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Challenges of IoT deployment in the context of developing countries

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Abstract. The concept of the Internet of Things (IoT) is not exactly a novelty, even if it has not burst out yet with all the force that the market expected. The 5th generation of mobile telephony (5G) is rushing to deploy in the midst of a real trade war, and intends to get one's own way on this and others fronts. This paper analyses how to overcome the challenges of an IoT deployment, which can be too complex to fulfil its promise of massification and ubiquity. This analysis is primarily intended to identify whether 5G will be the key to a current IoT deployment in all contexts, or whether it is wise to pursue other development paths first.

Keywords: 5G, IoT, Road to Development

Introduction

Although all the current development of communication technologies has been oriented mainly to communication between people, new trends are encouraging machines and devices to connect massively, giving rise to Internet of Things (IoT). The IoT represents an ecosystem that is expected to be made up of 100 billion devices by 2025: sensors, alarms, wearables, mobile phones, household appliances, code readers, etc. According to Huawei's estimations, on this date only 10% of the total connections will be between humans; the rest will be between devices in autonomous way.

Technologically speaking, when dealing with the IoT there are three layers or levels. The first corresponds to devices, sensors and actuators whose main function is to capture different variables such as temperature or light, which are converted into electrical impulses (data). The second level is the "IoT gateway" or gateway, which includes the hardware and software components that serve as a connection point between the cloud and the controllers, sensors and intelligent devices. This level

configure the architecture required for data processing. Finally, the third layer of the IoT platform is where business, consumer applications and services are located [1].
The International Telecommunication Union (ITU) has created the overall roadmap for the development of 5G mobile technology and has defined the term "IMT-2020" to designate it. Following the completion of its work on the 5G "Vision" at the ITU Radiocommunication Section (ITU-R) 5D Working Party meeting in San Diego, California, the ITU defined the overall objectives, process and time frame for the development of 5G mobile systems [2].
To fulfil its promise of massification and ubiquity, IoT requires an infrastructure deployment that industry has been unable to supply, and 5G promises to deliver. This paper attempts to analyze whether 5G will be the key to a current IO deployment in all contexts, or whether it is wise to pursue other development paths first.

5G for IoT

One of the strongest reasons to think about revolutionizing mobile telecommunications is the IoT. The 5G is intended for this purpose, and its architecture has been redesigned by up to 36% to support the news requirements [3]
In the words of Asha Keddy, general manager of mobile standards for advance tech at Intel, "we'll see computing capabilities getting fused with communications everywhere, so trillions of things like wearable devices don't have to worry about computing power because network can do any processing needed" [4].
The IHS Markit consulting firm has conducted a forecasting exercise through 2035 based on knowledge of the impact of previous generations of wireless technologies and forecasts of the enormous opportunities. One of their conclusion was that "5G value chain will generate a return of $3.5 trillion and 22 million jobs. This figure is larger than the value of today's entire mobile value chain" [5].
The basic performance criteria for 5G systems have been established by the ITU in its Recommendation IMT-2020. ITU-R M.2083 describes three general usage scenarios for 5G systems [6]:

- Enhanced Mobile Broadband, to cope with vastly increased data volumes, global data capacity and user density
- Massive machine type communications. This use case is characterized by a very large number of connected devices typically transmitting a relatively low volume of non-delay sensitive data. Devices are required to be low cost, and have a very long battery life
- Ultra-reliable and low latency communications to support mission-critical and safety-critical applications

At this definition stage, one might ask whether the work teams will make the standardization and regulatory decisions that make it feasible to meet these expectations.
Figure 1 shows the increase in 5G network capabilities with respect to LTE-Advanced, technology for 4G by the 3GPP group.

