Vodafone Response to Ofcom Consultation:

Promoting investment and innovation in the Internet of Things

0. <u>EXECUTIVE SUMMARY</u>

Vodafone is pleased to provide comments to Ofcom's consultation on the future of the Internet of Things ('IoT').

The IoT market is fast moving, with keen competition across different technologies a constant feature, which is in turn driving innovation. IoT also has a number of distinct commercial and technical characteristics which set it apart from other electronic communications services, particularly those in the mobile sector.

Ofcom's role in this marketplace is obviously one of regulator, but also one of resource manager with respect to spectrum and numbering.

In Ofcom's role as regulator, in such a nascent market the key approach will be one of proportionality. Where a need for regulatory intervention has been demonstrated on the basis of a clear cost-benefit analysis, it is vital to ensure it is proportionate, technology-neutral and targeted to the issue at hand. Otherwise, it risks having a damaging or chilling effect.

Where Ofcom acts as resource manager, it has a duty to ensure that availability of such resources doesn't impede deployment of the IoT, or indeed that the IoT does not consume resources to the detriment of other services. At this stage, with respect to numbering/addressing resources, Vodafone is of the view that Ofcom should "wait and see", monitoring the usage of these via business-as-usual allocation processes and ongoing Information Requests (particularly those associated with the annual Infrastructure Report). With respect to spectrum it may be necessary for Ofcom to vary the conditions on existing licences as international standards agencies update technology to better support the IoT. Further, there may be scope for IoT-specific spectrum in the centre gap of the 700MHz band: Ofcom should lead analysis of whether this is appropriate.

1. INTRODUCTION

Vodafone welcomes the opportunity to shape Ofcom's thinking on the Internet of Things (IoT). Machine-to-Machine (M2M) represents a rapidly growing but still fairly nascent market. It is a market that is complex, in that involves multiple stakeholders in the value chain, and typically spans national regulatory boundaries.

This response sets out the main characteristics of the market in terms of structure and technology. Whilst we highlight areas that will be of interest to Ofcom, at this stage Vodafone does not believe that any specific regulatory action is required.

The response is structured around the main topics identified by Ofcom.

2. IOT DEFINITION, APPLICATIONS AND DEMAND

Creating the IoT presents unique challenges in the breadth of stakeholders involved. There are many different actors involved in the development and delivery of services, across a number of different technologies. As Berg Insight stated in its report "The Global Wireless M2M Market 2013"[1]

"Virtually any communication network may accommodate M2M applications. Fixed-line networks are viable for monitoring fixed assets, whereas wireless networks may be used under all circumstances even though they are required for mobile assets. There is a great diversity of wireless network technologies available in different parts of the world. Cellular wireless – the focal technology family of this report – is only one of several wireless options available for M2M solution developers. These range from satellite communication and legacy wireless networks to next generation wireless broadband technologies".

Given this diversity, estimates of market size will differ according to the M2M technologies that have been included within scope. For example, Machina Research[2] calculated that in 2012 there was an installed base of 3 billion M2M connections worldwide, of which 57% were short range connections (e.g. wi-fi). Conversely, GSMA estimated that there will be 250 million cellular M2M connections worldwide by end of 2014[3]. GSMA also highlights that the use of mobile technology for M2M is rapidly growing, with global M2M connections, growing at almost 40% per year (38% CAGR) between 2010 and 2013.

The IoT market is also characterised by partnerships between different players in the value chain – M2M is a complex market and cross-industry partnerships (involving hardware providers, device suppliers, application developers, communication service providers and systems integrators) enable the market to meet the differing requirements of the businesses that are now

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[1] Berg Insight, "The Global Wireless M2M Market" M2M Research Series 2013
[2] Machina Research, "M2M Global Forecast and Analysis 2012-22", December 2013
[3] GSMA,' From concept to delivery: the M2M market today', February 2014,
http://www.gsma.com/newsroom/gsma-predicts-250-million-m2m/

