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EMERGING TECHNOLOGIES: 5G AND IOT

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Abstract. The fifth generation mobile network 5G is a set of emerging global telecommunications standards, generally using high-frequency spectrum, to offer network connectivity with reduced latency and greater speed and capacity relative to its predecessors. One example is emerging autonomous cars and intelligent transportation, to which small latency is essential. Imagine a world where cars will be able to communicate with passengers, surrounding pedestrians, other vehicles, bicycles, traffic lights, parking meters and other urban infrastructure. To meet 5G requirements, we need dramatically new network architectures and technologies, such as heterogeneous ultra-dense networks, massive multiple-input-multiple-output (MIMO), and millimeter wave communications.

Key words: *Enormous amounts of data, security, mobile broadband, fiber optic cables, higher transmission rates, IoT.*

Introduction

The "old" infrastructure of satellite and cable operators will continue to play a role in the future. Strictly speaking, they even bring advantages that will prove usefulness in the further development of 5G.

It is clear that there is no single perfect method to create a cost-effective infrastructure. For example, a satellite or wireless infrastructure in a mountain village may be the best option, while in a densely populated urban area fiber optic offers the greater benefits. It all depends on the environment.

Combinations of technologies, including cable and satellite, will therefore continue for some time. Implementing a technology suite that includes legacy networks can already provide services up to one gigabyte per second. This will improve with further development in the coming months and years.

As efficient providers of broadcasting services, cable network and satellite operators are thus in a strong position. Video content is a prime example. Far from giving in to competition from over-the-top providers, operators predict that the satellite will remain a dominant platform for video content well into the next decade due to three advantages: Cost efficiency, universal reach and quality of service.

According to recent research by European satellite operator Eutelsat, the satellite market is growing steadily in developed countries, while growth is accelerating in most emerging markets. He also predicts that the satellite market share of TV households will increase by two percentage points to 26 percent by 2030.

Accordingly, 5G is not seen as a threat. The satellite is and will be a good solution for backhauling in areas where the cost of terrestrial data transport - fibre or microwave - is too high, Of course, there are inherent blind spots in satellite technology. In particular, there is the lack of a return channel, which requires providers to offer hybrid satellite and Internet distribution networks. Ultimately, cable and satellite operators do not have to fear 5G. On the contrary, they are in an excellent position and are expected to become important players in the 5G ecosystem.

The rivalry between the USA and China does not stop before the introduction of the new mobile radio standard. The Americans cover up the Chinese network supplier Huawei with different accusations. They are also trying to convince their allies to keep their hands off Huawei technology.

Many decision-makers are cautious about 5G technology; the main reasons are high upfront investments, safety concerns and a shortage of skilled workers. This is the result of a global study among 1800 managing directors and IT decision-makers from medium-sized and large companies, which *Accenture* has presented at *MWC* 2019. According to the study, decision-makers underestimate the disruptive potential of 5G-technology, which will result from the increase in network speed and capacity, and leave potential for their own business development untapped. Only 37 percent of decision-makers expect 5G to revolutionize the speed and capacity of network solutions. More than 53 percent currently see very few new deployment scenarios that 5G will enable compared to 4G- technology. Six out of ten executives surveyed believe that 5G will cover almost the entire population by 2022.

5G future looks for mobile operators

As mobile broadband and IoT traffic in mobile networks grows exponentially, the demands for latency, throughput, reliability and security grow dramatically and will require more than a simple network upgrade or expansion. The enormous increases in capacity, performance and speed that mobile networks must achieve must therefore be supported by an efficient fixed network infrastructure. Mobile operators must realise that convergence between 5G fixed and mobile networks will be the key to the full realisation of 5G.

For example, they will need to install millions of small mobile cells in the coming years to compress the network and ensure that they can meet growing capacity needs. The higher frequencies that 5G uses have a lower range than the lower frequencies used today, and are also less able to penetrate physical barriers such as walls or trees. It is therefore clear that in the future cells will be required that cover smaller areas and serve fewer people - albeit at much higher speeds.

