications – OECD digital economy papers, October 2018 No. 271, DSTI/CDEP/CISP-MADE(2017)1/FINAL

[5] This assessment is based on the responses sent by NRAs to two questionnaires circulated by BEREC in August and October 2018 with questions regarding their needs and current data collection.

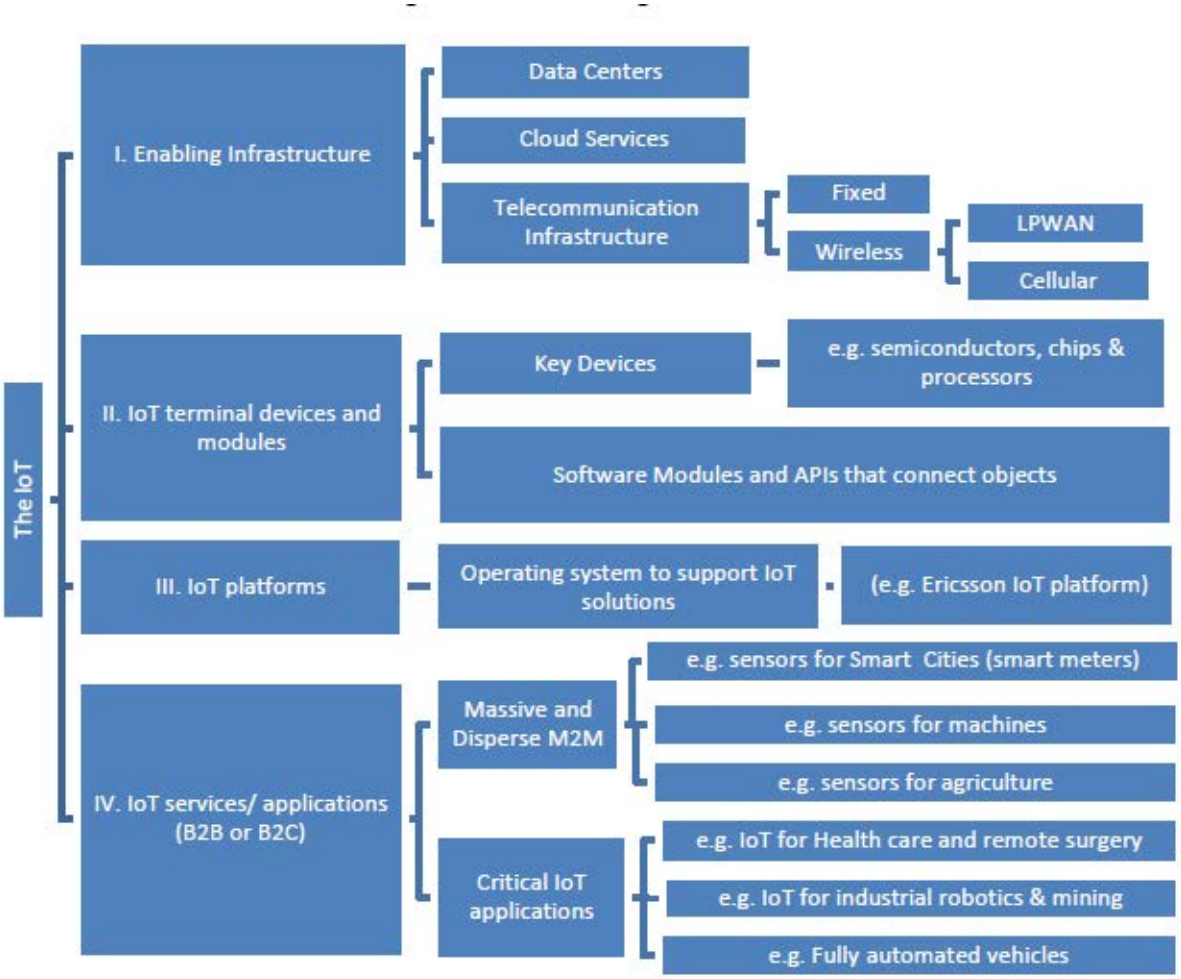
Scope

Three important facts matter in deciding on whether and which indicators to benchmark at the European level. The first one is the temporal scope of the data gathering. Generally, this is because an early benchmarking can only be provided on data that is already being collected as opposed to data that is not. In this case, moreover, the timing is important because the approval of the new European Electronic Communications Code (Directive (EU) 2018/1972) ('EECC') is an important change in Europe's regulatory regime. This document looks into future benchmarking possibilities providing an early investigation of the issues to take into account for benchmarking possibilities in 2021 and beyond, when national legislators will have transposed the new directive.

A second important matter is the focus of the data collection: what type of indicators may be collected and what is it that the data might shed light upon. This is especially true in an area such as IoT that touches on many markets, policies and initiatives[6]. Indeed, the aforementioned 2018 OECD Report provides a figure that describes well the different actors involved in the IoT value chain, which range from agents providing infrastructure (including connectivity) to the IoT platforms and services, and which may either be commercially distinct or have varied degrees of vertical integration.

[6] BEREC and the different stakeholders participating in the public consultation have identified a number of different organisations for whom IoT related data would be relevant. This includes national and supranational emergency services and security organizations, national statistical offices, standard development organisations (Internet Engineering Task Force ('IETF'), Institute of Electrical and Electronics Engineers ('IEEE'),, European Telecommunication Standards Institute ('ETSI'), civil society organisations (notably community networks and open developer communities such as OpenWRT) and as well the different market agents.

Figure 1 - The IoT enabling environment, OECD 2018



Source: OECD

Given the wide array of actors and interests, it is necessary to state that BEREC considers that most of the indicators it may benchmark shall relate to the notion of "connectivity" (at least in an initial phase). Some stakeholders point at the fact that connectivity is only a small part of the IoT universe, and, for example, one operator believes it to be the smallest revenue contributor in the IoT value chain[7]. Whilst BEREC admits that connectivity is only a part of the fuller system, still, it is indispensable for the delivery of IoT services and, more crucially, it is the concept that lies at the core of NRAs' and BEREC's functions and capabilities. The data collected should enable to inform BEREC's regulatory policy as to ensure the level and quality of connectivity services in Europe so that the IoT can be successfully deployed, and also, secondarily to understand if and how this services may affect competition in the provision of ECN and ECS.