integrating M2M technology within their everyday operations. Figure 1 shows a typical value chain.
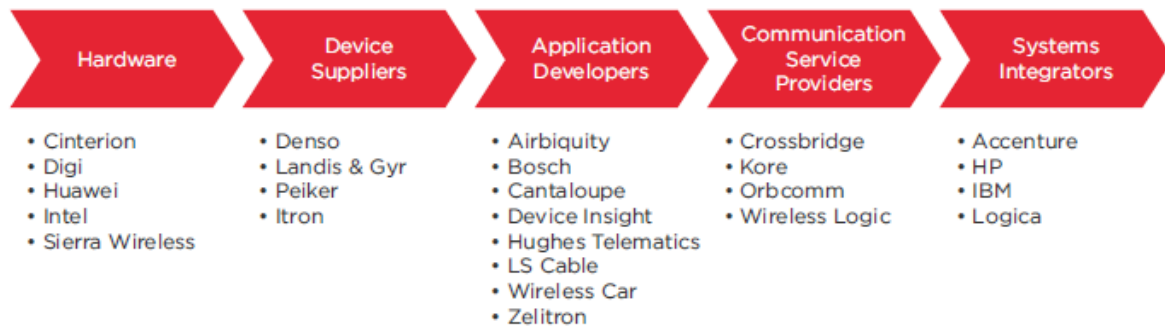

Figure 1: Typical M2M value chain

Vodafone has published its "M2M Adoption Barometer 2014" which provides a detailed insight into the changing world of M2M communications and IoT[4]. This report paints a vivid picture of the M2M market, its speed of change, and industry use of M2M.

In carrying out this research, Vodafone (in conjunction with the business-to-business market research agency Circle Research and the technology research and consulting firm Machina Research) conducted interviews with over 600 executives from companies around the world on their understanding of M2M and attitudes towards it, current use of M2M (including which applications they were using) and plans for the future.

In terms of industry usage, three sectors (automotive, energy & utilities, consumer electronics) emerged as front runners of M2M adoption, with a further four industry sectors (Retail, Transport & Logistics, Healthcare/life sciences and Manufacturing) forming their own cluster of adoption in second place. This is set out in figure 2:
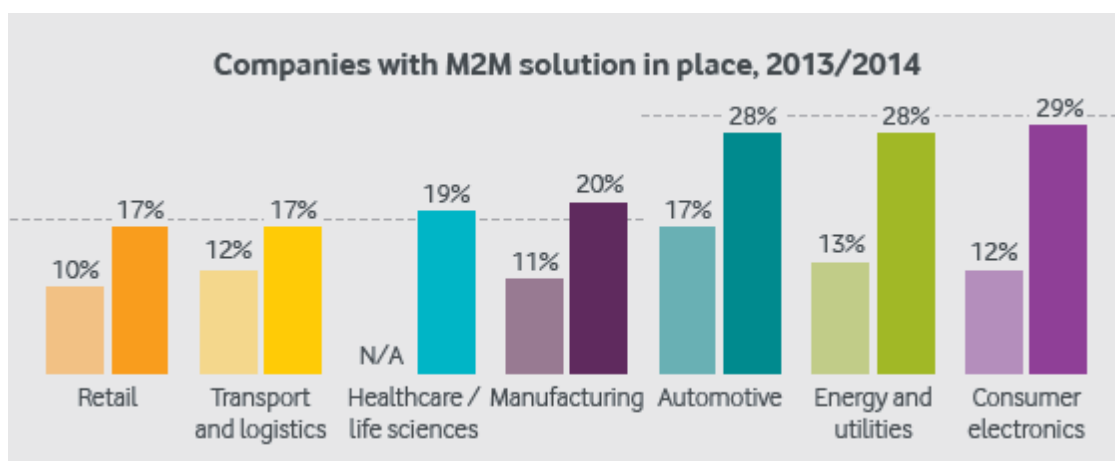

Figure 2: M2M usage by sector

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[4] "The M2M Adoption Barometer 2014"at http://m2m.vodafone.com/cs/m2m/insight_news/2014-07-02-the-m2m-adoption-barometer-2014

Vodafone set up a dedicated M2M business unit several years ago with a significant investment in technology, because M2M is different from the traditional mobile communications business. Vodafone provides M2M services via a centrally hosted, secure self-service platform – which delivers authentication and access control, and near real-time usage and management of any Global SIM, on any Vodafone and Vodafone M2M Partner mobile network anywhere in the world. It has a web 'self-service' interface that allows M2M business customers to log in and access the management information required to effectively manage their M2M enabled devices.

The SIM or communications device will be embedded in a Machine (for example, a vending machine or automobile) which will have a secure private connection with Vodafone's M2M services platform. The device will also communicate with the host mobile network, for example via SMS. The business customer (for example the owner of the vending machine or car manufacturer) will be able to access the platform to manage the SIM, including SIM activation and production of reports on performance and data usage (in the vending machine example, monitoring how quickly items are depleted from the machine so it can be restocked at appropriate time intervals; in the automobile example, monitoring performance of the vehicle).

