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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

ITU-T Y.3100-series – Awareness on use cases and migration aspects of IMT-2020

ITU-T Y-series Recommendations – Supplement 64

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Supplement 64 to ITU-T Y-series Recommendations

ITU-T Y.3100-series – Awareness on use cases and migration aspects of IMT-2020

Summary

IMT-2020 is rapidly evolving and for many organizations, including administrations, it is important to be aware of these new developments. At this stage, it is critical to have an awareness on use cases of IMT-2020 and possible migration scenarios from existing networks to IMT-2020.

Supplement 64 to the ITU-T Recommendation series ITU-T Y.3100.x on IMT-2020 has been developed to provide awareness on use cases and migration aspects of IMT-2020. The Supplement was developed by Q5/13 with initial collaboration of Q20/13.

History

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FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Introduction

In May 2015, the Focus Group on network aspects of IMT-2020 (FG IMT-2020) was established to analyse how emerging 5G technologies will interact in future networks as a preliminary study into the networking innovations required to support the development of 5G systems. The group took an ecosystem view of 5G research of development and published the analysis in a report with nine draft Recommendations and Technical Reports to ITU-T Study Group 13 that led ITU's standardization work on next-generation networks and now caters to the evolution of next generation networks (NGNs), while focusing on future networks and network aspects of mobile telecommunications by end of 2016 (FG IMT-2020: Report on Standards Gap Analysis TD 208 (PLEN/13). Five study areas: high-level network architecture, end-to-end QoS framework, emerging network technologies, mobile front haul and back haul, and network softwarization were recommended.

The establishment of Q20/13 was motivated for the development of IMT-2020 so as to address the anticipated needs of user of mobile services in the years 2020 and beyond. In this case, the vision and service scenarios will have been identified by related standards development organizations (SDOs) such as ITU, 3GPP, NGMN, etc., so as to be able to achieve enhanced mobile broadband (eMBB), ultra-reliable and low latency communications and massive machine type communications (mMTC) among others.

IMT-2020 systems differentiates themselves from fourth generation (4G) systems not only through further evolution in radio-interfaces but also through greatly increased end-to-end flexibility that brings challenges to the architecture and functional design considering the diversity of service requirements. Incorporation of network softwarization into every component such as network function virtualization (NFV) and software defined network (SDN) allow unprecedented flexibility in the IMT-2020 systems, enabling network slicing.

Today, the application of artificial intelligence including machine learning technologies have been developed considering ongoing work in the FGML5G that is very beneficial for IMT-2020 systems in terms of network operations and application support capabilities.

To improve network performance and enhance user's experience, new machine learning (ML) methods for big data analytics in communication networks can extract relevant information from the network data while taking into account limited communication resources, and then leverage this knowledge for autonomic network control and management as well as service provisioning. Considering the growing complexity of SDN/NFV and IMT2020/5G networks and beyond, ML may be very applicable for automatic network orchestration and network management. ML also impacts information and communication technology (ICT) in areas related to security or protection of personal information. Another aspect that researchers need to consider is the issue of deployment of IMT-2020 considering its interoperability and most importantly interworking as well as interconnecting with existing networks without using extra equipment or devices by either a network operator or a user for a perfect user experience.

Supplement 64 to ITU-T Y-series Recommendations

ITU-T Y.3100-series – Awareness on use cases and migration aspects of IMT-2020

1 Scope

This Supplement will investigate Q20/13 work on the study of the requirements, capabilities, and architecture and key technologies to realize IMT-2020 networks, and the ecosystem from business models and use cases, as well as the newly developed recommendations and use case scenarios by the FGML5G.

It will mainly look at several migration aspects between existing technologies and IMT-2020 which will focus on regulatory aspects of the following areas:

– Technical requirements.

– Architecture of networks.

– Standardization of technologies.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 download [b-ITU-T E.800]: Transfer of data or programs from a server or host computer to one's own computer or device.

3.1.2 latency [b-ITU-T G.9961]: A measure of the delay from the instant when the last bit of a frame has been transmitted through the assigned reference point of the transmitter protocol stack to the instant when a whole frame reaches the assigned reference point of receiver protocol stack. Mean and maximum latency estimations are assumed to be calculated on the 99th percentile of all latency measurements. If retransmission is enabled for a specific flow, latency also includes retransmission time.

3.1.3 jitter [b-ITU-T G.9961]: A measure of the latency variation above and below the mean latency value. The maximum jitter is defined as the maximum latency variation above and below the mean latency value.

3.1.4 IP packet loss ratio (IPLR) [b-ITU-T Y.1540]: IP packet loss ratio (IPLR) is the ratio of total lost IP packet outcomes to total transmitted IP packets in a population of interest.

3.1.5 Internet of things (IoT) [b-ITU-T Y.4000]: A global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving, interoperable information and communication technologies.

3.1.6 end-to-end quality [b-ITU-T E.800]: Quality related to the performance of a communication system, including all terminal equipment.

3.1.7 network softwarization [b-ITU-T Y.3100]: An overall approach for designing, implementing, deploying, managing and maintaining network equipment and/or network components by software programming.

3.1.8 quality of service (QoS) [b-ITU-T E.800]: Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.

3.1.9 service reliability (SR) [b-ITU-T K.138]: Reliability of service provision.

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 vertical industry: Vertical industry is the integration and digitization of various services that affects societal changes. Vertical industry includes smart cities, connected vehicles, connected factories, smart utilities, and connected healthcare with broadband services.

3.2.2 millimetre wave (mmWave): mmWave is a term that indicates the band of spectrum between 30 GHz – 300 GHz and wavelength at these frequencies are between 1 mm and 1 cm long.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

ADAS	Advanced Driver Assistance System
AR	Augmented Reality
CDN	Content Delivery Network
CPU	Central Processing Unit
C-RAN	Cloud/Central Radio Access Network
CS	Circuit Switch
eMBB	Enhanced Mobile Broadband
ICT	Information and Communication Technology
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
IPLR	IP Packet Loss Ratio
LTE	Long Term Evolution
ML	Machine Learning
M2M	Machine to Machine
mMTC	Massive Machine Type Communications
MTD	Machine-Type Device
NFV	Network Function Virtualization
NGN	Next Generation Network
NG-RAN	Next Generation Radio Access Network
QoS	Quality of Service
RLAN	Radio Local Area Network
SDN	Software Defined Network
SDO	Standards Development Organization
UE	User Equipment

UHD	Ultra-High Definition
URLLC	Ultra-Reliable Low-Latency Communication
VoLTE	Voice over LTE
VR	Virtual Reality
VSAT	Very Small Aperture Terminal

5 Conventions

None.