[7] According to Global DaTa 2018, connectivity will represent 11% of the worldwide revenues of IoT, which are estimated at 317 billion USD.

Finally, and related to the previous point, BEREC should provide a definition of what it considers the IoT to be, certainly with respect to any monitoring and measurement of the IoT it may undertake. In previous work, BEREC has been using the 2015 European Commission ('EC') definition[8], which defined the IoT as enabling "objects sharing information with other objects/members in the network, recognizing events and changes so to react autonomously in an appropriate manner. The IoT therefore builds on communication between things (machines, buildings, cars, animals, etc.) that leads to action and value creation."

However, having reviewed the existing different definitions and the views expressed by the stakeholders in the public consultation, one realises that BEREC's conclusion of the 2016 report[9] "there is not yet a common understanding or definition of what IoT services and devices really are" is still valid. Definitions vary, for example, with respect to the admission of human involvement in the IoT service (whether it incorporates or not human interaction and to which extent) and also in the reference to the Internet – which provides end to end connectivity - as opposed to using more general wordings of "interconnection" and "communication".

2. NRAs' current data collection

According to the NRA responses to the different BEREC's questionnaires, most NRAs collect some IoT related data from providers of ECS and ECN. However, this statistical information is almost exclusively related to M2M[10]. While one NRA began collecting data on M2M as far back as 2000, typically, the regular collection of statistical information of this type started in 2010. In general, the M2M-related statistics that are collected by NRAs include the number of subscriptions, data volumes and revenues (yet, not all NRAs collect all three indicators).

It is worth noting that the EC Directorate General for Communications Networks, Content and Technology ('DG Connect') regularly collects data on M2M from the different European countries and requests NRAs to use the following definition for this concept: ""M2M is about enabling the flow of data between machines and machines and ultimately machines and people. Regardless of the type of machine or data, information usually flows in the same general way -- from a machine over a network, and then through a gateway to a system where it can be reviewed and acted on." From the NRAs' answers to the questionnaires, it seems that some NRAs[11] use this definition (or a similar definition) in their own statistical processes. In occasions, NRAs resort to examples such as portable navigation services, vending machines, remote electricity metering and others to explain the concept, and sometimes they mention that consumer subscriptions, dongle and table subscriptions should be excluded from

[8] "Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination", Study prepared by International Data Coorporation ('IDC') and TXT for the EC (2015): http://ec.europa.eu/digitalagenda/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination

[9] BoR (16) 39. Enabling the Internet of Things, page 5.

[10] It is worth mentioning that the Authorité de regulation des communications électroniques et des postes ('ARCEP') is as well collecting subscription and revenue information about IoT LPWAN services and that the Bundesamt für Kommunikation ('BAKOM') is collecting information on embedded sim cards.

[11] Not all NRAs provided their definition of M2M.

the data collection. Although the definition used by the EC does not circumscribe to cellular technology, most NRAs request this information from mobile operators[12].

BEREC also collects data on M2M subscriber identity module ('SIM') cards, since 2017, in its regular questionnaire on Mobile Termination Rates). To calculate M2M SIM cards, BEREC defines M2M as "a communication technology where data can be transferred in an automated way with little or no human interaction between devices and applications."[13]

In addition, a couple of NRAs have elaborated some statistical information on the IoT sourced from the demand side; this is, by using surveys, which are mainly directed to residential consumers.

Finally, only five NRAs indicate that they would collect statistical information on the IoT beyond what is already being collected (i.e., as set out above, statistical information on M2M) during the next 12-24 months[14]. NRAs were not asked to comment on their longer term plans to collect such statistical information. The rest of the NRAs provided responses where they clearly articulated no plans for collecting such information in the short-run, or mentioned that there was uncertainty as to whether such a future collection of statistical information would take place.

3. The reason for BEREC to collect and benchmark IoT data

As mentioned in the introduction the IoT is an important phenomena that is already affecting the lives of European citizens. There are multiple and important issues related to the IoT, and, as mentioned by the Global System Mobile Association ('GSMA') in its response to the public consultation, it would be good to have an understanding of the phenomena beyond connectivity to put it in the right context. For example, the European Digital Rights mentions that "given its priorities in terms of users' protection and empowerment, BEREC could move quickly on societal aspects of IoT by encouraging its members to actively look out for information about home automation misuse".

In absence of official statistics on IoT, one option could be to examine other sources of data collection (e.g. CISCO, Ericsson, and so forth). In fact, these sources have been used in recent studies but there is no consensus to data on definitions, which can hamper conclusions.

[12] One NRA mentioned that it uses a definition which explicitly mentions mobile-cellular machine-to-machine subscriptions, as it uses the International Telecommunication Union ('ITU') definition: "M2M mobile-network subscriptions refers to the number of mobile-cellular machine-to-machine subscriptions that are assigned for use in machines and devices (cars, smart meters, consumer electronics) for the exchange of data between networked devices, and are not part of a consumer subscription. For instance, SIM-cards in personal navigation devices, smart meters, trains and automobiles should be included. Mobile dongles and tablet subscriptions should be excluded."

[13] However, for the purpose of the Statistics and Indicators EWG Questionnaire, M2M SIM cards only take into account the SIM cards exclusively used for M2M to avoid double-counting. (Note: The situation may well arise that a SIM exclusively used for M2M is also activated by limited human intervention (e.g. remote control/maintenance in industrial IoT applications via smartphone/tablet).

[14] One NRA would like to collect more data in the future, in particular concerning LPWAN (Low Power Wide Area Network), such as LoRa or SigFox networks.

Moreover, there is a list of well-understood general benefits of having EU harmonized statistics for any subject that is mentioned both by stakeholders and by NRAs in their different contributions in reference to the IoT. Harmonized statistics allow for the comparison of national experiences but also, set a common terminology for concepts that fosters a better communication between all kinds of agents, regardless of what is their country of origin and their status (public or private).

Yet, whilst there is a consensus on the advantages of a common approach regarding IoT statistics, any information requests to providers must be justifiable, proportionate and not excessively burdensome for the providers of information. In alignment with this, it is important to establish the exact purpose of any data collection. Because of all of this, and also because of the added resources that any new data requirements pose on NRAs, BEREC has carefully considered the kind of data that it may seek to gather and will also endeavour to size and reason any future requests in an appropriate manner.