In conclusion, there is a complex, fluid interaction between different market players in the M2M service delivery chain. The variety of market players shows that IoT is a convergent technology, both between the IT and Telecoms sector, and also across different industry segments where M2M solutions are being deployed. The IoT landscape has developed very quickly and will continue to do so, with new entrants continuing to enter the market.

This complexity inevitably presents regulatory challenges. For example, consider a scenario where an M2M provider concludes an agreement with an M2M customer based in one country, with the M2M customer installing M2M SIMs in equipment that is then shipped to numerous other countries with the SIM being used on a roaming basis. This raises issues of which regulator has oversight: it would be disproportionate for that M2M provider to be authorised as a Provider of Electronic Communication Services in each of the countries where the customer has shipped the M2M-enabled equipment – the provider may not have a presence or be engaged in any commercial activity in these other countries, yet the visited network can't be expected to be responsible for regulatory compliance either: this suggests the need for a common European regulatory approach.

3. SECURITY, RESILIENCE AND DATA PRIVACY

Security is a key consideration for businesses adopting IoT/M2M technology, which means that for many businesses M2M is not a simple 'plug and play' technology. Vodafone's 2014 M2M Barometer found that 72% of respondents said that security breaches are a major concern, but just 12% said that security was the main barrier to use. Vodafone has a team of M2M specialists who are responsible for securely integrating M2M customers onto our global M2M platform.

In relation to privacy and security, clearly there are real concerns if due consideration is not given. A failure to provide reassurance of the both the security of personal data and the limits on what it will be used for could stifle take-up of IoT technologies. Security breaches on seemingly insensitive data could have significant effects: for example data security breaches on smart remote control of domestic heating would yield valuable information to criminals of whether homes were empty at a given moment in time.

Attacks can be envisaged on various levels;

- Physical attacks (probes, open ports and interfaces, etc)

- Radio bearer (e.g. false cellular base station, malicious WiFi hotspots, and equivalents for other radio bearers; breaking weak radio crypto, like A5/1 for GSM or WEP for WiFi; fuzzing protocols, e.g. malformed SMS delivered locally)

- Network level, e.g. IP (log into admin using default username and password; scan for open ports; exploit software vulnerabilities; fuzzing protocols, e.g. IP-based or malformed SMS delivered from distance; exploit poorly designed crypto protocols, e.g. failure to check certificates; attack one device to reach others, e.g. attack home hub over WAN to reach LAN devices within the home)

Vodafone considers that regulatory focus needs to shift from 'operational' risk management to 'design' risk management. Concepts like privacy-by-design within an accountability model are essential to helping regulate this fragmented environment in a way that is adaptive and flexible, but allows innovation and development.

For high levels of assurance, a defence-in-depth strategy is likely to be best, e.g. a device/application design that assumes that an attacker can reach a device remotely, coupled with a communication system architecture that makes it hard for an attacker to reach that device remotely.

The Privacy Impact Assessment is a flexible model that can be used to complement this approach. For example, in 2012 the European Commission published a Recommendation on the roll-out of smart metering systems. This included guidelines for member states on data privacy, including a recommendation for Privacy Impact Assessments. DECC's Privacy Impact Assessment considered a number of issues such as transparency & consumer awareness - and built in requirements into operator licences & an industry code. There is no reason why we can't take such an approach for other important M2M applications.

Vodafone's views on the application of privacy by design principles apply equally to security of critical IoT supported infrastructures. We strongly support its use in this context. In relation to whether we need policy maker guidance on 'security by design' and applicable security

technologies, Vodafone believes that we need policy makers to focus on principles, and leave implementation to the industry. The key will be forming effective multi-stakeholder processes for helping industries create interoperable infrastructures that address security risks, within a framework that holds actors to account for their role. In practice this will involve close working between industry and government.

4. <u>NETWORK-RELATED ISSUES</u>

As already identified by Ofcom[5], the diversity of IoT applications drives very different physical layer access requirements and solutions, which in turn drives spectrum requirements (see Section 5).

Many IoT applications are well served by short-range technologies such as Bluetooth, WiFi, or Zigbee enabling connectivity between a sensor and an aggregation point such as a smart-phone or residential gateway.