6 Overview of Supplement

The objective of the ITU is to establish the vision for IMT-2020 and beyond, by providing guidelines on the framework and capabilities for potential users, application trends, growth in traffic, technology trends and spectrum implications. The development of other industries such as medical science, transportation, education, aeronautical, agriculture, etc. depends on all international mobile telecommunications (IMT) systems which serve as a communication tool for people and places. IMT-2020 is expected to play an important role in accessing current broadband connectivity, and it will act as one of the key pillars to enable the following industrial and professional applications:

Bridging the digital divide: IMT-2020 will provide affordable, sustainable and easy-to-deploy mobile and wireless communications systems. Its effective energy efficient objective and maximized efficiency will help in the quest to close the gaps caused by the increasing digital divide.

ICT market: Deployment of IMT-2020 systems is expected to promote the development of an integrated ICT industry which will be the main driver for economies around the world. The possible scenarios to concentrate on will include the accumulation, aggregation and analysis of big data as well as network services (wireless or fibre) delivery for industries and social network groups. Big data management is essential in this regard and for all other applications.

Content delivery providers: Content providers will want to come up with new and improved contents and IMT-2020 to enable sharing of any type of content without being limited by time and location or even data caps.

Digital forms of essential services: Considering the trends and behaviour of the social and political activities of various countries leading to a growing norm, this will eventually lead to a new way of communicating. IMT-2020 will boost applications such as e-governance, e-learning, e-health and e-commerce to realize applications that support this.

IMT-2020 is created to support diverse use cases and scenarios that will continue beyond the 5G technology. The different usage scenarios and applications depend on the requirements of IMT-2020, see Figure 1.

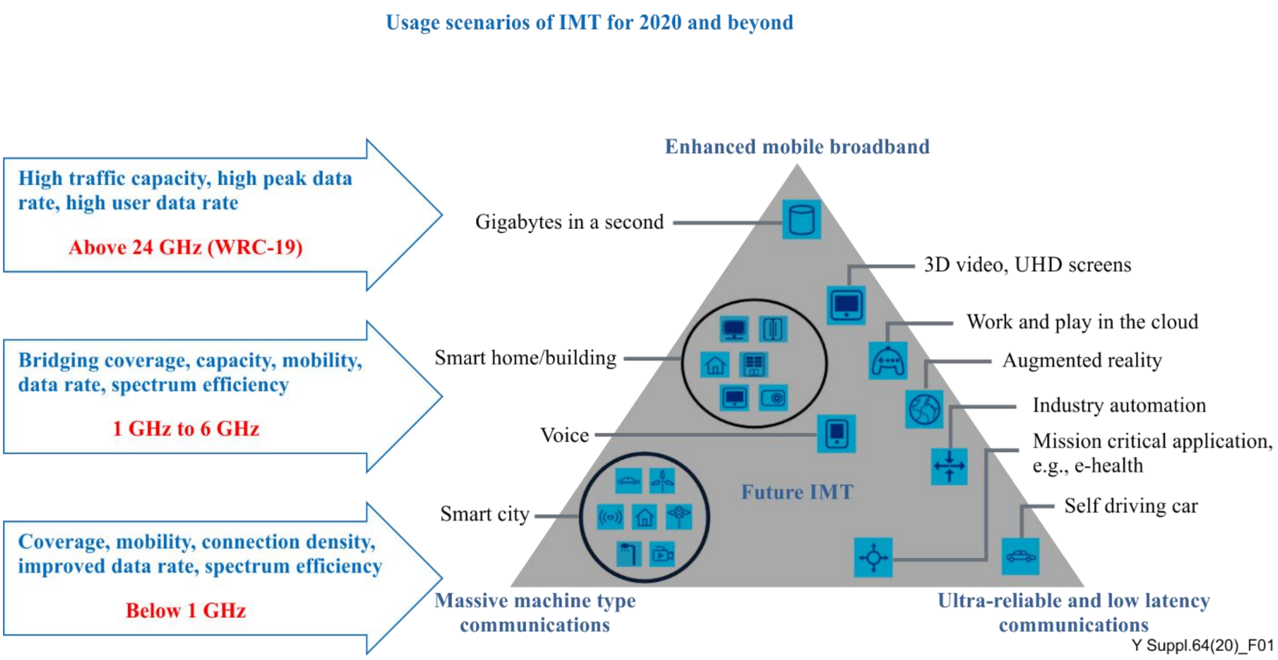

Figure 1 – Usage scenarios of IMT for 2020 and beyond

Many more use cases currently unforeseen, are expected to emerge due to the flexibility of IMT-2020. Future situations such as force majeure, international conflicts or pandemics may necessitate adaptation to new use cases depending on the circumstances and different needs in different countries. This means that in the long term IMT-2020 systems should be designed in a highly modular manner to encompass a large number of different features depending on the circumstances and the different needs in different countries so that not all features have to be implemented in all networks.

Users should be able to access services anywhere and anytime. To achieve this goal interworking among various access technologies will be necessary. This might involve a combination of different mobile, fixed, terrestrial and satellite networks. Each component will be expected to satisfy its own role, and also be integrated or interoperable with other components to provide seamless coverage in an ubiquitous environment. IMT-2020 will interwork with other radio systems, such as radio local area networks (RLANs), NG-RAN, broadband wireless access, satellite systems, broadcast networks, and their possible future enhancements. IMT systems will also closely interwork with other radio systems for users to be optimally and cost-effectively connected.

In view of this the planning of IMT-2020 and its future enhancement of the existing systems IMT should consider the following user centric and technical factors for users to enjoy the full benefits. It is however worthy to state that all these factors are interrelated:

– Requirements and demands of users.
– User trends or behaviour of users.
– Technology development and technical capabilities.
– Technical standards and their enhancements.
– Spectrum utilization issues for enhanced capabilities.
– Regulatory requirements of various administrations.
– Systems and their deployment in new networks.

