Radiocommunication Study Groups

Received: 01 June 2023

Document 5D/1679-E
15 May 2023
English only

GENERAL ASPECTS

IAFI

PROPOSALS FOR THE DRAFT NEW RECOMMENDATION ITU-R M.[IMT.FRAMEWORK FOR 2030 AND BEYOND]

1 Introduction

ITU-R Working Party (WP) 5D has been developing a draft new Recommendation ITU-R M.[IMT.FRAMEWORK FOR 2030 AND BEYOND] (Annex 3.7 to Doc. 5D/1668) based on the WP 5D work plan (Doc. 5D/1555 Chapter 2 – Annex 2.24.3). In parallel many organizations around the world have started work on 6G activities through their national, regional and global engagements.

The work carried out by the ITU-R on IMT-2030 is important for the ongoing 6G development activities globally. The Framework Recommendation being developed by ITU-R serves to communicate the overall objectives of IMT-2030 to researchers and developers around the world, thus helping them to focus their activities on a common goal. It is therefore imperative that this Framework Document captures the aspirations of the organizations engaged in 6G development activities around the world.

This contribution provides a summary of the different efforts of some of the national, regional and global organizations, based on excerpts taken from their published information and gives proposals to reflect some key elements from these documents into the framework recommendation.

2 Discussion

With ITU-R WP 5D finalizing the workplan for the evolution of the next generation of IMT technology (Doc. 5D/1555 Chapter 2 – Annex 2.24.3), administrations worldwide have initiated research and development efforts on the development of yet another highly improved, generation of wireless cellular technology that could change the way the future of communication is perceived. Each new generation provides an almost disruptive impetus to the state of technological advancement, spearheads societal change, and leaves the world wondering if we have truly understood how limitless communication technology can be.

The scope of this contribution is to provide some excerpts from the prominent national and regional efforts on the salient terrestrial IMT aspects identified for 6G candidate technology and research areas that contribute to and influence the 6G vision, technology roadmap, and ongoing R&D efforts. For this purpose, the following highlighted excerpts have been included in some of the sections of the document 5D/1704 made available by the editorial team of the correspondence group.

2.1. Excerpts taken from publication by North America Next G Alliance titled "North American Audacious Goals" (Ref: https://www.nextgalliance.org/research-priorities/north-american-audacious-goals/)

Conventional cellular networks assume fixed network topology, so the connectivity between the device and the network has been the primary focus of system design. In 6G, it is expected that radio technologies for advanced topology and networking — such as UE cooperative communication, Non-Terrestrial Networks (NTN), and mesh networking — will play more critical roles to support various non-conventional types of connectivity, as well as continuously evolving network topology to adaptively meet the varying traffic demand.

AI-based air interface design and air interface enablement for distributed computing and intelligence are recent new areas of radio technology and considered to play an important role in 6G. Through these technologies, 6G can achieve holistic end-to-end system optimization, seamless automation, and true convergence of communication and computing.

Advances in mobility management that will enable more reliable and seamless communication in mobility scenarios with interruption-free and robust data transmission and reception across radio technologies.

Waveform and multiple access technologies are expected to continue evolving to provide improved coverage, improved power efficiency, higher spectral efficiencies, and higher link efficiencies.

2.2. Excerpts taken from publication by Europe 6G-IA titled "European Vision for the 6G Network Ecosystem"

(Ref: https://5g-ppp.eu/european-vision-for-the-6g-network-ecosystem)

One of the biggest promises of the next decade is that immersive communication, holographic telepresence, and AR/VR will become our default way of communication. With 6G we should expect to approach a fully connected world, where the physical world is represented in high detail in the digital domain, where it can be analyzed and acted upon. The network would provide the links between the domains by devices embedded everywhere, as well as provide the infrastructure and the intelligence of the digital domain.

Key features of 6G will include intelligent connected management and control functions, programmability, integrated sensing and communication, reduction of energy footprint, trustworthy infrastructure, scalability, and affordability.

The 6G architecture should be sufficiently flexible and efficient to enable easy integration of everything, i.e., a network of networks, joint communication and sensing, non-terrestrial networks, and terrestrial communication, encompassing novel AI-powered enablers as well as local and distributed compute capabilities.

The use of AI everywhere in the network, where it can be beneficial, i.e., the "AI everywhere" principle, will be used to enhance network performance and to provide AI-as-a-Service in a federated network.

2.3. Excerpts taken from publication by China IMT-2030 PG titled "White Paper On 6G Vision and Candidate Technologies" (Ref: http://www.caict.ac.cn/english/news/202106/t20210608_378637.html)

From mobile internet to the internet of everything, and then to the intelligent connection of all things, 6G will realize the transition from serving people, people, and things to supporting the efficient connection of intelligent agents. Through the intelligent interconnection of people, machines and things, and collaborative integration, it will meet the needs of high-quality economic and social development, serve smart production and life, and promote the construction of an inclusive and intelligent human society.