Indeed, whilst BEREC recognizes the importance of collecting many types of data related to the IoT[15] it has come to the conclusion that, initially, its efforts in gathering statistics should focus on the need to understand the demands that the IoT will place on networks and ECS and related public resources, such as numbering and spectrum. Also, BEREC has established that IoT data requests should be kept as high level as possible.

IoT harmonized statistics should allow to check on the availability of connectivity services of sufficient quality across Europe so that the IoT can develop properly, and also enable to detect problems and shortages at the national level. In particular, the total number of IoT devices alone is of less importance than assessing the network impact of those; this network impact may help identify how IoT devices strain the potential bottlenecks within the network and also to see how competition evolves in the provision of IoT connectivity[16]. In this way, BEREC will aim at improving the consistency of the application of European telecom rules, and contribute to the development of the Digital Single Market and the European Gigabit Society[17].

Finally, as the following section establishes NRAs can (mainly) collect information regarding ECS and ECN and because of this, there is a more motivated need to delineate the object of the statistical gathering.

At this stage it is relevant to establish that for connectivity, every IoT service will depend on traditional fixed or mobile (2G/3G/4G/5G) communication networks, commercial networks in unlicensed spectrum (such as the SigFox or TheThingsNetwork) or private networks (e.g. WiFi, Bluetooth, ZigBee). Indeed, it is foreseen that unlicensed low power wide area networks ('LPWAN') will play an important role for IoT. For this reason, BEREC sees that there is a need to understand better how the different IoT services are supported by the different connectivity

[15] For example, stakeholders have mentioned data collection in relation to home automation misuse, related to the security of electronic communication services, on potential effects of electromagnetic pollution related to the proliferation of low power devices or even a measurement of the IoT in the economy.

[16] It would also be interesting to study the different business models prices and price-models for the different IoT networks and services.

[17] https://ec.europa.eu/digital-single-market/en/policies/improving-connectivity-and-access

solutions in order to assess what are the requirements that these services pose on services and networks and also to clearly identify who the providers of these connectivities are and how these data may be collected[18].

Moreover, this kind of assessment is also needed before engaging in any formal data collection such as the one proposed by two stakeholders to collect data on the number of IoT connections that are operating in the licensed and unlicensed spectrum, in order to estimate their impact on spectrum usage/allocation. And, also, regarding this point, it must be noted that spectrum management developments take place at the EU level and that there are a number of organizations, such as the European Conference of Postal and Telecommunications Administrations ('CEPT'), European Telecommunications Standard Institute ('ETSI') and ITU Radiocommunication Sector ('ITU-R') that already monitor the developments that affect spectrum needs.

Regarding numbering, it is BEREC's view (in agreement with all stakeholders) that there is no immediate problem of scarcity of numbering resources and that this should not be a problem in the future, as long as numbering is properly managed. As mentioned in the previous BEREC report on IoT[19], at present and under the current numbering plans, the possible scarcity of numbering resources does not appear to be the main obstacle to the development of IoT.

Indeed, BEREC is currently working to develop the guidelines on common criteria for the assessment of the ability to manage numbering resources by undertakings other than providers of ECN or ECS and of the risk of exhaustion of numbering resources if numbers are assigned to such undertakings. These guidelines shall cover all kind of services and numbers, including IoT/M2M services and possibly to providing special numbering resources for such services.

Similarly, BEREC has established that its future database on numbering resources with an extraterritorial use (derived from the new EECC obligation) is sufficient for the time being to assess which national numbers for IoT devices are used outside their domestic market/territory. Moreover, within the tasks regarding the guidelines on common criteria for the assessment of the ability to manage numbering resources by undertakings other than providers of ECN/ECS and of the risk of exhaustion of numbering resources, BEREC will be analyzing the possible impacts on numbering resources in case those are assigned to undertakings other than providers of ECN/ECS with extra-territorial use rights

As an alternative, or in complement to the data collection from the supply-side, it might be worth to consider other sources from the demand side, through consumer usage surveys. However, from a usage perspective, the reliability of the answers depends on the awareness of consumers of the connected nature of the devices they own.

OECD in the aforementioned 2018 Report suggested a list of categories of devices according to application domains (e.g. home or health) could be implemented in modules within ICT

[18] Currently NRAs are not collecting data of this kind.
[19] BoR (16) 39. Report on enabling the internet of things.

household and Individuals usage surveys. Indeed, the European Statistical Office ('Eurostat') added an IoT related question in its 2019 ICT household survey.

4. Legal possibilities for NRAs to collect data from providers

Currently the legal possibility for an NRA to collect data from suppliers is set by Article 5 (1) of the Framework Directive[20]: "Member States shall ensure that undertakings providing ECN/ECS provide all the information, including financial information, necessary for national regulatory authorities to ensure conformity with the provisions of, or decisions made in accordance with, this Directive and the Specific Directives. (..)". Article 2 of the Framework Directive provides the definition of ECN and ECS. The former is a broad definition encompassing all transmission networks, regardless of the service or application running on them. The definition of ECS hinges on three criteria: first, that the service normally is provided for remuneration (where remuneration has been interpreted in very broad terms, considering any benefit that results from the provision of the service[21]); second, that the service consists wholly or mainly in the conveyance of signals on ECN; and, third, that the service consists in the transmission of content.

The BEREC Report on enabling the Internet of Things (BoR (16) 39) elaborates on this, and provides the following conclusion: "Under the present regulatory framework, the connectivity service provider who provides connectivity over a public network for remuneration is generally the provider of an ECS in the IoT value chain; he is responsible vis-à-vis NRAs for the compliance with the obligations deriving from the EU regulatory framework. In contrast, the IoT user (e.g. car manufacturer, provider of energy including smart meter) typically does not seem to provide an ECS. According to such an approach, IoT users would not be subject to the rules of the EU regulatory framework. However, there would be a finding of an ECS if the IoT user wholly or mainly resells connectivity to the end-user. Overall, since there are so many different types of packages including connectivity and since business models are just beginning to evolve, it has to be carefully assessed by NRAs in which situations an IoT user may – or may not be – be qualified as a provider of an ECS."