Challenges and opportunities, however, balance each other out for mobile operators. To maximize the potential of 5G, they should move away from their traditional business models. One option, for example, would be to offer managed end-to-end broadband solutions that work seamlessly both inside and outside the home. This can be achieved by adding wired capabilities to network capabilities, enabling flexible service design and faster time to market.

Value Added Distributor

On the corporate side, factors such as the shift of workloads from the central cloud to the decentralized, a mobile workforce and new workloads at the edge (VR/AR, smart

sensors, autonomous vehicles, etc.) offer an immense opportunity for service providers in the 5G context.

These factors open up potential new revenue streams such as wireless sensors and 4K streaming. Both show how important flexibility in pricing and billing is for mobile operators to be able to offer 5G services in a sustainable and profitable way.

Essentially, there are four main application areas that mobile operators can enter. The first - and by far the largest - is Enhanced Mobile Broadband. It is predicted that this area, which includes applications such as real-time augmented and virtual reality, will generate global revenues of around one trillion dollars by 2026.

The second area is Fixed Wireless Access (FWA), which also promises great financial opportunities. Over the next eight years, it is expected that around 100 billion dollars will be generated worldwide by networking companies and residential buildings in conurbations.

The last two application areas are the Internet of Things (IoT) and consumer-based services. The IoT is expected to provide mobile operators with important revenue streams in various industries over the next few years. Offering *Network as a Service* (NaaS) solutions to businesses and consumers should also open up additional revenue streams.

IoT devices, for example, will create a need for wireless networks with much higher data capacity and devices with low power consumption. Many of these devices are "always on" and "always connected" to the Internet via wireless network bandwidth. This is in contrast to a smartphone, which may sit idle for long periods with no consumption of network capacity. But many IoT devices will need to remain connected, such as for medical and health-care monitoring, and that expected network capacity must be available in 5G systems. Projections vary on the number of IoT devices that will require wireless network access in the next few years, but numbers as high as several trillion devices suggest huge bandwidth/data-capacity requirements just based on IoT devices, without even considering a growing number of smartphones on the same networks.

It is expected that 5G will support very high speed connection speeds much faster and much more intensive use of data than previous generations, while allowing the full potential to be realized of the Internet of Things. From autonomous cars to smart cities, from the industrial Internet to communications with speed similar to fiber, the 5G will be at the heart of the future of communications. 5G is also essential for preserve the future of the most popular mobile applications - such as video to demand - ensuring that the growth in their uses will be sustainable.

Operating frequency has been a widely discussed and debated topic for 5G, and clarity is starting to emerge. Below is a summary of the frequencies being considered based on activity in the 3GP.

Table 1

LTE vs. 5G capabilities

Frequency range	Supporting companies (min. 3)
3.3 - 4.2 GHz	NTT DOCOMO, KDDI, SBM, CMCC, China Unicom, China Telecom, KT, SK Telecom, LG Uplus, Etisalat, Orange, …
4.4 - 4.99 GHz	NTT DOCOMO, KDDI, SBM, CMCC, China Unicom, China Telecom,
24.25 - 29.5 GHz	NTT DOCOMO, CMCC, KT, Verizon, T-mobile, Telecom Italia, BT…
31.8 - 33.4 GHz	Orange, Telecom Italia, British Telecom
37 - 40 GHz	AT&T, Verizon, T-mobile

Internet of Things (IoT)[1]

The term "Internet of Things," also known as "*cyber–physical systems* (CPS)," at macro level, was first coined by Kevin Ashton in his presentation made to Procter & Gamble (P&G) in 1999. IEEE has defined it as follows: "Broadly speaking, the Internet of Things is a system consisting of networks of sensors, actuators, and smart objects whose purpose is to interconnect 'all' things, including everyday and industrial objects, in such a way as to make them intelligent, programmable, and more capable of interacting with humans and each other."

The Internet of Things will be the ideal application for 5G. What currently stands in the way of the IoT are disconnected systems.

Intelligent devices are on the Internet of Things wirelessly networked; typically sensors and actuators are with very low energy consumption and limited functionality. Data is only processed slowly and with high delay. Already in the next innovation leap, minimum response times, maximum availability, reliability and safety is demanded. As with networking on a large scale, with Cloud Computing also exists in the small, in the IoT, the need to create secure systems against cyber attacks. Therefore, two fundamental issues are urgently needed for the IoT to solve problems: *Privacy and security*. Also the energy supply of the distributed integrated entities and their robustness against environmental influences, the provision of mobile transmission capacity as well as the evaluation of the heterogeneous big data to bridge the gap between pure data and to beat information and knowledge.