7 IMT-2020 standardization roadmap

A number of standardization development organizations (SDOs) and Foras are continuing to work on standards that will enable IMT-2020 to work well. Key among these are ITU, 3GPPP, Broadband Forum, ETSI, IEEE, ISO/IEC, MEF, NGMN and the TM Forum.

In the ITU both the ITU-R (radio parts of IMT-2020) and ITU-T (non-radio parts of IMT-2020) are working on Recommendations (Standards) for IMT-2020. In ITU-T the following Study Groups are all working on recommendations for IMT-2020, most have completed a number of recommendations, with some still under study.

The Study Groups involved are; SG2, SG5, SG9, SG11, SG12, SG13, SG15, SG17 and SG20.

There are not that many standards that directly deal with migration to IMT-2020, however all the groups have produced work that enable migration to IMT-2020 from existing networks.

In ITU-T SG13, there is ITU-T Recommendation ITU-T Y.3101 (2018) *Requirements of the IMT-2020 network* [b-ITU-T Y.3101]. This Recommendation describes requirements of the IMT-2020 network. The Recommendation first provides general principles of the IMT-2020 network, then the requirements for overall non-radio aspects of the IMT-2020 network are specified from both service point of view and network operation point of view.

The Broadband Forum, has published a standard "BBF MR-464" which speaks directly to the subject of migrating fixed access to 5G core.

In ITU-T there is a detailed Technical Paper, ITU-T Technical Paper (1 March 2013) Y.2000 series, Next Generation Networks-Migration scenarios from legacy networks to NGN in developing countries [b-ITU-T TP Y.2000.x]. These very important documents when used together provide a very good technical guidance on the subject of migration to IMT-2020.

8 Use cases of IMT-2020

8.1 Overview of identified use cases of IMT-2020

ITU has defined three representative service categories, including enhanced mobile broadband (eMBB), massive machine-type communication (mMTC) and ultra-reliable low-latency communication (URLLC). This is necessitated because of the coexistence of human-centric and machine-type services as well as a hybrid of these two to make future mobile and wireless environments more diverse.

8.1.1 Use cases for eMBB

Mobile broadband is the user centric use case for access to services multimedia content and data. The demand for these services by users continues to grow leading to IMT-2020's enhanced mobile broadband (eMBB). This will meet the high demand for new applications and improve performance and increase seamless user experience. The defined performance requirements for high data rates and traffic densities will be the basic service requirement for the various use cases.

With respect to specific use cases for IMT-2020 there will be increased demand for high definition media such as ultra-high definition (UHD) video i.e., 4K, 8K and immersive games displayed on mobile devices. Applications for mobile high definition media may go well beyond entertainment and could include augmented reality, video conferencing, medical treatment, safety and security. These use cases translate into e-governance, e-health and other electronics services in the event of an outbreak and a pandemic or any other force majeure that restricts the movement of people from place to place.

8.1.2 Use cases for mMTC

IMT-2020 requirements include the support of a multiplicity of services and applications. The objective is to attach a large number of low-rate, low-power devices known as machine-type devices (MTDs). 5G mobile networks are particularly designed to enrich future massive machine type communications (mMTC) with increased throughput, reduced end-to-end delay, wide coverage, increased battery operating time, and support for an enormous number of devices per cell.

The massive IoT market segment includes several applications widely used in industries and societies and these includes but not limited to the following:

- **Utilities** – Smart metering systems and smart grid management.
- **Smart cities** – Parking sensors, smart lighting, waste management, flood monitoring alert systems and smart bicycles.
- **Smart buildings** – Home automation systems, Alarm systems and smoke detectors.
- **Consumers** – Wearables, medical monitoring, sensor trackers, etc.
- **Transport and logistics** – Fleet management, goods tracking, speed detectors, etc.
- **Agriculture** – Environmental and climate monitoring, livestock tracking, etc.

8.1.3 Use cases for URLLC

Ultra-reliable low-latency communication (URLLC) is the category designed to meet delay-sensitivity services where the response time and delays are critical, such as for vehicular-to-vehicular communication and autonomous driving, remote control. Several use cases require the support of URLLC, and the overall service latency depends on radio transmission delay on the radio interface. Scenarios requiring URLLC service include:

Automation for electricity: Electricity distribution is characterized by high requirements on the communications service availability. In contrast to the above use cases, electricity distribution is deeply immersed into the public space. Since electricity distribution is an essential infrastructure, it will, as a rule, be served by private networks.

Intelligent transport systems: Automation solutions for the infrastructure supporting street-based traffic. This use case addresses the connection of the road-side infrastructure, e.g., road-side units, with other infrastructure, e.g., a traffic guidance system. As is the case for automation electricity, the nodes are deeply immersed into the public space.

Tactile interaction: Tactile interaction is characterized by a human interacting with the environment or other humans, or controlling a user equipment (UE), and relying on tactile feedback.

Remote control: Remote control is characterized by a UE being operated remotely, either by a human or a computer.

Factory automation and remote control: Deals with the automation, monitoring and optimization of processes and workflow within the factory. It requires reliable communication systems characterized by high infrastructure connectivity such as latency and communications service availability. Access to the communication systems may include an isolated network of resources used by authorized users on the other side and therefore end-to-end latency, communication service availability and jitter are essential in this regard.

Agriculture: One very important sector of the economy that will generate gains from IMT-2020 is agricultural techniques that will produce improved mechanization, vertical farming as well as precision farming where drones are used to save on high irrigation costs.

8.2 Overview of network slicing in IMT-2020

A typical IMT-2020 network deployment will make use of network slicing to enable network operators or service providers to create logical segregated networks that help provide customized solutions for numerous application scenarios. The services should be provided in the context of each network slice to support the different requirements of the different applications that meet the services and use cases.

Access networks agnostic common core network instituted in an IMT-2020 network will help to provide various services with respect to an access network. In order to enable existing service providers to provide diverse services without building a new or separate end-to-end network for each service, It is required that 'an access network agnostic common core network' separate access network is deployed based on an appropriate set of network functions and employed technologies. The distributed architecture is based on softwarized network functions that allow on-demand flexible deployment of the necessary functions and programmable network configuration.