Indeed, most NRAs can only request information from the providers of ECN/ECS and have no legal powers to request information from other undertakings[22]. Also, each NRA establishes on a case by case basis whether an undertaking is also a provider of an ECS depending on the assessment it makes on this agent being responsible for a connectivity service, either directly or through resale.

[20] Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive)
[21] See BoR (16) 39 and EECC recital (16).
[22] For a few NRAs the national legislation has extended the capacity of NRAs to request information from agents which are not ECS providers, as long as these requests are proportionate and well-reasoned.

The right to request information in the new EECC

Articles 20 and 21 of the new EECC deal on the duty of undertakings to respond to NRAs' and other competent authorities' (proportionate and reasoned) information requests. Paragraph 1 in Article 20 establishes that "Member States shall ensure that undertakings providing ECN/ECS, associated facilities, or associated services, provide all the information, including financial information, necessary for national regulatory authorities, other competent authorities and BEREC to ensure conformity with the provisions of, or decisions or opinions adopted in accordance with, this Directive and Regulation (..)"

Article 21 establishes further rights to request information from the undertakings, which are subject to the general authorization established in Article 12; this is, providers of ECN/ECS, other than number-independent interpersonal communication services. It states that NRAs and other competent authorities may require undertakings to provide information with regard to the general authorisation, the rights of use or the specific obligations referred to in Article 13(2), which is proportionate and objectively justified for several purposes. These purposes include, among others: safeguarding the efficient use and ensuring the effective management of radio spectrum and numbering resources, collating statistics, reports or studies and responding to reasoned requests for information by BEREC. Article 21 also states that "BEREC may develop templates for information requests, where necessary, to facilitate consolidated presentation and analysis of the information obtained."

Therefore, both articles establish the right for NRAs to gather information from electronic ECN/ECS providers. Article 2 in the EECC defines these two terminologies, which differ from the definitions provided by the 2002 Framework Directive.

In the case of ECN, the new definition incorporates the idea that these network may be based (or not) on a permanent infrastructure or centralised administration capacity. Recital (12) qualifies this: "the regulatory framework should cover the use of radio spectrum by all ECN, including the emerging self-use of radio spectrum by new types of networks consisting exclusively of autonomous systems of mobile radio equipment that is connected via wireless links without a central management or centralised network operator, and not necessarily within the exercise of any specific economic activity. In the developing 5G wireless communications environment, such networks are likely to develop in particular outside buildings and on the roads, for transport, energy, research and development, eHealth, public protection and disaster relief, the Internet of Things, machine-to-machine and connected cars".

The new EECC definition of ECS states that: "ECS means a service normally provided for remuneration via ECN, which encompasses, with the exception of services providing, or exercising editorial control over, content transmitted using ECN/ECS, the following types of services:

(a) 'internet access service' as defined in point (2) of the second paragraph of Article 2 of Regulation (EU) 2015/2120;
(b) interpersonal communications service; and
(c) services consisting wholly or mainly in the conveyance of signals such as transmission services used for the provision of machine-to-machine services and for broadcasting".

In its answer to the BEREC public consultation, one stakeholder interprets this as follows: “EECC considers any type of M2M connectivity to be part of the Electronic Communication Services, therefore commercial networks in unlicensed spectrum such as those referenced in the consultation document should be included within the scope of ECS.” Similarly, another stakeholder states that: “In consideration that the EECC considers now any type of M2M connectivity to be part of the ECS, unlicensed spectrum and private networks need to be included within the ECS circle”.

BEREC wants to note that, in accordance with the principle of technology neutrality, any service that consists of transmission or of wholly or mainly of the conveyance of signals between devices or software-based applications (with limited or no human interaction) and that is supplied for remuneration must be considered an ECS. First, the EECC needs to be transposed to the different national legislations. Second, currently the precise kinds of services that fall under the ECS category are being analysed on a case by case basis by NRAs and it is foreseeable that this will also the case in the future. Note that it is necessary to ensure an alignment of legislative and NRA decisions so that harmonized statistics can be sought.

Finally, Article 21 also establishes that “Where the information collected in accordance with the first subparagraph is insufficient for NRAs, other competent authorities and BEREC to carry out their regulatory tasks under Union law, such information may be inquired from other relevant undertakings active in the electronic communications or closely related sectors”. A priori, this grants a possibility to gather information from providers other than the providers of ECN/ECS, in so far the information is necessary to carry out regulatory tasks, and the information that may be provided by the providers of ECN/ECS is deemed insufficient.

5. IoT definitions and categories

In its latest work on IoT[23] BEREC closely tied M2M communication and IoT, specifying that “the terms M2M and IoT are used as synonyms”. To take into account the latest technical and legislative work done at an international level, the responses received to the public consultation and the ambition of BEREC, it may be needed to clarify these definitions.

IoT and M2M definition

The EECC clearly makes a distinction between the IoT and M2M communication in its recital (12). It also clarifies in recital (249) the definition of machine-to-machine services, defining them as “*services involving an automated transfer of data and information between devices or software-based applications with limited or no human interaction*”. Moreover, while having a very broad approach in terms of terminology for IoT, the OECD[24] indicates that M2M communications are “*a subset*” of the IoT. The ITU has also adopted a broad definition that includes the “*global infrastructure for the information society, enabling advanced services by interconnecting [..] things*”[25].