For practical use, plug-and-play, modular, self-configuring and self-healing implementations of the IoT are required. Existing applications, systems and data must be made compatible with the new IoT platforms. The basic scientific knowledge of engineers is required to solve all these questions. Cooperative research and development will be driven forward on a broad basis. New technical norms and standards must also be created.

The Internet of Things has its scientific roots in Communication networks and wireless communication, special attention is paid to communication protocols. The IoT includes cyber-physical systems. However, these have their roots in controllers, computer science, real-time systems and sensor networks, and corresponding research focuses on hybrid systems and the formal verification of dynamic systems.

Between 2018 and 2025, the number of global IoT connections will triple to 25 billion, while global IoT revenue will quadruple to $1.1 trillion. With connectivity becoming increasingly commoditised, mobile operators are looking to expand their role in the value chain – from providing essential tools and capabilities for ecosystem partners to build IoT solutions, to becoming end-to-end IoT solutions providers themselves.

The IoT is rapidly developing with the new technology, especially the new application domain. Nowadays, IoT systems are improving the quality of lifestyles that involve the interconnection between smart home devices and smart environments. Automation and machine learning will be a crucial component in IoT cybersecurity. Leveraging machine learning technology allows organizations to draw correlations among the massive volume

[1] The IoT will interconnect a significantly larger number and broader range of devices than today's Internet; from simple sensors to wearable devices on humans and animals; to consumer goods such as clothes and parcels; to complex endpoints such as automobiles, trains, bicycles, drones, smart appliances, and commercial and consumer robots that will each contain multiple-networked subsystems; to sophisticated systems such as industrial control systems, connected transportation systems, smart buildings and cities, oil and gas systems, and smart energy grids.

of data they collect, all in a streamlined manner. With the amount of emerging vulnerabilities, automation and machine learning are vital to combating cybercrime effectively.

Many technologies enable the IoT in connecting products, or things, and services (*Table 2*). The new version of the Internet Protocol (IPv6), supporting 128-bit or 3.4×10^{38} addresses that can connect most atoms in the world (1.33×10^{50} atoms), enables almost unlimited number of devices connected to networks.