9 General migration issues

9.1 Existing networks and IMT-2020

In many ways IMT-2020 (5G) is evolutionary, rather than revolutionary. Nonetheless, it may lead to significant changes, including: increased use of small cells to achieve higher data rates; possible entry of non-traditional network operators focusing on cell densification; differentiation of service characteristics through network slicing to meet the diverse needs of various 'vertical' industries and other user groups; possibilities for creating private networks (for example, in industrial spaces, especially indoors and hotspots), new opportunities for intermediation of various forms to integrate different networks and provide connectivity tailored to particular user needs leading to low-latency edge computing being provided by network operators. Network configurations to satisfy end-to-end service design requirements have many variations, a high-throughput broadband network is necessary to satisfy the service requirements of remote diagnostic service and low-latency network configuration. This is needed to satisfy the needs such as robotic surgery and other critical services. The redesigning of networks, if done manually, is time consuming. ML may provide solutions for agile service design and automated network design by automatically translating service requirements of use cases to network requirements.

In parallel with these developments, other existing and legacy networks will continue to work and will augment the new configurations. This will improve the overall user experience in respect of numerous user applications of the technology.

In most developing countries, the predominant networks are 3G, 4G and LTE-A. There are countries with sizeable amounts of both fixed and 2G in operation. What seems to be emerging within reasonable consideration is that of the wireless networks, at least 4G and LTE-A can easily be migrated to IMT-2020. 2G and 3G networks will be difficult to migrate directly to IMT-2020 due to IP issues. Fixed networks are relatively easy to migrate to IMT-2020.

The decision to either migrate to IMT-2020 component by component or implement a new IMT 2020 network, will depend on a number of issues but the use case or demand for IMT-2020, the spectrum availed of for IMT-2020, the extent of existing network and cost implications will be big considerations.

For countries with predominant 2G and 3G, the most viable option is to implement a new network of IMT-2020 to exist side by side with the existing network.

9.2 IMT-2020 migration strategies

A variety of spectrum bands are available for deployment of IMT-2020, which can be sub-divided into three macro categories: sub bands (1 GHz), mid bands (1-6 GHz) and above 6 GHz. Each of these will require a different migration consideration. Furthermore, the numerous and different IMT-2020 new use cases such as smart cities, smart agriculture, logistics and public safety agencies, have different demands and as such will dictate how the operators migrate to IMT-2020.

In addition, there are different IMT-2020 systems that are being developed, which means that the variety of requirements, spectrum needs and standardization leanings show that there are many options for migrating to IMT-2020.

Operators must therefore consider the feasibility of the different options in meeting their intended initial use cases and the interoperability of their choice with other options to ensure that their networks deliver the use cases effectively while supporting global interoperability.

There are two clear migration paths that are emerging in as far as IMT-2020 is concerned. The first is an all-out new IMT-2020 network installation. This is being seen in countries where they have developed and implemented new concepts such as smart cities, where the network installed is IMT-2020. The network is new and different from the other already existing networks.

The second migration path is the one where the migration is somewhat based on an existing network and the migration is done through upgrading of components or replacing components with IMT capable components, depending on the need.

The choice of which general path to follow, is guided by the availability of funds and the demand for IMT-2020. For developing countries the issue of maturity of the use cases is important, as it talks about demand for the IMT-2020 services. Figure 2 illustrates the two basic migration options as per migration component by component.

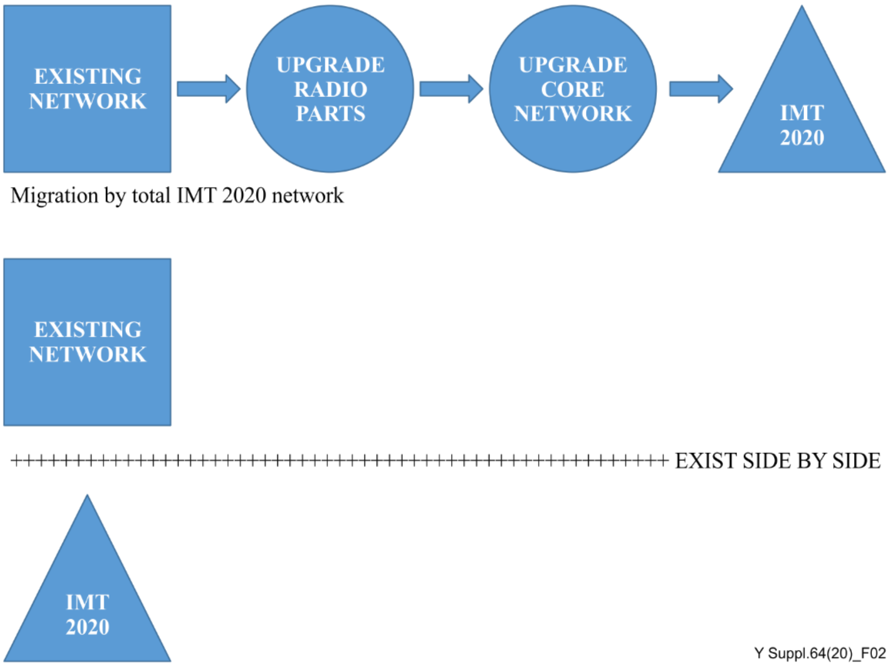

Figure 2 – Migration by total IMT 2020 network

9.3 Guidance to developing countries

Cross sector competitive issues: Most countries are intensifying the era of moving deep into the digitization of their economies. Service providers and economies need to invest in their existing networks to attain faster speeds and lower latency network. Many operators and other value added service providers will have to invest in an evolving telecom industry to meet the growing demand of increasing coverage and capacity of their 3G and 4G networks to be able to migrate to IMT-2020 (5G).

Spectrum related issues: Spectrum is one of the most important issues in the wireless communications industry due to the limited resource of amount of available spectrum to support a dynamic industry. Industries in developing countries can leverage on the following initiatives to harness on all available spectrum for IMT-2020 and beyond:

– Adapt international specifications to enable multi technology operations in all available bands,

– Adapt multiple radio channelling (inter and intra frequency bands) techniques such carrier aggregation, mmWave communications and flexible spectrum access to improve both peak data rate and efficiency.