On the other hand, industrial devices, closely associated with the term 'M2M', require bi-directional point-to-point communications, wide-area coverage and are mostly served by cellular.

There is an emerging class of battery-powered applications which are associated with near ubiquitous wide-area coverage and are less well served by existing cellular solutions. Analysts predict that technologies that are developed to address this market could increase the global M2M/IoT market by billions of connections. Such applications tend to be characterised by low-throughput, delay-tolerant, and being event-driven; for example, a sensor in a water-meter monitoring water-flow and usage, or a sensor in a smoke-alarm that monitors the battery status of the device and reports back to a Home-Insurer to improve safety in the house. These technologies are often referred to as Low-Power Wide-Area (LPWA) networks.

In order to address this new class of applications, cellular technologies require further evolution; otherwise it is inevitable that a new physical layer optimised for such applications will be introduced. Although efficient for each application in isolation, this would be inefficient overall.

5. <u>NET-NEUTRALITY</u>

Certain customers may have a requirement for traffic management, now or in the future. One such example would be a customer requirement for prioritisation of traffic for critical points in a smart grid in case of congestion. Future applications which may require service prioritisation could include drone technology or self-driving cars.

It is critically important that innovative M2M services are not caught by the 'unintended consequences' of net neutrality regulation preventing communication service providers from offering prioritised carriage of traffic. Were this to occur, at best it would mean that inefficient

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[5] Section 1.13 of the consultation

dedicated networks would be deployed, and in reality some applications would simply be stifled and not come to fruition.

6. SPECTRUM REQUIREMENTS

DIVERSITY OF APPLICATION

Vodafone broadly agrees that the proposed framework[6] is a correct way to interpret the spectrum requirements against different application and network demands.

We recognise that applications with a low-power, short-range characteristic are well matched to using shared spectrum model using the bands 870MHz, 2.4GHz and 5GHz; however we do not foresee usage for such applications being sufficient to justify an increased requirement on spectrum in these unlicensed bands.

For M2M applications using mobile networks, the capacity of existing cellular systems is such that the current and predicted M2M traffic will remain a relatively small proportion of total network traffic demand and therefore in itself will not drive increasing spectrum requirements.

INNOVATIVE USE OF SPECTRUM

Vodafone agrees with Ofcom's spectrum management strategy[7] that "*enabling growth and innovation in the M2M/IoT"* should be a key priority, and the recently released spectrum allocations at 870MHz and 915MHz will greatly support innovation of new services for generic Short Range Devices, Smart-Meters, and Metropolitan Mesh Machine Networks.

Further innovation can be enabled through the repurposing of existing spectrum allocations. This may be appropriate where greater value can be demonstrated with the emergence of new business applications aligned with technology developments. Addressing the requirement of a LPWA network is one such example.

The success, or otherwise, of an LPWA network will depend on spectrum access, a fit-for-purpose technology, and availability to nationwide infrastructure. In order to reduce cost and environmental impact, it is desirable to reuse existing networks and infrastructure as far as possible. This re-use of existing infrastructure becomes especially important when considering that the revenue per connected device may be two or three orders of magnitude less than that of consumer broadband; this has a consequential impact on spectrum. The desirable characteristics of spectrum for LPWA include:

- Alignment with existing cellular spectrum bands, or adjacent to future allocations, in order for systems to reuse radio infrastructure such as antennas and power amplifiers.

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[6] Figure 1 in the consultation document
[7] Ofcom Spectrum Management Strategy,
http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-management-strategy/statement/statement.pdf

- Frequency division duplex operation when used in bands adjacent to cellular system to avoid inter-system, adjacent channel, interference.

- Unconstrained duty-cycle to enable M2M/IoT modules to receive occasional, but large, downloads associated with firmware updates.

- Effective radiated power at the base station comparable to existing cellular systems to enable capacity, and coverage, to be served optimally.

- Availability of licensed spectrum to enable service providers to assure Quality of Service through interference management and capacity dimensioning.

- Availability of spectrum in the sub GHz band to maximise the geographic reach of the network including hard-to-reach rural areas, and deep indoors.

The spectrum bandwidth requirements to support a LPWA network are anticipated to be modest. For event driven sensors and devices, with occasional messages of length of approximately 20 bytes, then many thousands of devices can be supported in a limited bandwidth (for example a 2x180kHz sub-carrier in LTE, or a 2x200kHz GSM channel) in the area of a single cellular site. Scaled nationwide, and across multiple service providers, then several hundred million devices can be served.