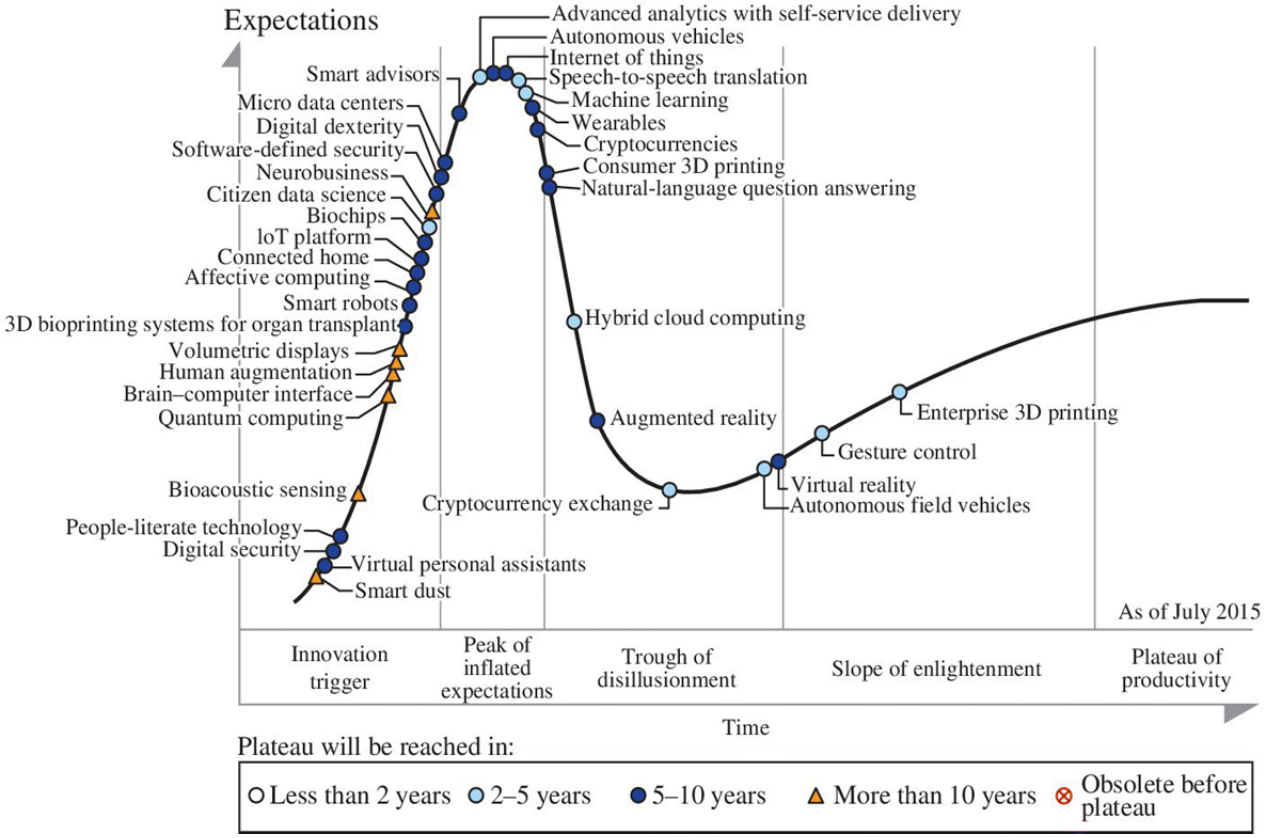

Figure 1 Hype cycle for emerging technologies, 2015.

Table 2

Technologies enabling the IoT. © Deloitte. Use with permission

Technology	*Definition*	*Examples*
Sensors	A device that generates an electronic signal from a physical condition or event	The cost of an accelerometer has fallen to 40 cents from $2 in 2006. Similar trends have made other types of sensors small, inexpensive, and robust enough to create information from everything from fetal heartbeats via conductive fabric in the mother's clothing to jet engines roaring at 35,000 ft.
Networks	A mechanism for communicating an electronic signal	Wireless networking technologies can deliver bandwidths of 300 megabits per second (Mbps) to 1 gigabit per second (Gbps) with near-ubiquitous coverage.

Continuation Table 2

Standards	Commonly accepted prohibitions or prescriptions for action	Technical standards enable processing of data and allow for interoperability of aggregated data sets. In the near future, we could see mandates from industry consortia and/or standards bodies related to technical and regulatory IoT standards.
Augmented intelligence	Analytical tools that improve the ability to describe, predict, and exploit relationships among phenomena	Petabyte-sized (1015 bytes, or 1,000 terabytes) databases can now be searched and analyzed, even when populated with unstructured (e.g., text or video) data sets. Software that learns might substitute for human analysis and judgment in a few situations.
Augmented behavior	Technologies and techniques that improve compliance with prescribed action	Machine-to-machine interfaces are removing reliably fallible human intervention into otherwise optimized processes. Insights into human cognitive biases are making prescriptions for action based on augmented intelligence more effective and reliable.

Deloitte analysis. *http://dupress.com/collection/internet-of-things/*.

The Promise of 5G

Expectations are great for 5G networks, even before the infrastructure has been built (*Figure 1*). Earlier-generation wireless/cellular networks were based on supporting voice communications, although that started to change with 2G and 3G systems. The nature of modern communications has changed, largely due to the influence of the Internet, and has become very data-centric, with network performance defined in terms of data transfer speeds and data capacity.