The ITU Radiocommunication sector (ITU-R) plays a key role in the global management of radio spectrum and identification of needed variations to existing spectrum and allocations to accommodate changes in demand.

QoS/QoE policy and regulatory aspects: To promote a dynamic market, competitiveness and consumer satisfaction a very good policy and vibrant regulatory practice with strict standards needs to be instituted. Policy makers and regulatory bodies must create vibrant regulatory conditions to attract investment and to enable widespread access to mobile services. Use a measurable approach to enforce compliance to instil performance based standards to deliver the quality of service (QoS) needed. It is worth stating that broadband networks are growing rapidly and therefore QoS in a mobile broadband network should be based on definitions of QoS classes and parameters and their mapping on well-defined bearers to satisfy the requirements of various scenarios and applications. This is because most compliance requirements of network performance objectives are best achieved by focussing on the performance of service achieved to consumers. Innovation and a modernized regulatory regime and further policy development in infrastructure and spectrum management are key areas to realize the full potential of IMT-2020 for consumers, societies and industries. Other regulatory intervention such as net neutrality and promotion of fibre deployment in rural areas will all be a good initiative to help boost investment in developing countries.

9.4 Aspects relating to migration from 2G to IMT-2020 scenarios

Second generation networks are the most widespread legacy networks in developing countries especially in rural areas. Most developing countries are looking at deployment of the existing networks side by side with the new IMT-2020 technology, therefore to do this, the following should be considered:

– Hardware of existing equipment.

– Intelligent gateway system.

– C-RAN.

– Massive fibre deployment.

– Interference due to densification of IMT-2020 technology.

9.5 Aspects relating to migration from 3G to IMT-2020 scenario

Third generation (3G) network is based on parallel existence of a circuit switch (CS) part and a packet switch (PS) part. This is one of the most important aspects of the 3G technology which makes it very possible to integrate IP and Internet connectivity in terms of the networking. 3GPP has standardized this in three main segments namely IP core network, high-speed mobile access and services which comprise a service overlay network implemented over an existing mobile network with an IP multimedia subsystem. Developing countries are looking at ways that existing service providers will be able to leapfrog from their existing technology to IMT-2020 technology.

9.6 Aspects relating to migration from 4G to IMT-2020 scenario

From a technical development perspective IMT-2020 technology is both innovative and revolutionary. Most developing countries that have already deployed 4G technology or any existing networks that are more extensively covered are looking at converging or running side by side with new technologies. Long term evolution (LTE) advance Pro (Gigabit LTE) establishes the foundation for 5G by providing ubiquitous coverage and essential services such as Gigabit LTE, voice over LTE (VoLTE), LTE IoT (eMTC + NB-IoT), cellular V2X and private LTE networks that complement IMT-2020. To this end migration to IMT-2020 is highly recommended when starting a network from scratch. Most developing countries that have already developed 4G technology are looking at upgrading to the LTE advance Pro to be able to migrate easily to IMT-2020, other countries have also initiated studies in relation to spectrum and standardization policies by performing simulations and test trials.

From the technical development perspective, 5G is an innovation and revolution based on 4G and is also a natural evolution and extension of the 4G technology. From the perspective of network deployment, initial 5G networks may not be deployed on a continuous and complete basis but need to converge and collaborate with existing 4G networks that are more extensively covered and well developed.

LTE Advance Pro (Gigabit LTE) establishes the foundation for 5G by providing ubiquitous coverage and essential services such as Gigabit LTE, Voice (VoLTE), LTE IoT (eMTC + NB-IoT), Cellular V2X (C-V2X) and private LTE network that complement IMT-2020. Currently some countries in Africa (Ghana and Rwanda) are using the 3G and 4G technology to deliver drone services for the health sector. These drones are used to deliver blood to underserved areas within these countries and the implementation of 5G will augment the use of both technologies at the same time.

9.7 Aspects relating to migration from fixed network to IMT-2020 scenario

Input is short on the migration use cases for fixed network to IMT-2020.

10 Practical use cases

A number of countries have implemented IMT-2020 and have case studies to show. The Russian Federation for example initiated a formulation of the 5G concept by the Radio Research & Development Institute (NIIR) for the Russian Federation Digital Economy. Nigeria also performed a 5G trial test and embarked on a Proof of Concept of 5G to study and observe among others any health or security challenges the 5G network might present. For this work both Russia and Nigeria have shared their cases which are outlined in Appendix I of this Supplement for the benefit of readers. Important aspects of these case studies that stand out and need to be mentioned include information on preparation for implementing IMT-2020 and lessons learnt and challenges.

10.1 Case study 1: Russian Federation

As part of the implementation of the national programme on "Russian Federation Digital Economy" and with a view to rolling out 5G/IMT-2020 networks, principles were defined for the construction of 5G/IMT-2020 networks (network architecture), along with frequency bands for their introduction, and a concept for the creation and development of 5G/IMT-2020 networks on Russian Federation territory.

Preparations: Russia Federation considered high-level requirements for the construction of a 5G network infrastructure, taking into account the virtualization of network components and functionality, introduction of cloud-based radio access technologies and virtualization of the transport network.

Lessons learnt: Specific frequency bands taking into account international trends in the development of the telecommunication market were considered as an approach for the creation and use of 5G networks on Russian Federation territory.

Challenges: The main economic issue raised by the concept of Russian Federation is the question of 5G network infrastructure costs. The lack of fit-for-purpose spectrum resources for all operators necessitated consideration of different deployment options for 5G networks, including scenarios involving a single infrastructure operator in the form of a consortium.

10.2 Case study 2: Nigeria

The Nigeria Communications Commission which is the Telecommunications Regulatory body, approved a trial test and embarked on a Proof of Concept of 5G with MTN in six locations in Nigeria using different equipment vendors for a period of three (3) months. The trial among others was to study and observe any health or security challenges the 5G network might present. The trial was conducted to enable the Commission to assess the performance of the 5G technology in comparison with existing technologies, evaluate compliance to health and safety guidelines and also use the lessons learnt to guide policy towards commercial deployment.