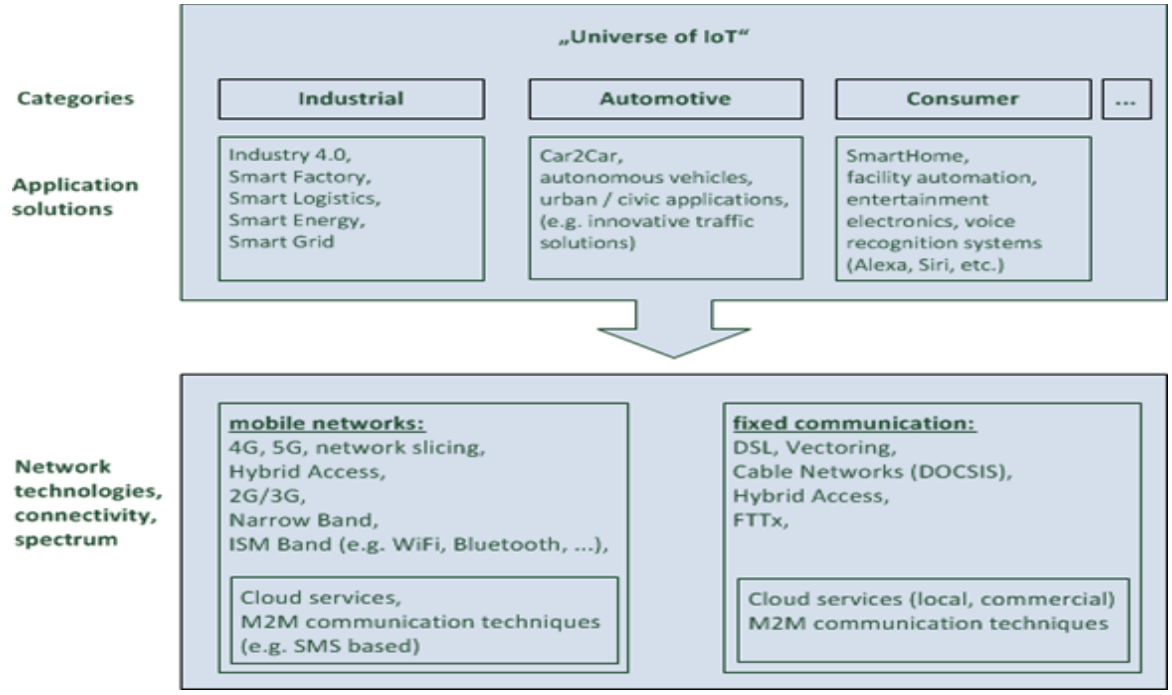
[23] *ibid*
[24] ibid
[25] Recommendation ITU-T Y.2060 Series Y: global information infrastructure, internet protocol aspects and next-generation networks

Some NRAs have pursued studies at a national level on this matter and it could be considered that the IoT encompasses:

- specialized devices[26] connected to either the internet in order to reach other devices, platforms or individuals or to other specialized devices through peer-to-peer technologies or number based technologies;
- the technical ecosystem allowing such connectivity;
- the services provided by such specialized devices and technical ecosystem.

Figure 2 below summarises the aforementioned points.

Figure 2 - BEREC's IoT universe



Source: BEREC

Hence, BEREC concludes that the IoT is a wider concept than M2M and that these two terminologies cannot be used interchangeably. Moreover, in what follows, BEREC adopts that the definition that the EECC has provided for M2M, which differs from the one provided by

[26] Specialized devices are considered as devices which have, by design, a limited number of functionalities and uses.

BEREC in the 2010 Report on Convergent Services in that it allows for limited human interaction[27].

IoT categories

In its public consultation document BEREC had classified the most relevant IoT applications into three different very broad categories: industrial sector, the automotive sector and the consumer sector.

- *Industrial Internet of Things (´IIoT´)*

The IoT can greatly improve connectivity, efficiency, scalability, time savings, and cost savings for industrial organisations. Interoperability and security are probably the two biggest challenges surrounding the implementation of IIoT.

- *Automotive Internet of Things ('AIoT')*

There exist several use cases in the automotive sector which are based on communication between vehicles. Mainly these services should improve road safety and prevent accidents. For example, a car could inform another vehicle that is approaching about a potential danger. In addition, in the future autonomous cars can help to make the use of the existing infrastructure more efficient and could also increase the comfort of the users, who can make other use of their travel time. These developments, which are currently in progress in the automotive sector require a comprehensive connectivity of the vehicles.

- *Consumer Internet of Things (´CIoT´)*

In essence, CIoT refers to the IoT in the context of consumer applications, use cases and devices (for example, wearables).

However, several stakeholders provided good arguments in their responses to the public consultation so as to why the boundaries between these categories are quite blurred. For example, health care applications cut across two of the categories previously identified by BEREC, and the same happens for IoT related to smart cities or asset tracking. BEREC therefore agrees that these categories are rather fluid and that the list of categories cannot be exhaustive as new services may appear in the future. Indeed, as one stakeholder points out, official government statistic may be better placed than BEREC to provide a full and ongoing categorization of the different IoT services, with regards to their kinds of uses or the economic sectors that they affect.

[27] BEREC, Report on convergent services, BoR (10) 65, December 2010, p. 6, defines M2M as "a generic concept that indicates the exchange of information in data format between two remote machines, through a mobile or fixed network, without human intervention."

Instead BEREC should aim at categorising IoT services in so far they depend on different connectivity technologies (for example, cellular versus non cellular connectivity), different spectrum usage (licensed or unlicensed) or their requirements on the network performance.

In this sense, the OECD[28] has proposed a categorisation that BEREC finds very useful. The IoT is classified into: Wide Area IoT, and Short Range IoT. The first category includes devices connected through cellular technology as well as those connected through Low Power Wide Area Networks, whereas the Short Range IoT category includes devices using unlicensed spectrum with a typical range up to 100 metres. Within the category of Wide Area IoT, two subcategories are further suggested:

1) Massive M2M devices which are not sensitive to latency or network speeds (e.g. sensors for agriculture or smart cities), and

2) Critical IoT applications which require high reliability and low latency connectivity (e.g. remote surgery applications, fully automated vehicles and other industrial robotics applications).