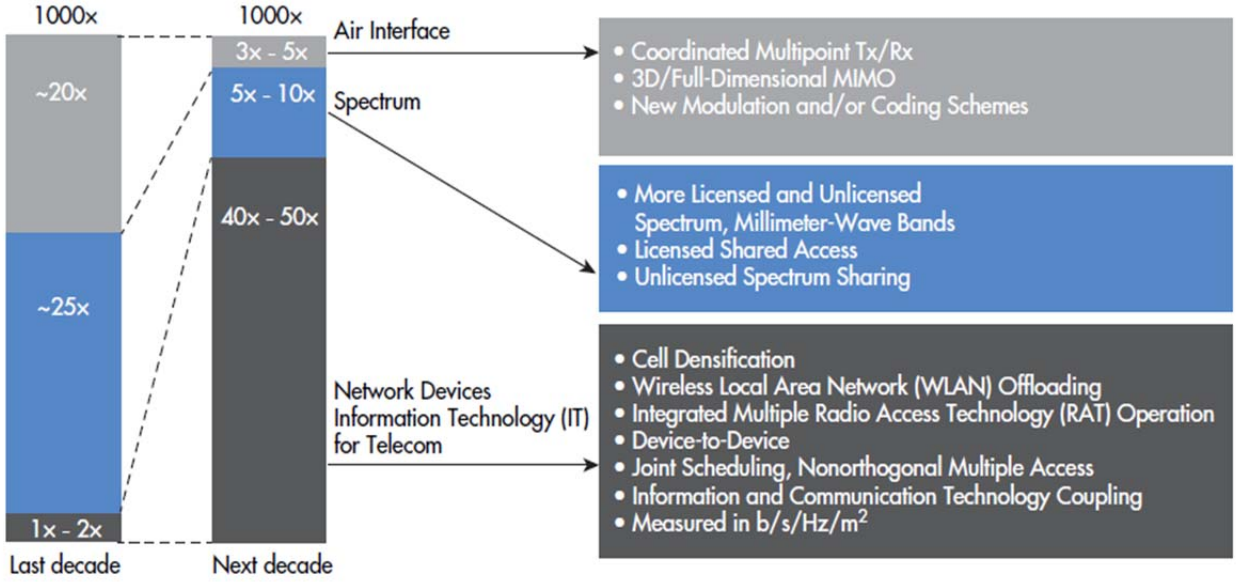

Figure 2 The need for bandwidth to transfer large amounts of data through wireless channels makes the use of millimeter-wave frequencies in 5G wireless networks inevitable. (Graphic courtesy of National Instruments).