EVOLUTION OF CELLULAR TECHNOLOGIES

In Section 11 we set out the key standards evolution to serve M2M/IoT. From this analysis, it can be noted that the GERAN Rel13 work-item is the only activity that will have a spectrum impact. Spectrum for this service could be made available through repurposing existing GSM allocations, or making available new bands such as the 2x3MHz proposal as part of the duplex gap for future allocation of mobile broadband at 700MHz. Vodafone notes that a proposal related to a clean-slate approach[8] may be able to be allocated in small allocations of spectrum, and therefore multiple licences could be awarded in an allocation of 2x3MHz.

CHALLENGES WITH SHARING SPECTRUM

Vodafone believes that shared spectrum delivers maximal value when used in short-range deployment; this ensures that spectrum can be utilised by many applications and reused in an efficient manner.

However Vodafone notes that spectrum which was originally allocated for short-range-devices (SRD), such as the 868MHz band, is now being used for wide-area networks; a purpose which CEPT did not envisage when the band was initially identified. The level of interference that these networks will generate to other users sharing the spectrum is therefore unknown, and should multiple wide-area networks emerge using the same shared spectrum then the performance will inevitably degrade.

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[8] Neul, Huawei, "Introduction to 'Clean-Slate' Cellular IoT Radio Access Solution"
 http://www.cambridgewireless.co.uk/docs/Clean-slate%20Cellular%20IoT%20radio%20access%20solution.pdf

Whilst the recently released shared spectrum allocations at 870MHz and 915MHz provides new opportunities for emerging IoT services to be provided, care is needed when considering this spectrum for wide area access for the following reasons:

- Any system using shared spectrum requires methods to maintain equitable access to spectrum; duty-cycles (or interference avoidance techniques) are therefore essential but this constrains the activity of a single device - this is particularly problematic for a network which is serving a very large number of devices for wide-area connectivity.

- Shared spectrum allocations require power to be constrained to limit over-spill into non-primary areas. This constrains the number of simultaneous users that can be served, introducing capacity constraints on the downlink when used for wide-area connectivity.

- The allocated 870MHz spectrum band is adjacent to the cellular (base station receive) band, and for bi-directional communications would require the use of time-division-duplex. This adjacency may generate interference into cellular equipment when deployed in close proximity (for example, on the same site) and restrict the ability to share infrastructure.

- Future occupancy of a shared band is unknown, therefore it is impossible to predict interference or provide assurances on quality of service. The applications that can be served are therefore limited to non-critical and best-effort.

For these reasons Vodafone believes that most wide-area M2M/IoT networks will be deployed using spectrum awarded in a licenced regime. The most problematic part of the proposed framework remains the positioning of a dedicated wide area IoT network in shared spectrum. A new dedicated band, such as the proposed 700MHz allocation, provides the opportunity to resolve this anomaly.

Existing bands should also be able to be repurposed to reflect developments within 3GPP standards (GERAN and RAN) such as new modulation schemes, if/when agreed within those organisations.

7. <u>NUMBERING AND ADDRESSING</u>

Vodafone believes that there will be many billions of IoT devices, so scalability is a consideration for addressing. Depending upon the individual application, it may be necessary to use E.164 numbers, E.212 IMSIs, IP addresses, private addressing schemes (which may or may not be based upon the format of the standardised identifiers) or a combination of these.

LEGACY NUMBERING

In general, Vodafone considers data-centric identifiers will dominate, in line with the IoT being a data-centric activity. However there will be consumption of other numbering/address types, for example SIM cards being embedded in machines using an E.164 and E.212 identifier. It should

be noted that where such resources are used, they may not consume national resources: Vodafone has typically used globally-allocated E.164/E.212 resources from ranges assigned directly by ITU, so placed no demand on the UK allocations; this approach should be welcomed by Ofcom.

We note that in some countries, dedicated resources (both E.164 and E.212) have been set aside for M2M applications. However, such an approach does not well-align with the business models set out in Section Two of this response. For example, where a Chinese manufacturer is deploying communications modules in their equipment, it would overly complicate things to have separate national resources used for each of the countries in which the equipment will be sold. Even where the SIM is configured remotely once ready for use, national resources would complicate this process versus using a single global pool of resources. It is for this reason that we expect the predominate model to be one of global resource usage.