Connectivity

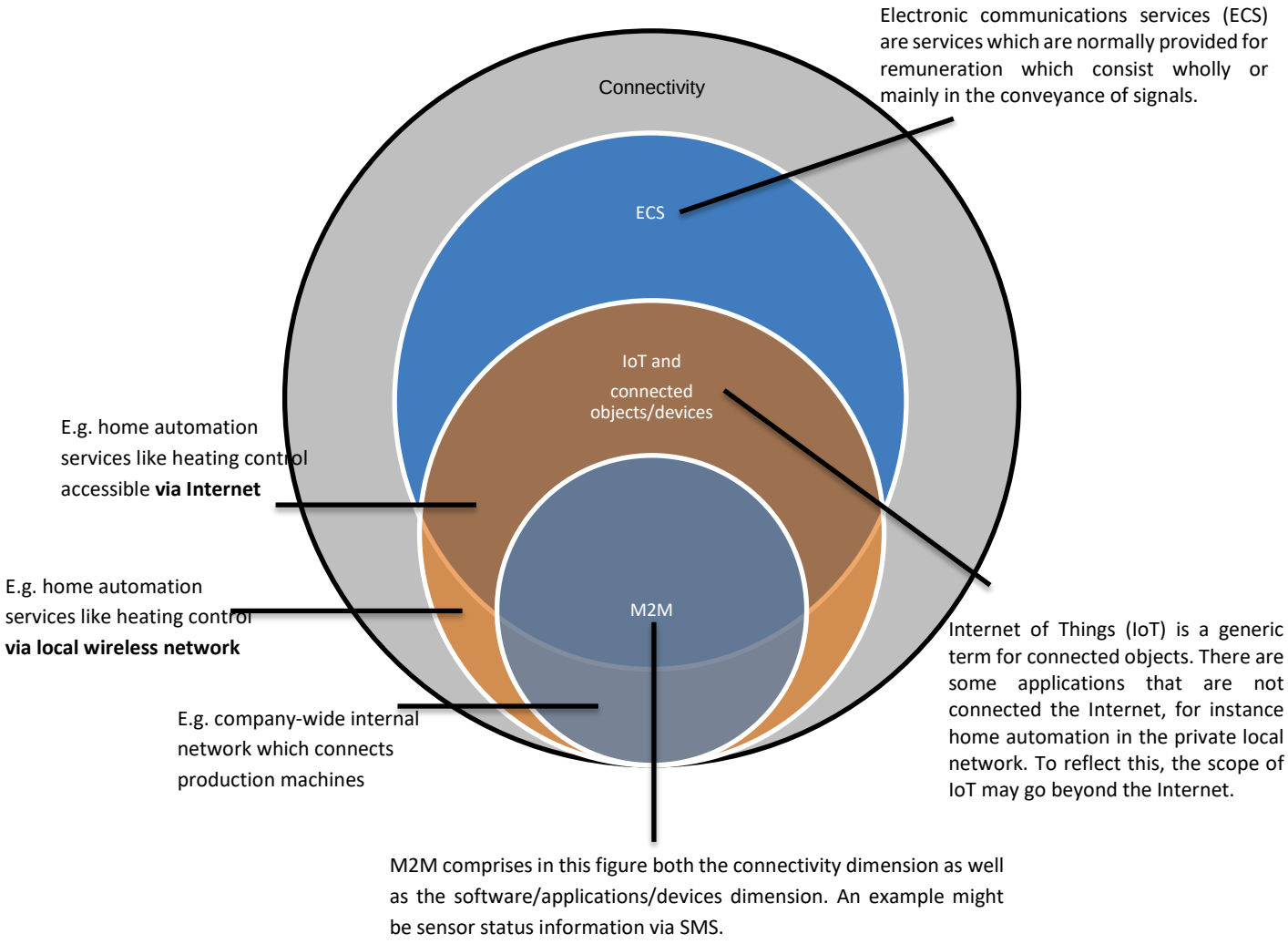
Currently, every IoT/M2M-Service depends on some kind of Connectivity, e.g. via:

- Traditional ECS (e. g. fixed or cellular such as 2G/3G/4G networks)
- Commercial networks in unlicensed spectrum (e.g. SigFox, TheThingsNetwork)
- Private networks (e.g. WiFi, Bluetooth, ZigBee)

Figure 3 provides examples of each kind of connectivity and portrays the relationship between the concepts of M2M and ECS.

[28] ibid

Figure 3 - The concept of IoT in relation to M2M and ECS



Source: BEREC

Finally, note that, the IoT is an ambivalent concept, as it suggests Internet access, whilst many services – for example home metering services in the private local network- actually imply non-Internet connected objects/devices. In fact, most of the definitions quoted by BEREC in its public consultation document encompass non-internet connected objects/devices and for this reason, one stakeholder has argued that instead of using the IoT terminology, BEREC should refer to connected objects/devices.

6. Set of M2M indicators

BEREC concludes that the IoT is a wider concept than M2M and that these two terminologies cannot be used interchangeably. Moreover, in what follows, BEREC adopts the definition that

the EECC Directive has provided for M2M communications. Thus, for **future data collection purposes, BEREC proposes the following definition** similar to the one used by one NRA[29]:

> *M2M communication stand for* **services involving an automated transfer of data and information between devices or software-based applications with limited or no human interaction.** Limited voice/short message service ('SMS') communication as an additional component of the M2M is also included as long as they constitute an ancillary part of the main service.
>
> *In order to clarify the concept of 'limited human intervention': if limited human involvement is part of a service, this does not preclude classification as M2M communications for the purposes of the statistical data collection at least in the following cases:*
>
> *- activation/operation/control/monitoring of an M2M application or an M2M device using technical equipment such as a computer, smartphone, tablet etc. by a human in either a private (e.g. smart home) or an industrial environment;*
>
> *- activation of an application that enables individual communication in the sense of a preselected point-to-point communication but not a call to a freely selectable number. Examples of this are eCalls in vehicles, private emergency calls in lifts and/or vehicles, and concierge services in vehicles. This list is not exhaustive and is without prejudice to an assessment of new business models.*

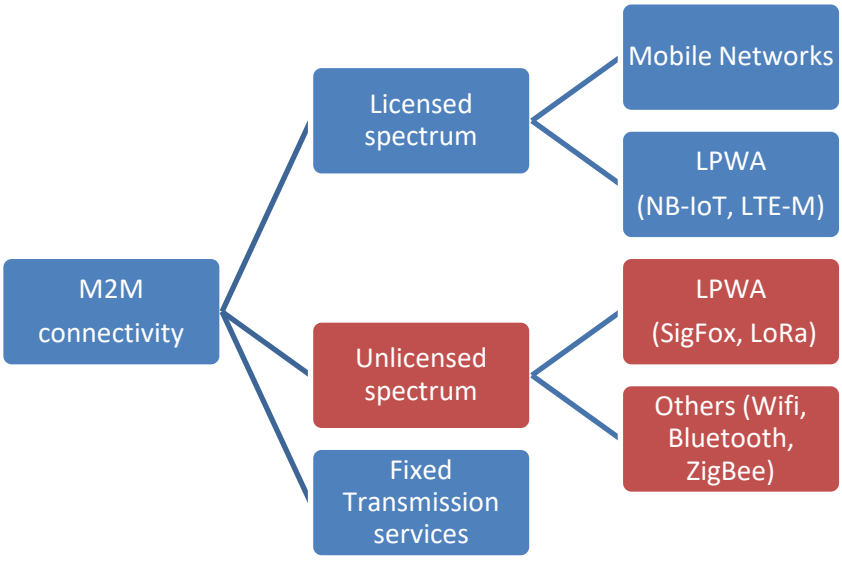
Given that the collection of statistical indicators on the IoT currently focuses on rather general information on M2M, a step forward would be to just expand the M2M statistics that are collected.