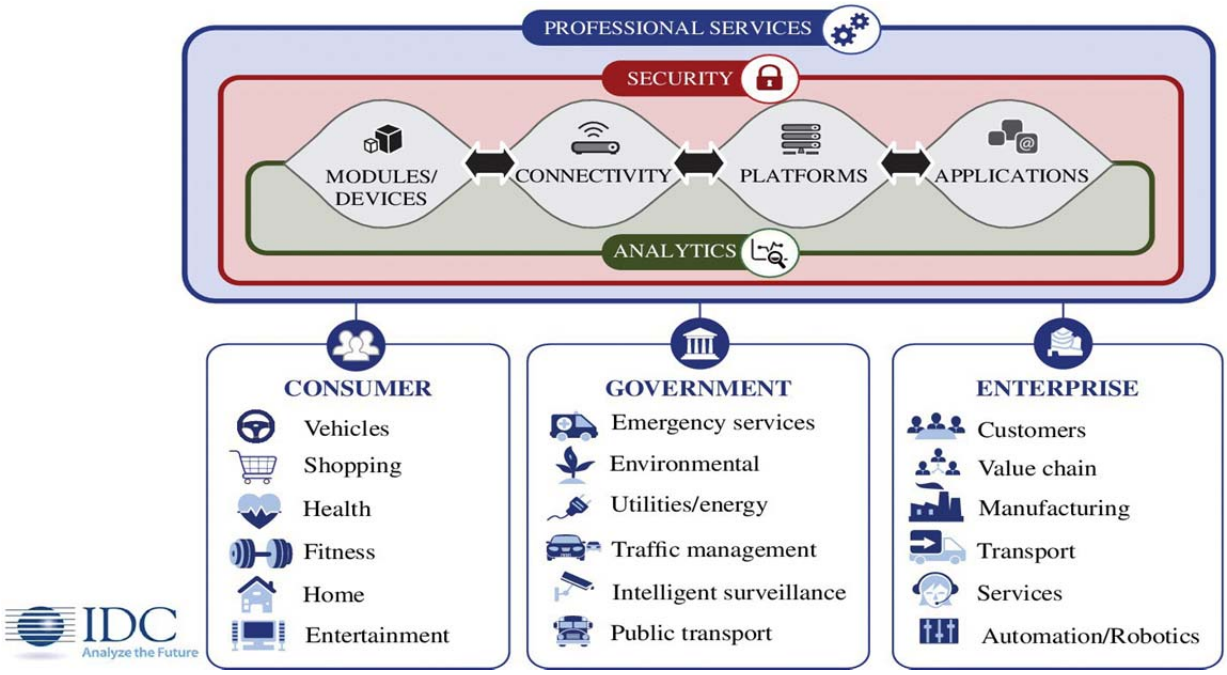

Figure 3. Internet of Things ecosystem. (© International Data Corporation. Use with permission).

Monitoring activity can lower risks against the growing numbers of devices. Monitoring the reputation scores of IPs, URLs, files, and mobile apps that are related to an unknown object is an effective way to predict whether they pose a security risk. In addition, the continual, real-time monitoring and tracking of changes in IPs, URLs, files, and mobile apps is essential toward decreasing security incidents.

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5G and health problems

It is expected that 5G will be used in frequency ranges from 24 to 86 GHz, known as millimetre waves, From a scientific point of view, concerning these waves and in comparison with 3G and 4G, little is known about human exposure to these waves and potential health effects. Few scientific studies have been conducted to date. However, it is known that the radiation emitted by millimetre waves penetrates less deeply into the body than the frequencies used so far for 3G and 4G, and that this energy is, therefore, absorbed by a smaller volume of tissue.

Rats and mice, which had been exposed to high doses of waves, did not show an increase in cancer, but ultimately lived longer than others that had been preserved. With regard to human studies, it has been and will always be difficult to conduct studies on subjects not subjected to waves. Even though the use of mobile phones has exploded in recent years, there has been no massive increase in cancer cases. In general, the increase in the number of cancers is mainly because humans are living longer. Age is a well-known risk.

Despite the uncertainties, the experts assume that the new mobile radio standard will not significantly change radiation exposure overall. While there are places where radiation exposure will increase, the new technology should reduce exposure in other places, according to the opinion. The same also applies to the radiation exposure of the individual, which cannot yet be reliably estimated due to the many question marks in the concrete implementation of 5G.

It has been proven that long telephoning heats the part of the brain near the device; however it has not yet been enough to demonstrate that it has a harmful effect on health. Remember that we are talking here about the telephone, which is recommended to moving away from the head via a hands-free kit. We're not talking about waves generated by the antennas, but by the phone. This brings us back to what was stated above: it is above all the use of electronic devices that count. And much less so for mobile phone antennas. The most important and direct risk to the health of mobile phones remains the inattention that mobile phones can generate, especially on the road and for pedestrians.

5G and meteorological problems

At the European Centre for Medium-Range Weather Forecasts in Reading, England, concern is high, while, 5G technology is potentially a threat. Several frequencies are measured that have particular properties. For example, water vapour emits a signal of about 24 gigahertz, very close to one of the frequencies that could be used by 5G. As a result, this extremely important information signal, observed from space, could become blurred. Another problem: About 50 meteorological satellites circulate around the Earth. They provide valuable information for weather forecasting. If this data were to be corrupted, the consequences could be disastrous. This is a question that will arise in October 2019 at an international conference that will have to decide on this subject. In practical terms, it will be a matter of choosing the right frequencies for 5G, so that they do not disrupt other services such as weather satellites in particular.

Conclusions

5G makes a significant breakthrough in the traditional mobile communication system. While enhancing the service capability of the traditional mobile networks, it further evolves to

support the applications of IoT in various fields including manufacturing, business, and health care transportation. Hence, 5G is becoming the basic technology for the future IoT that connects and operates the whole society. Aiming at supporting differentiated applications with a uniform technical framework, 5G is facing enormous challenges. Network service providers are facing a lot of heavy lifting in order to scale their networks up and out by an order of magnitude in terms of capacity, the number of connected devices and vast numbers of networks.

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