When coupled with an evolution to approaches which don't consume E.164/E.212 resources, it is Vodafone's view that allocation of specific national resources for M2M applications is unlikely to be necessary, but it would be prudent of Ofcom to monitor the situation via its business-as-usual allocation processes and annual infrastructure report.

Where E.164 numbers are used, Vodafone considers that Ofcom should be proportionate in enforcing regulation. For example Vodafone does, of course, support the ability of customers to change communications provider and the concept of number portability. However, it can make little sense to impose support of number portability for numbering resources which are associated with SIMs embedded in machines where the end-user is unaware of the existence of the number.

DATA ADDRESSING
There will be many billions of IoT devices but not all will require the capability of being addressable over the global public internet, specifically for the reason that a proportion of these devices will be low cost, low power devices. Some of these devices will be connected by local gateways (e.g. Zigbee type devices) and some will be connected over WAN (e.g. Cellular IoT). By their nature, these latter devices will not be 'always on' since they operate on batteries and must remain dormant for a large proportion of their lifetime to conserve energy. These devices will be isolated from direct real-time interaction with end users in order to optimise their usage of battery power. These devices will exist within the operator's domain (private network) and end users will most likely communicate with a service level proxy, operated by the M2M service provider, when querying or controlling these devices. Consequently there is a reduced requirement for unique, globally routed IP addresses here.

Vodafone considers that the reasons for deploying IPv6 extend beyond address scalability. IoT devices hosted within the operator's WAN will require management in large volumes (i.e. device

management functionality), and in order to ensure that devices are manageable efficiently the networks will need to have efficient multicast capability, which is not available using legacy IPv4 or its associated protocols/extensions.

Vodafone's networks are IPv6-ready. Migration to IPv6 will occur, as and when it is demanded by customers. There is thus little need for regulatory intervention as the market will drive adoption.

8. DEVICES

Vodafone recognises that the availability of low-price M2M/IoT devices is critical to the growth of the market.

Many factors contribute to the cost of an M2M/IoT module and include the baseband processor and memory; RF components; packaging; testing; and royalty payments. Devices may also require to be designed for physical and environmental protection and greater EMF shielding depending on where the device will be placed. The final pricing is also heavily influenced by volumes and forecasted growth.

Ericsson's analysis[9] indicates that globally 60% of all M2M devices are GSM/GPRS with 4% using GSM/EDGE; this supports the view that many applications are well served by modest data rates, and are sensitive to module pricing. However the pricing differential between 2G and the 3G/4G technologies remains significant; relative to GSM/GPRS there is at least a doubling in prices for 3G devices, and a tripling in prices for 4G devices[10].

This price differential introduces significant challenges to the industry as to how to migrate future M2M/IoT to the more spectrally efficient technologies supported by 3G/4G.

The challenge in pricing arises, at least partially, because M2M modules contain chipsets which have been developed for the primary market, which is mobile broadband. In most cases, these chipsets offer a level of performance that exceeds the requirements for many IoT applications; however the upfront costs associated with silicon design have deterred M2M device manufactures from investing in the research and design to develop 3G/4G chipsets that are specific for M2M/IoT. Devices also tend to be developed for global markets, meaning that for inclusion of 4G (LTE), up to 42 frequency bands require to be considered, further adding complexity and cost.

In recognition of this challenge, Vodafone has been at the forefront of industry activities, leading the RAN1 work-item on lower complexity devices for Machine Type Communications (MTC)

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[9] Ericsson, "Ericsson Mobility Report." http://www.ericsson.com/res/docs/2014/ericsson-mobility-report-june-2014.pdf

[10] Machina, "Global M2M Modules Report: Advancing LTE Migration Heralds Massive Change in Global M2M Modules Market." https://machinaresearch.com/strategy-report-global-m2m-modules-report-advancing-lte-migration-heralds-massive-change-in-global-m2m-modules-market/

which will result in a new LTE Category 0 device that will enable future MTC devices to be manufactured at less cost. Vodafone currently leads an activity in GERAN which enables both non-legacy (clean-slate) and GSM evolutionary solutions to be evolved towards ultra-low complexity and low-power devices; if successful this solution could lead to an optimised technology appropriate for future LPWA networks.

9. DIGITAL LITERACY

IoT poses both an opportunity and risk to consumers in terms of digital literacy. "Mobile, A powerful tool for Digital Inclusion"[11] a Vodafone sponsored report by Communication Chambers in 2013 found that some 7 million adults or 13% of the UK were not online. The report found that the over 65s, those with disabilities and those on lower incomes were key constituents in these figures. It also found that those not online cited a lack of need to do so, implying a demand-side issue rather than a supply-side lack of availability.