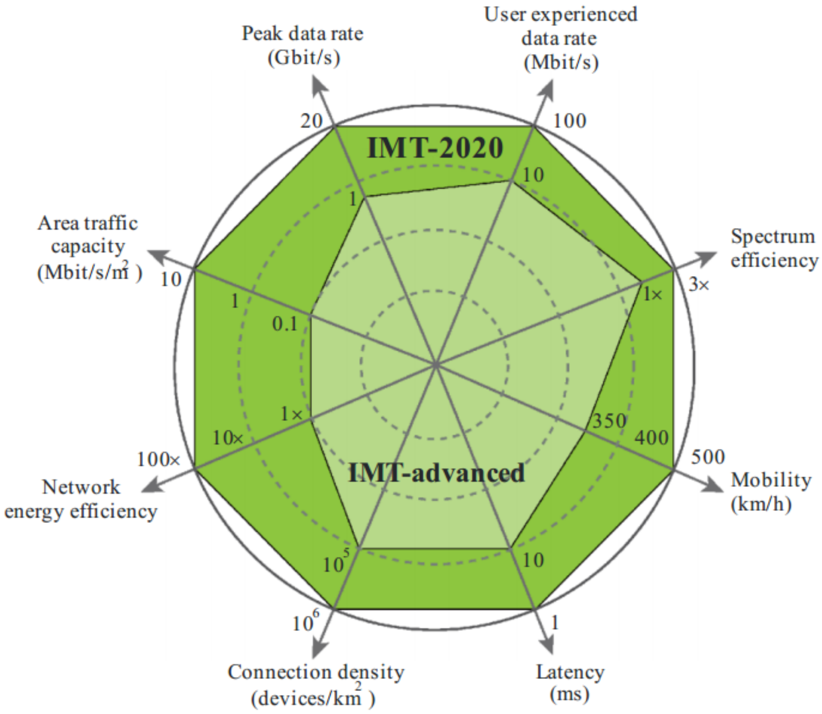

Figure 1. Enhancement of key capabilities from IMT-Advanced to IMT-2020 [6].

The 5G still has several major challenges to overcome that may slow down its massive deployment. The most illustrative are:

- **The radio spectrum:** This is probably the most important technological challenge facing 5G communications [7]. Brett Tarnutzer, director of the Spectrum GSMA, says "Operators urgently need more spectrum to deliver the endless array of services that 5G will enable (...) Without strong government support to allocate sufficient spectrum to next generation mobile services, it will be impossible to achieve the global scale that will make 5G affordable and accessible for everyone [7]. According with this goal, the GSMA has published the 5G Spectrum GSMA Public Policy Position [8].

  In order to support all expected performance, the ITU proposes to use the frequency bands above 24 GHz [8]. This means that operators will need to deploy thousands (or perhaps millions) of small cells throughout the territory: on streetlights and urban layouts, on the facades of buildings, and even inside individual homes, a deployment process that will be slow and require multi-million dollar investments.
- **Security issue:** More data means more challenges. Let's add that the 5G is the first generation of mobile networks designed for M2M machine-to-machine communication. The biggest security challenge posed by 5G networks is privacy. 5G networks will enable new types of applications and allow us to connect more

devices to the network (and each other), encouraging us to capture and share more and more of our personal data. Some of which may never have been captured digitally before. In this regard, the 5G Americas group makes an analysis of the emerging threats facing 5G and the different mitigation mechanisms [9]. Threats that are not exactly new, but of a greater scope, so potentially more invasive and with catastrophic effects.
- **Money Matters:** All the promises of 5G will not exactly be painless for mobile ISPs. The 5G requires that the deployment of the networks responds to the ambition of those who have designed the new technology, multiplying several times the number of antennas and modifying their topology. The key is that, with 5G, ISP networks can be used for functions that are now impossible, significantly extending their range of use and therefore also increasing, at least theoretically, revenue. However, the high cost of deploying these new networks in all their magnitude is a great challenge especially for telecommunication operators who have to bear it, especially when the differential economic return, although intuited, isn't yet evident.

IoT Deployments for Developing Countries

5G promises many technological advances and a great economic boost; but without a clear business model for all, and a prohibitive deployment cost for many economies. Maybe this new revolution in the field of mobile technology will have to wait for better times.
The biggest impact expected for 5G is on services and manufacturing. 5G's main customers are machines and objects, so in economies with weak and obsolete industry, based on infrastructures with very poor or no automation, you will have very few customers to help you with ROI (Return on Investment). In the end, the funds for deployment will be taken from the development of other sectors that also need it, sectors whose activity will be reversed in development in a faster and more objective way.
So, if it is not wise to think about the deployment of 5G for now, it could be thought, do we have to postpone the IoT as well? Of course not.
Although the 5G's sellers show it as the key piece for the massive deployment of the IoT, this concept has its own live, and has been born from several previous technologies and paradigms, so there are always excellent options.
LPWAN
LPWA (Low Power Wide Area) or LPWAN (Low Power Wide Area Network) for many authors. These terms do not denote any particular technology, but can be use as generic term to refer to any network designed perfom a low-power wireless communication with other networks, such as telephony, satellite communications or WiFi networks.
There are several technologies based on open or proprietary standards, such as LoRaWAN, Telensa, Sigfox, Igenu Networksentre's Random Phase Multiple Access (RPMA) and others. In a general sense LPWANs provide long range, promising