Collecting additional data on the specific sectors the M2M services are used within (for example, industry, health, automotive, agricultural etc.) could be interesting. However, considering the burden for service providers, and how feasible and reliable is the process, BEREC needs to prioritise measurement efforts of those elements of the IoT that are of most relevance to policy makers. Thus, as stated in previous sections, BEREC considers that most of the indicators it may benchmark, in an initial phase, shall relate to "connectivity".

BEREC's proposal is to collect data based on the categorization of networks used for some IoT devices to communicate (Figure 4).

[29] BNetzA, Numbering plan for mobile numbers, Administrative Order No 11/2011 (last updated by Administrative Order No. 80/2017)

Figure 4 – M2M connectivity



Source: BEREC

In its previous report BEREC[30], found, based on data by Machina Research, that only a minor fraction of M2M connections will be based on cellular technologies, which means that some of the IoT devices may require a SIM card, but most of the IoT devices will not. Other connectivity networks used are for example Low Power Wide Area Networks (LPWAN). Unlicensed LPWA are playing an increasing role in IoT and BEREC and NRAs need to understand the real dimension of this part of the market.

BEREC considers, however, that data collection about connectivity using private (end-users) networks (respectively about objects/devices connected via these networks) can be rather ambitious for NRAs and BEREC.

The proposed set of M2M indicators to collect include a number of connected devices and traffic where technically possible, as follows:

NUMBER OF CONNECTED OBJECTS/DEVICES

1. Number of connected objects/devices that operate in licensed spectrum networks:

1.1 Number of connected objects/devices that operate in Mobile networks (with numbering) *by technology, if possible.*

1.2 Number of connected objects/devices that operate in LPWA (NB-IoT and LTE-M)

2. *Number of connected objects/devices that operate in unlicensed spectrum networks:*

2.1. LPWA (e.g. SigFox, LoRa)

[30] BoR (16) 39. Enabling the Internet of Things.

TRAFFIC GENERATED FROM CONNECTED DEVICES

3. Amount of traffic generated by objects/devices that operate in Mobile networks (with numbering), by technology (2G, 3G, 4G, 5G), if possible.

4. Amount of traffic generated by objects/devices that operate in LPWA (NB-IoT and LTE-M)

5. *Amount of traffic generated by objects/devices that operate in* LPWA (SigFox, LoRa)

The proposed set of M2M indicators is to be collected from undertakings providing public electronic communications networks and/or publicly available electronic communications services.

The number of connected objects/devices that operate in mobile networks are already collected by some NRAs. BEREC also collects data on M2M SIM cards, since 2017, in its regular questionnaire on Mobile Termination Rates ('MTR'). To calculate M2M SIM cards, BEREC defines M2M as "a communication technology where data can be transferred in an automated way with little or no human interaction between devices and applications." The M2M definition should now be updated according to this report.

For the purpose of the MTR questionnaire, M2M SIM cards only take into account the SIM cards exclusively used for M2M to avoid double-counting[31]. The criteria is still valid for the current proposed collection.

Another motivation for collecting information about M2M connected devices concerns the measurement of mobile penetration. M2M connected devices should be excluded, at least because they make penetration measurements less useful.

However, mobile connectivity is but one type of connectivity used for IoT devices and networks. It is imperative to have a holistic view of the entire M2M market collecting data on alternative networks that also enable M2M connectivity as figure 4 suggests.

BEREC believes that, with the transposition of the new EECC, NRAs and BEREC will have further rights to request information from undertakings providing ECN/ECS, associated facilities, or associated services[32]. However, it is necessary to ensure an alignment of legislative and NRA decisions so that harmonized statistics can be sought on these areas.

Moreover, as mentioned previously in the report, NRAs hold no experience in collecting most of the M2M indicators suggested in the aforementioned lists. Because of that, at a preliminary stage it is necessary to:

(1). understand better how the different IoT applications are supported by the different connectivity solutions. Note that many IoT applications are in a stage of development, and there is uncertainty about how they will be marketed, their possible success but, of more

[31] The situation may well arise that a SIM exclusively used for M2M is also activated by limited human intervention (e.g. remote control/maintenance in industrial IoT applications via smartphone/tablet.

[32] See discussion in section 4. Article 20 in the EECC also establishes that primarily NRAs can collect information from the providers of electronic communication services and networks in a proportionate manner and when motivated for a regulatory reason.

importance to this report, with regards to the kind of connectivities/electronic communication services that may support them.

(2) identify the means of collecting information. This implies identifying who the providers of the different electronic communication services are and whether and how they can provide information, but also thinking of other means of retrieving information as it will not always be the case that these providers will be in the position to gather this information.

A third party study should be commissioned by BEREC on the second half 2020, prior to the deadline for the EECC transposition into national law, to identify and assess who are the providers of the different M2M services, whether and how they can provide information, and move forward with a first attempt to collect data, in particular the indicators proposed in this report.

7. Conclusions

The IoT is an important worldwide phenomena that is expected to grow exponentially in a short span of time, and because of this, it may eventually place important demands on the deployment and capabilities of communication infrastructures and services and, possibly on complementary public resources such as spectrum and numbering.

Because of all of this, BEREC has started to consider the different implications of the IoT in several initiatives. In particular, this piece of work starts by acknowledging that although there are several sources of information about the IoT (e.g. Ericsson, the GSMA, and others), there is no single definition for this concept and for other related concepts such as M2M. As a result, what is measured in each study is not harmonized leading to the need to produce better statistics.

A common terminology regarding the definition of M2M and a harmonized collection of a set of indicators across Europe can contribute to gather information relevant to the development of good quality connectivity services across the EU at scale, which is critical to IoT development and adoption.