The IoT offers the opportunity for new services and devices to be brought to market which are attractive to consumers and will potentially counter any demand side reluctance in uptake. However, in order to achieve the Government's Digital Inclusion aims, it is vital that a consumer driven demand is also accessible to those very groups which make up the digitally excluded. There is also a danger that if inadequately considered security policies lead to breaches in information privacy, the digitally excluded may be further discouraged from taking the leap to the digital economy.

10. DATA ANALYSIS AND EXPLOITATION

With the emergence of the Big Data Society, organisations are under increasing pressure to utilise data assets for both commercial and socioeconomic applications.

Mobile operators are uniquely positioned to combine a validated identity (the SIM) with passive data analysis from network management and transport layers. This capability can be used to provide high accuracy identity management, geo fencing and central control for permission management on a global scale.

Usage Based Insurance (UBI), Energy Management, Connected Cabinet, Connected Car, and Connected Building are all examples of existing Vodafone IoT/M2M solutions where data analysis forms the nervous system of the solution. Vodafone is rapidly becoming a data-centric organisation and can appreciate how 'mobile data analysis' has the potential to solve some of the world's greatest social and economic challenges.

As IoT develops into a critical infrastructure component, data protection and data sharing controls will become mission critical. Vodafone has made significant investments in technology

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[11]"Mobile, A powerful tool for Digital Inclusion",
http://www.vodafone.co.uk/cs/groups/configfiles/documents/assets/vftst050334.pdf

and process to manage data privacy and security to mitigate against threat and exploitation. As described in Section Three, 'Privacy and permission by design' is essential to ensure IoT data can be shared and protected in line with evolving Data Privacy Regulation and Vodafone's own Permission Management strategy.

The overwhelming majority of IoT applications will create and consume a variety of data. As people and infrastructure come together to form more complex economic and social constructs, new services will emerge that capitalise on an understanding of these relationships. Innovation in data science and data processing will flourish as service providers seek to augment a myriad of data sources to create supplementary data points for machines and people to interact in beneficial and productive ways.

Standardisation and interoperability will be essential in unlocking the full market potential for IoT and citizen data as an economic force for good and significant contributor to the global productivity engine. As described in Section 11, Vodafone will continue to work with international standardisation bodies, partners, and public authorities to define industry standards and best practice for data interoperability.

11. <u>INTERNATIONAL DEVELOPMENTS</u>

OPEN VERSUS PROPRIETARY STANDARDS
As with any communication network, interoperability between elements of an IoT network is particularly important for a successful deployment of the technology, with standards playing an important role. Standards work on a basic principle – a company that invests in and contributes significant technology to their development is entitled to appropriate compensation in the form of an IPR licence fee. Standardisation and the associated IPR frameworks established within traditional ICT industries – most notably the mobile telecommunications eco-system – has been a major contributor to rapid deployment and technical evolution. However, the existing IPR licensing models may not be as practical for IoT when considering the relatively low value of IoT devices and the much higher deployment rates of such devices. International collaboration between regulatory bodies, institutions and industry is essential to ensure that an efficient framework for interoperability and IPR is established that reflects the need for low value devices at large scale deployment, whilst balancing the need for adequate compensation to those players investing in innovation and contributing key technology. It is also necessary to analyse the international aspect of standardisation and the global nature of IoT to avoid duplication of technology, territorial variances in technology and territorially discriminating operation and deployment costs.

It is equally important to recognise that companies need to compete on the IoT marketplace through technical and commercial differentiation, in particular when it comes to managing large numbers of connections (in the order of billions) and providing over-the-top services. This

differentiation is often achieved through proprietary solutions which, although "closed" to other companies, communicate with other proprietary solutions thanks to the interoperability mentioned above. Thus, care must be taken that nothing is done to deter companies from differentiating their offers on the marketplace through investment in innovation and development of proprietary solutions.

EVOLUTION OF CELLULAR STANDARDS

The choice of cellular technology for M2M/IoT (i.e. 2G, 3G or 4G), is driven by the data throughput, latency requirements, power consumption and affordability. Where data rates are modest, and devices are cost-sensitive, then 2G technologies including GPRS/EDGE are sufficient for most requirements, but the higher capability of the 3G/4G mobile broadband networks ensures that operators can also serve the high-end requirements.