coverage up to 15 Km in open environments and up to 2 Km in urban environments. They are designed to give access to a potentially high number of devices that have to transmit small amounts of data (few bytes) sporadically (e.g. every few minutes), mostly to the server.
LPWA networks are used almost exclusively in the field of IoT devices and M2M communications. Its applications are in remote meter reading, public lighting control, theft alarms or control systems in infrastructure, crop irrigation system, unattended weather stations, animal control, and many others.
Another great advantage of these technologies is the use of unlicensed spectrum, although it is not in the classic 2.4GHz and 5GHz. The chips typically offer channels in the 867 and 869 MHz bands (Europe), 902 and 928 MHz (America and Asia). The regulations on this subject should be reviewed for non-invasive use of licensed frequencies.

NB-IoT

Taking care your own network infrastructure, especially when there are nodes in the field, can be quite problematic for companies that don't want to have too large an IT structure. It would be desirable if our mobile provider have solutions that do not include the trauma of paying for a SIM card for hundreds of devices. The solution has been NarrowBand - Internet of Things or NB-IoT for short.
The GSMA's initiative, NB-IoT uses the mobile phone bands and is designed to operate in several ways, including the use of the GSM band replacing the current deployment (standalone). Also uses the LTE band and therefore sharing it (in-band), or even using the spacing between LTE channels to maximize the communications spectrum (guard-band).
NB-IoT is a half-duplex technology that enables efficient uplink communication, that is, it allows the establishment of connection to the cellular network, the allocation of network resources to the node (known as User Equipment or UE) and the transmission of data (MT Data). In the most typically application, an UE will remain disconnected from the network and, when it has data to transmit, e.g. a meter reading, it will establish the connection, transmit the data and disconnect as soon as it receives confirmation of delivery [10].
NB-IoT is reliable because it guarantees the data delivery. This is significant if is compare with other LPWAN technologies based on an ALOHA access. Also, the use of a licensed band makes it more reliable due it does not coexist with other technologies. However, using a licensed band has implications such as being dependent on an operator and therefore subject to a service and coverage model beyond control of the application. E. g. if LoRaWAN used, and there is little coverage, an extra Gateway can always be deployed; but with NB-IoT, all is on the operator's hands.

LLNs

Like LPWA, LLNs (Low-power Lossy Network) is a set of technologies that include devices with very limited resources, both energy, computing performance and embedded memory. The main different with LPWA is the coverage area, just a few meters (around 200 m). This networks are formed in multi-hop meshes to connect to

the Internet. This idea follows the principle that multiple short jumps within a mesh are much more energy efficient than a single jump to a sink (gateway).
As in engineering, what is usually earned in one hand is sacrificed in the other. In an LLN, finding neighbors and then having them find a route to the gateway is not exactly a simple task. In LLNs, nodes (known as motes) must enter their work area, recognize their neighbors, and collaboratively find their way to the sink.
IEEE 802.15.4 is the standard for Low-Rate Wireless Personal Area Networks or simply Low-Rate Wireless Networks from 2015. The reduction of the acronym is due to the fact that its uses, potentialities and expectations began to go beyond the personal area to endorse the IoT's lines.
An important step towards the robustness of these networks was the 802.15.4e amendment [11] which specifies the TSCH (TimeSlotted Channel Hopping) mechanism within the multi-channel mechanism to mitigate the effects of multi-path fading and interference generated by different commercial devices.

Conclusions

For the first time, objects are the primary customer of a commercial telecommunications network. This is undoubtedly the most revolutionary contribution of the 5G, which expects to deploy the massive IoT and applications with critical performance and delay requirements. Its gradual implementation of 5G will have an economic impact on all industrial sectors.
However, it should be keep in mind that any forecast will depend on the implementation timetable, national regulations and the possibility of consolidating the new business models. For now, its cost and deployment challenges are not justified in economies with a underdeveloped infrastructure that will presumably not exploit the capabilities and benefits of this new generation of mobile telephony.
But the IoT is not intrinsically linked to 5G. There are several solutions that can be deployed by both public operators and other companies that wish to expand their service portfolio using a more competitive model.

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