Moreover, the new EECC gives added powers to NRAs and BEREC to collect data on M2M, in so far as it gives way to consider M2M as an ECS. The main issue regarding the possibility to gather harmonised statistics is for all countries to have the same understanding when transposing the directive into national law.

BEREC proposes to measure, in the future, a set of indicators related to connected objects/devices that operate in mobile networks, in line with what is proportional and feasible. This is, to update the M2M definition and expand the data collection on M2M indicators already been undertaken by NRAs and BEREC. BEREC proposes to collect data on connected objects/devices and related traffic.

Moreover, BEREC sees the need to further elaborate the statistics being collected so as to have the data on number of connected objects/devices and traffic from other kinds of licensed spectrum and non-licensed spectrum. However, this is a longer term initiative as it may only take place after the transposition of the EECC (in 2021 and beyond) and also because

currently there is no NRA experience in collecting this kind of information, so that BEREC requires a better understanding of these technologies to engage in a benchmarking exercise.

Thus, given the importance of IoT, and given the limited power to NRAs to collect data on M2M and IoT a third party study should be commisioned by BEREC on the second half of 2020, prior to the deadline for the directive's transposition into national law. This study shall identify and assess who are the providers of the different M2M services, whether and how they can provide information, and move forward with a first attempt to collect data, in particular the indicators proposed in this report.

8. List of acronyms

AIoT - Automotive Internet of Things

ARCEP - Autorité de régulation des communications électroniques et des postes

BAKOM - Bundesamt für Kommunikation

BEREC – Body of European Regulators for Electronic Communications

BMK EWG – Benchmarking Expert Working Group

BNetzA – Bundesnetzagentur

B2B – Business-to-Business

B2C – Business-to-Consumer

CEPT – European Conference of Postal and Telecommunications Administrations

CIoT - Consumer Internet of Things

CSOs – Civil Society Organisations

DETNET – Deterministic Networking

DG Connect - Directorate-General for Communications Networks, Content and Technology

DOCSIS - *Data Over Cable Service Interface Specification*

DSL – Digital Subscriber Line

EC – European Commission

EECC - European Electronic Communications Code

ECS – electronic communication service

ECTA – European Competitive Telecommunications Association

ETSI – European Telecommunications Standards Institute

EU – European Union

EUROSTAT - European Statistical Office

FTTx – Fibre to the x

GSMA – Global System Mobile Association

ICT – Information and Communication Technology

IDC – International Data Corporation

IEEE - Institute of Electrical and Electronics Engineers

IETF – Internet Engineering Task Force

IIoT - Industrial Internet of Things

IoT – Internet of Things

ISM - Industrial, Scientific and Medical

ITU – International Telecommunication Union

ITU-R - ITU Radiocommunication Sector

ITU-T – ITU Telecommunication Standardization Sector

LPWA - Low Power Wide Area

LPWAN - Low Power Wide Area Networks

LTE-M - Long Term Evolution-category M1

MTR – Mobile Termination Rate

M2M – Machine-to-Machine

NB-IOT – Narrowband Internet of Things

NRA – National Regulatory Authority

OECD – Organisation for Economic Co-operation and Development

SIM - Subscriber Identity Module

SMS – Short Message Service

SUIT – Software Updates for Internet of Things

6LO – Internet Protocol Version Six over Networks of Resource-constrained Nodes

9. Appendix

- Gartner Forecast - Internet of Things[33]: Gartner forecasted that 8.4 billion connected things would be used worldwide in 2017, up 31% from 2016, and will reach 20.4 billion by 2020.

- Cisco Visual Networking Index[34]: According to Cisco, in 2016 there were 780 million M2M connections around the world, out of which 325 million were wearable devices (e.g. smart watches, smart glasses, health and fitness trackers, wearable navigation devices, smart clothing, and so forth.). Of these wearable devices, 11 million already had embedded cellular connections (i.e. eSIM) in 2016. Their forecast is that by 2021 there will be 3.3 billion M2M connected devices, i.e. a fourfold growth in five years.

- Cisco Cloud Index White Paper[35]: Globally, the data created by Internet of Everything devices will reach 507.5 ZB per year (42.3 ZB per month) by 2019, up from 134.5 ZB per year (11.2 ZB per month) in 2014. Globally, the data created by Internet of Everything devices will be 269 times higher than the amount of data being transmitted to data centres from end-user devices and 49 times higher than total data centre traffic by 2019.

- IDC Worldwide Internet of Things Forecast[36]: By 2021, global IoT spending is expected to total nearly €1 trillion as organizations continue to invest in the hardware, software, services, and connectivity that enable the IoT.

- IHS Enabling the Internet of Things[37]: Forecast of global IoT installed base from 2015 to 2025.

- Vodafone's publishes an annual IoT Barometer[38]. In the 2017/2018 edition, Vodafone interviewed almost 1,300 business respondents globally, and covered multiple industries and company sizes. According to its analysis, Vodafone states that IoT adoption has grown from 12% of respondents to their survey in 2013 to almost 30% in 2017. Further, according to Vodafone, many respondents have increased their number of connected devices. Finally, based on Vodafone's survey, the proportion of companies embracing the IoT "on a massive scale" – over 50,000 connected devices – has doubled since 2016.

- ETSI's website details the ongoing standarisation efforts in the field. The IETF LPWAN, 6LO, Deterministic Networking ('DETNET') and Software Uppdated for Internet of Things ('SUIT') contain further information on technical capabilities.

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[33] https://www.gartner.com/en/newsroom/press-releases/2017-02-07-gartner-says-8-billion-connected-things-will-be-in-use-in-2017-up-31-percent-from-2016
[34] https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visualnetworking-index-vni/mobile-white-paper-c11-520862.pdf
[35] http://cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/Cloud_Index_White_Paper.html
[36] https://www.idc.com/getdoc.jsp?containerId=prUS42799917
[37] https://www.ihs.com/Info/0416/internet-of-things.html
[38] https://business.vodafone.com/barometer2017#download

- The GSMA intelligence elaborates figures for total licensed cellular IoT by type (cellular M2M and Licensed LPWA) and estimates that by 2025 there will be 25.2 billion connections globally, out of which “only” 3.1 billion will be cellular (cellular M2M and licensed LPWA). The OECD IOT Measurement and applications Report, of October 2018 provides a good overview of the IoT ecosystem and market structure.