Broadband technologies such as 3G and 4G continue to evolve, with recent focus in standards the emergence of lower-complexity devises which should lead to a reduced cost of implementation of the communication module – an essential pre-requisite for the migration of many M2M services to 3G/4G.

It is likely that new IoT applications will drive further requirements as 5G technology visions mature – indeed IoT is a key driver of such technology - but for now these remain largely speculative and are unable to be used to drive the spectrum framework.

For GSM and LTE, the requirements associated with a LPWA type network, are being addressed in both the GSM standards body (3GPP GERAN) and LTE standards (3GPP RAN). A summary of recent developments, key characteristics, and consequences on spectrum are described in the following table.

3GPP technical body and release	Work-Item Description	Key Technology Components	Spectrum Implications
GERAN Rel13	Cellular System Support for Ultra Low Complexity and Low Throughput Internet of Things	(1) Non-legacy based design; and/or (2) Backward compatible evolution of GSM/EDGE	Possible introduction of new/modified channel modulation requiring amendment to IR2014 (for both non-legacy and backward compatible solutions). Note 1.
RAN1 Rel12	Low cost Machine Type Communications (MTC) UE for LTE	De-feature some aspects of LTE and reduce peak-data rate for a new category of device (Cat-0)	None.
RAN1 Rel13	Further LTE Physical Layer Enhancements for MTC	De-feature further aspects of LTE including reduced UE bandwidth to 1.4MHz	None.

12. OFCOM'S ROLE

OFCOM'S ROLE AS A REGULATOR

Regulatory intervention in IoT should be on the basis of demonstrable customer benefit and a clear cost-benefit analysis. Vodafone does not at this stage consider that any new regulation is required, but we do acknowledge that there are challenges around which national regulator should have competence where a service is sold on a global basis and uses non-national resources.

Where regulation already exists, Ofcom should take a proportionate approach to enforcement. For example:

- Regulators should be cognisant that the significant cost of implementing widespread M2M applications – for all stakeholders in the value chain – means that short contract durations may be inappropriate. Certain M2M applications, for example those in the utilities or energy sector, may be characterised by longer contract durations. For example, the contract awarded by DECC for smart metering was for some 15 years. This reinforces a point that has recently been made by the International Telecommunications User Group ('INTUG')[12] regarding the requirements of the business sector more generally:

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[12] INTUG Position, "The economic and social benefits of providing business users with a single market for telecommunications", Sept 2013, at http://intug.org/main/wp-content/uploads/2013/01/Economic-and-Social-Benefits-of-Providing-Business-Users-with-a-Single-Market-for-Telecommunications.pdf

> *"at times the needs of businesses and consumers are completely opposite: e.g., consumers generally prefer shorter contract periods while businesses prefer longer agreements. Yet, the regulatory environment does not seem to acknowledge the serious differences".*

• As highlighted in our comments on E.164 usage, where such telephone numbers are used but not in a manner that's visible to end-users, it makes little sense to mandate that they be portable between operators.

• For some M2M applications, international roaming will be inherent and will be factored into the design. However, where an application is static in nature and deployed to UK addresses, it makes no sense to incorporate the complexity and cost of supporting roaming. Even where roaming is a feature, it may make little sense to impose the full scope of roaming regulation: for example in an automotive application, while it may be appropriate for the capability to work when the vehicle is used internationally, it could be less sensible to insist on the capability to choose which communications provider facilitates this roaming and for the commercial arrangements for this roaming to be regulated, especially in a B2B relationship.

OFCOM'S ROLE AS A RESOURCE MANAGER

In addition to its role as an economic regulator, Ofcom acts as resource manager for radio spectrum and numbers (E.164 and E.212).

In the Spectrum section of this response, Vodafone has highlighted that it may be necessary for Ofcom to vary the conditions on existing licences as international standards agencies update technology to better support the IoT. Further, there may be scope for IoT-specific spectrum in the centre gap of the 700MHz band: Ofcom should lead analysis of whether this is appropriate.

As highlighted in the Numbering/Addressing section of this response, there is usage of E.164 and E.212, but Vodafone does not consider that this is sufficient to give rise to concerns around exhaust. Ofcom should of course monitor the situation on an ongoing basis, but there is unlikely to be a need for specific M2M/IoT ranges.

Vodafone UK
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