Preparations: The trial which was conducted on the 3.5 GHz and 26 GHz bands and relevant stakeholders including members of the security agencies were invited to participate during the trial.

Lessons learnt: Improvement of 5G over the previous technologies with the radiation levels well below the specified human safety guidelines (ICNIRP threshold). The need for collaboration among all relevant stakeholders in developing a policy document for IMT-2020 to aid seamless and smooth roll outs.

Challenges: No known challenges were stated by Nigeria.

11 General observations towards IMT-2020 migration

The general observation of migration patterns so far is that countries which have implemented or are in advanced stages of implementing IMT-2020, started with very clear uses case to determine what type IMT-2020 they need. After determining the use case to justify IMT-2020, they tested (piloted) IMT-2020 in small scale areas, then they issued licenses.

The observations below state some, but not limited to, certain approaches most countries use to deploy IMT-2020 based on their needs and expectations:

I) Maturity of IMT-2020

A number of countries have already carried out pilots and are now implementing IMT-2020, although the majority are still testing it out on small scale. Notwithstanding IMT-2020 is mature. The spectrum, the technology and the end user equipment are ready although still evolving. Costs are still high as uptake remains limited. This makes IMT-2020 sufficiently mature for countries to move very swiftly towards adaption.

Figure 3 summarizes the most commonly used approach to IMT-2020 implementation.

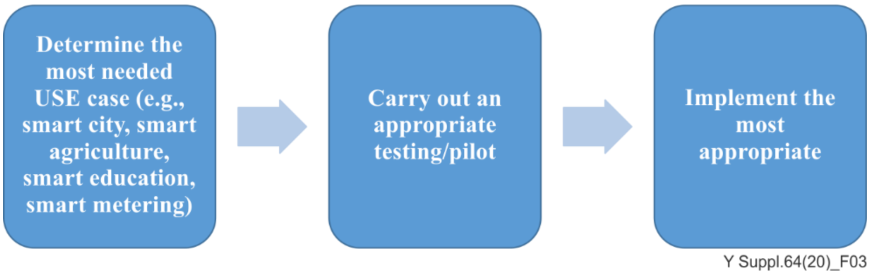

Figure 3 – Most commonly used approach to IMT 2020 implementation

II) Collaborations

Most countries which have implemented IMT-2020 or are in advanced stages of doing have done so through a very well-knit collaboration among:

– Government (policy guidelines on IMT-2020).
– Regulators (spectrum assignments and standards, permission for pilots).
– Operators (acquisition of equipment and choice of approach, carrying out tests).
– Users (use of the new technology).

III) Choice of technology and standards

Standards required for implementation of IMT-2020 have been developed and published. Currently there are not many competing standards, so the choices are easy to make depending what path of migration has been chosen and what use cases they are principally interested in. Operators are able to handle the issue of standards once the other aspects such as use case, spectrum band and quantity of spectrum, migration from existing to IMT-2020 component by component or installation of a new full blown IMT-2020 network in parallel to the existing network have been decided. Operators should then have no problem making the appropriate selection.

IV) Stage where most developing countries currently are

Most developing countries are concluding their initial limited testing stage before going to the stage of piloting it out on a much bigger scale before full implementation.

12 IMT 2020 migration recommendations

Developing countries generally need to follow the established path of selecting the most needed use case, then testing out the technology on a small scale and carrying out a pilot scheme on a larger scale before full implementation. In doing so these countries should consider the following recommendations:

I) Migration choices

Developing countries need not worry so much about the migration path, the choices are numerous and are ably made by operators, once issues of spectrum and use cases are established.

II) Roles of operators, regulators, Government and vendors

Government, regulators, operators, vendors and users each have a critical role to play in implementing IMT-2020. These must be made clear as they can vary from country to country.

In general though, governments will take care of the general issues of policy, regulators will take care of issues of spectrum, operators and vendors will take care of standards and technology choice as well migration path, and users will be using the technology.

III) Availability and use of standards

As mentioned before the standards need to be developed and implemented during IMT-2020 implementations.

13 Conclusion

This Supplement intends to provide both the regulatory and operator standpoint in terms of standardization, especially for developing countries. It provides guidance on the possibilities of migration from legacy and existing networks to the evolved IMT-2020. It gives some strategies that help to make good use of the interoperability of all network systems of the various generations to make good use of resources to meet the high demand of user requirements for the vast user application. This in the long term may improve regulatory efficiency and save on the costs of implementing a network from scratch while on the other hand network neutrality may not be an issue.

NOTE – For guidance on some use cases of various applications of IMT-2020 from some developed and developing countries, readers (regulators, service providers, consumers, etc.) are requested to further refer to Appendices I and II of this Supplement.

Appendix I

Appendix I outlines the two specific use cases of IMT-2020 as presented by the Russian Federation and the Nigeria Federation.

I.1 Deployment of 5G/IMT-2020 networks on Russian Federation territory

In 2018, as part of the implementation of the national programme "Russian Federation Digital Economy" and with a view to rolling out 5G/IMT-2020 networks, principles were defined for the construction of 5G/IMT-2020 networks (network architecture), along with frequency bands for their introduction, and a concept for the creation and development of 5G/IMT-2020 networks on Russian Federation territory (hereinafter the Concept) was formulated.

During the formulation of the 5G Concept by the Radio Research & Development Institute (NIIR), the following were determined:

– the principal characteristics of 5G networks and their comparison with existing IMT networks;

– the main services to be provided on 5G networks and demand for them in the Russian Federation;

– high-level requirements for the construction of 5G network infrastructure, taking into account the virtualization of network components and functionality, introduction of cloud-based radio access technologies and virtualization of the transport network.

The roll-out of 5G networks in the Russian Federation is expected to involve two stages: the organization of pilot zones for the certification of new services; and the deployment of a fully-fledged commercial 5G network in the Russian Federation.

In addition, NIIR proposed transitioning from LTE to 5G networks in three phases. The first phase involves construction of 5G base stations only, in order to increase capacity and throughput of existing LTE networks. The second phase involves the construction of the 5G core network and the second stage of 5G base station construction to ensure full radio coverage.

The third phase involves the dismantling of the EPC (4G) core network and only takes place once there is a prevailing number of subscriber LTE terminals on the network that support signal exchange with the 5G core network.

The overall conceptual scheme for 5G network development includes the following key components: description of the various network deployment scenarios (mainly, independent development, intensive shared use of network, construction of network by a single infrastructure operator in the form of a consortium), organization of pilot zones, assignment of frequencies and description of LTE-to-5G transition models.

Economic model for 5G in Russia

The main economic issue raised by the Concept is the question of 5G network infrastructure costs.

The lack of fit-for-purpose spectrum resources for all operators necessitated consideration of different deployment options for 5G networks, including scenarios involving a single infrastructure operator in the form of a consortium. The reasoning behind this is that the assignment of small spectrum resources to each operator will prevent full enjoyment of all the benefits of 5G networks.

The cost of Russia's 5G/IMT-2020 network project is expected to reach RUB 650 billion by 2030.

I.2 5G trail and proof of Concept in Nigeria

The Nigerian Communications Commission (NCC) in November 2019 approved a trial test and embarked on a Proof of Concept of 5G with MTN in six locations using different equipment vendors for a period of three months. The trial, among others, was to study and observe any health or security challenges the 5G network might present. Relevant stakeholders, including members of the security agencies, were invited to participate during the trial. The trial was conducted to enable the Commission to assess the performance of the technology in comparison with existing technologies, evaluate compliance to health and safety guidelines and also use the lessons learnt to guide Policy towards commercial deployment. The trial which was conducted on the 3.5 GHz and 26 GHz bands was successfully completed with performance showing improvement of 5G over the previous technologies with the radiation levels well below the specified human safety guidelines. The equipment used in the trials have long been decommissioned in all the locations.

In view of the successful completion of the trial, the Commission commenced the development of a policy for the deployment of 5G in Nigeria. In line with its powers under section 57 of the NCA, and the need for wide public consultation, the process of developing this policy will involve a Public Inquiry which will involve all relevant stakeholders in the review and consultation process.

The following stakeholders have been identified: Ministry of Communications & Digital Economy, Office of the National Security Adviser, the National Assembly, Ministry of Health, National Environmental Standards & Regulations Enforcement Agency, Consumer advocacy groups, Academia, Nigerian Society of Engineers, Nigerian Medical Association, World Health Organization, Council for the Regulation of Engineering in Nigeria, Mobile Network Operators, Nigerian Institute of Electrical and Electronic Engineers, Nigerian Institute of ICT Engineers, Association of Telecommunications Companies of Nigeria and the Association of Licensed Telecommunications Operators of Nigeria amongst others.

The Consultative Document is currently being developed and will be shared with these stakeholders and the general public, following which a Stakeholder Consultative Forum will be held. The views of all stakeholders will be considered in the final Policy.

Accordingly, the details of the proposed public consultation will be widely published in due course. 5G will not be deployed in Nigeria until the Policy is concluded and approved.

Use cases such as holographic communication, smart goalkeeper for gaming, etc., were tested with throughput of Giga bit speeds and a delay of less than 9 ms. Call set-up times of 1ms were also recorded.

Appendix II

"IMT-2020 use cases for developing countries" in the Supplement on "IMT-2020 in developing countries" – General use cases

II.1 Precision irrigation systems

Countries in Southern Africa have predominantly agro-based economies which have had to rely on overhead irrigation systems to mitigate the negative effects of unreliable rainfall patterns. Overhead irrigation systems have contributed to significant improvements in crop yields.

As a region, Southern Africa has historically been at high risk of droughts. In the late 2015 – early 2016 season, an El Niño event caused a drought in some parts of Southern Africa. As of the start of the 2018-19 an ongoing El Niño-induced drought, meant that some parts of Southern Africa had not yet recovered from the effects of the earlier drought. Because of the successive droughts, Southern African dam levels have been significantly reduced. To mitigate the effects of lower dam levels, Southern African countries are being called on to invest in more efficient drip irrigation systems with soil moisture sensors that only switch on and off watering systems when certain thresholds are reached. Once a designated amount of water has been detected, it shuts down any regularly scheduled irrigation. Soil moisture sensors can detect moisture at the level of the root system and are more exact in measuring how much water plants are receiving and thus offer greater water savings. Soil moisture sensors are a good candidate for massive machine type communications (mMTC) which can be enabled by IMT-2020 since a typical field can have thousands of plants and sensors per acre, which would place too heavy a burden on current IMT technologies. This use case is quite appropriate in drought prone areas where every drop of fresh water is important and cannot be wasted.

II.2 Telemedicine

Telemedicine enables remote delivery of healthcare services, such as health assessments or consultations, over the telecommunications infrastructure. In essence, telemedicine allows healthcare providers to evaluate, diagnose and treat patients without the need for an 'in-person visit'.

In Zimbabwe's Manicaland Province a telemedicine pilot project was jointly funded by the Universal Services Fund (USF) run by POTRAZ and the International Telecommunications Union (ITU). The aim of this project was to provide specialist healthcare services to rural health centres from specialist doctors stationed at Nyanga and Mutambara District hospitals, Mutare Provincial Hospital and Parirenyatwa National Referral Centre using a state-of-the-art ICT platform. Twelve remote rural clinics are part of the pilot project. The clinics are linked to the two district medical centres through very small aperture terminals (VSATs).

The pilot project has seen remarkable improvement in access to doctors and specialists by the communities served by the 12 remote clinics. Patients no longer need to travel long distances to see doctors and specialists because of remote consultations made possible by the telemedicine pilot project. However, the project cannot be rolled out to more remote rural clinics because of the cost of rolling out VSATs. It is envisaged that enhanced mobile broadband services provided by IMT-2020 will provide more affordable connection options for the remote rural clinics than the VSATs.

Figure II.1 shows the typical telemedicine hierarchy.

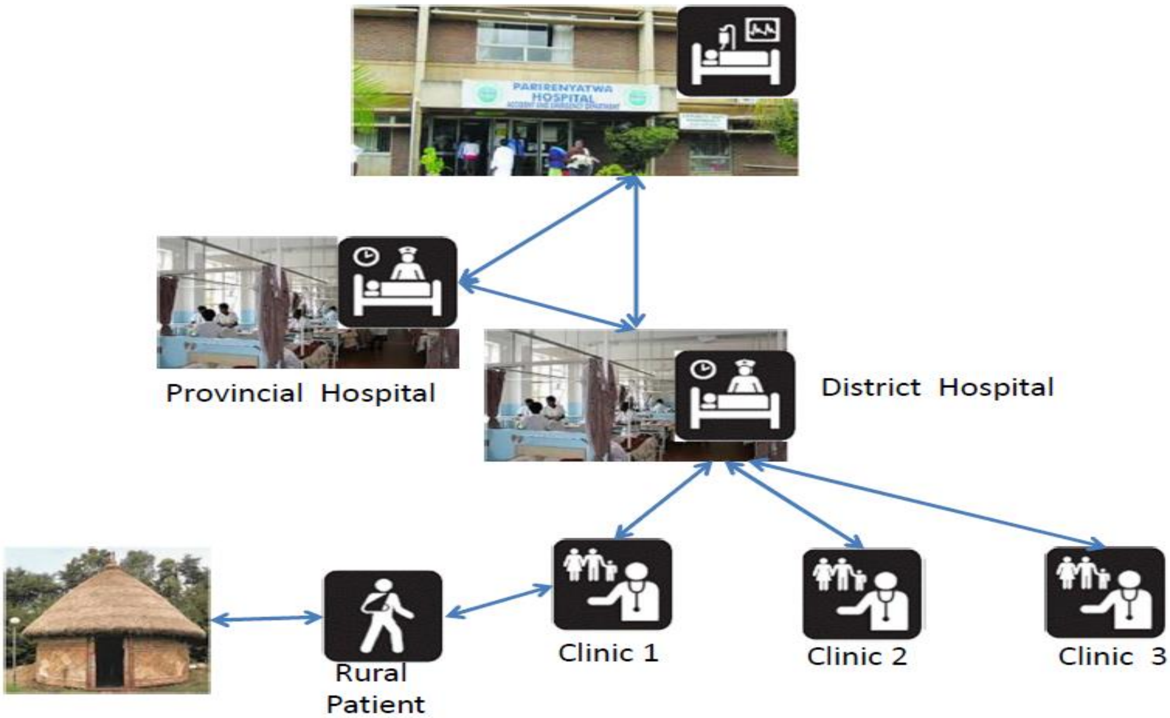

Figure II.1 – Typical telemedicine hierarchy

II.3 Market pilots and use cases for 5G – Benin experience

The use cases for 3G and 4G technologies have mainly focused on high-speed mobile, offering increased system capacity and data transfer rates. This will obviously continue in the era of 5G, with capacity and data rates determined by type of service, such as video. As users start using more interconnected devices to play games and interact, the capacity of the devices themselves will have to be increased to allow for the creation of personal networks. Even machines needing to communicate with wide area networks for alarm monitoring, home health, fleet management and many other applications will continue to be developed. It is not beyond the realms of possibility that machine clients will come to outnumber human clients. Problems that need to be solved include the manner in which the user community will have to interact with information in an environment where on-demand and high-speed mobile data have become a reality. This will entail significant changes in the design of user interfaces and the development of upper-layer functionalities. The Internet as we know it today might not be what best serves 5G users. In short, 5G involves the activation of new services and devices, the connection of new sectors and the creation of new user experiences, with the connection of persons and things in a variety of scenarios.

This section describes several anticipated 5G use cases across a handful of different sectors. It is important to remember that these comprise only a subset of possible use cases and that it is all still new. As-yet unforeseen use cases will likely emerge and 5G should be able to adapt accordingly.

II.4 Internet Of things (IoT)

By 2020, there will be a wide range of IoT applications compatible with cellular telephony, from smart utility networks to tsunami/earthquake detection sensors for public warnings. All these applications can be deployed even on current cellular networks and this has already begun. Existing cellular networks and technologies, however, will not be able to keep up with the expected rate of development of IoT applications.

In order to support potentially billions of IoT peripherals, there must be a wireless network infrastructure which is not only highly adaptable in terms of capacity, but also capable of ensuring the optimal management of the different service requirements of the various vertical IoT markets. The different service requirements can relate to various factors such as mobility, latency, network reliability and resilience and may necessitate a new architecture of key cellular network components in order to support on-demand mobility solely for devices and services.

II.5 Monitoring of smart networks and critical infrastructures

Today, societies depend on a wide range of critical infrastructures to function properly. Any malfunction or deterioration in this infrastructure can have serious financial consequences and degrade quality of life or even cause loss of life. The 2003 power outage in the north-east United States is an example of how infrastructure failure can devastate a region and its economy. Other examples of such disruptions include the structural failure of bridges and buildings, leading to the collapse or malfunction of water or sewer systems. It is important, therefore, to monitor the "health" of critical infrastructure both reliably and economically.

The monitoring of critical infrastructure is a costly undertaking and often necessitates a level of service only possible through a dedicated wired connection, for example in order to detect a defect on a high-voltage transmission line and take corrective measures to avoid cascading outages.

II.6 Smart cities

The world continues to trend towards mass urbanization, weighing heavily on municipal services, resources and infrastructures. According to the World Health Organization (WHO), six in ten people will be living in cities by 2030. Smart city initiatives aim to improve cities' efficiency in terms of costs, resources and processes, while maintaining a high quality of life for the growth of their populations. 5G will allow the real-time collection of huge quantities of data from vehicles, drivers, pedestrians, road sensors and cameras in order better to manage traffic. Also, for example, 5G-enabled sensors and actuators could help to optimize buildings' temperature, humidity and lighting levels depending on the activities taking place.

II.7 Automotive industry

Advanced driver assistance systems (ADAS) and autonomous vehicles are emerging trends in the automotive industry. Together, they offer many advantages, in particular: enhanced safety, fewer collisions, less congestion, improved fuel economy and even higher productivity for drivers. 5G wireless technologies supporting high-speed, low-latency vehicle-to-vehicle and vehicle-to-infrastructure communications are key components of ADAS and autonomous vehicles. In addition, todays drivers and passengers demand a greater variety of infotainment options, placing an added burden on wireless networks.

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