6G will provide fully immersive interaction scenarios and support precise spatial interaction to meet the requirements for multiple senses, feeling, and mind communications. Communication for sensing and inclusive intelligence will not only improve communications, but also supercharge the digitalization and intelligence of physical objects, greatly enhancing the quality of information and communication services.

6G will build innovative networks with both ubiquitous connections among people, machines, and things and efficient interconnection of intelligent agents.

2.4. Excerpts taken from publication by India B6G titled "Bharat 6G Vision Statement".

(Ref: https://dot.gov.in/sites/default/files/Bharat%206G%20Vision%20Statement%20-%20full.pdf)

New multi-sensor man-machine interfaces and devices leveraging edge cloud computing resources and AI to deliver tactile Internet, ambience awareness and realistic 3D experiences.

Identify various spectrum needs to enable 6G in the coming years with a focus on spectrum availability and allocation among various radio services with reasonable certainty to bridge adoption lag, maximize socioeconomic benefits and provide high-speed broadband through various access technologies to address the digital divide.

A flexible, seamless integrated optical and wireless network reaching each household, even in remote villages, is what we should aim for by the end of this decade.

Space-Terrestrial Integration for ubiquitous coverage … provides an opportunity … to plug the gaps in coverage of … rural hinterland and ensure that all … have broadband connectivity no matter where they are.

2.5. Excerpts taken from publication by Japan B5GPC titled "Beyond 5G White Paper～Message to the 2030s～"

(Ref: https://b5g.jp/doc/whitepaper_en_2-0.pdf)

Immersive XR (eXtended Reality) and holographic communications … Extremely high data rates, lower latency, and larger system capacity … Not only for dense urban but also for some rural areas.

Very stringent transmission reliability and latency characteristics by extending uRLLC of 5G.

Communication in the event of natural disasters as disaster-resilient infrastructures … Characterized by the situations where failure or unstableness of the communication service could lead to severe consequences for the applications, including safety-related applications.

Integrate sensing with communication systems to realize ubiquitous sensing and receiving of those sensed data.

(Ubiquitous coverage) Interworking between the terrestrial networks and non-terrestrial networks, such as HAPS and satellites

Using AI/ML tools to optimize Beyond 5G systems in all network layers to improve the performance and efficiency on air-interface and network itself.

3 Proposal

We propose to include some salient aspects reflected in these aspirations into the draft new Recommendation ITU-R M.[IMT.FRAMEWORK FOR 2030 AND BEYOND] (Annex 3.7 to Doc. 5D/1668 as updated in Document R19-WP5D-C-1704!P1!MSW-E). These are made available in track changes in the enclosed Attachment using the output document from the Correspondence Group and highlighted in turquoise.

Since this framework document from ITU-R WP 5D serves as the beacon from a lighthouse for guiding research & development efforts globally, we further recommend that this document be developed in accordance with the ITU-R workplan in Doc. 5D/1555 Chapter 2 – Annex 2.24.3.

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Annex 3.7 to Working Party Chairman's Report

[PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[IMT.FRAMEWORK FOR 2030 AND BEYOND]

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M.[IMT.FRAMEWORK FOR 2030 AND BEYOND]

IMT – Framework and overall objectives of the future development [of the terrestrial component] of IMT for 2030 and beyond

Attachment 1.

Begin Change #1

1 Introduction

With the evolution of information and communications technologies, Ubiquitous intelligent networks would enable human being use augmented intelligence. An enriched user experience will be facilitated through seamless unification of the physical and digital worlds, built on an ecosystem of networks and device technologies. An enhanced cyber-physical world will give an immersive user experience, enable new forms of human collaboration, bring benefits to industries, and open new business opportunities.

Future IMT systems will support additional capabilities in terms of enhancements to capacity, data rates, latency, security, privacy and resilience, and also new capabilities for ubiquitous intelligence and sensing, while providing economic and efficient coverage. In addition to and along with the increasing ambitions with various use cases and enhanced performance, IMT-2030 systems will support a sustainable world through significantly improved cost, energy, and resource efficiency.

The objective of this Recommendation is to provide guidelines on the framework and overall objectives of the future development of IMT-2030.

This Recommendation is organized as follows. Motivations and societal considerations are presented followed by trends of IMT-2030 in § 2. Usage scenarios and capabilities of IMT-2030 are derived in § 3 and 4, respectively. Finally, considerations of ongoing development are described in § 5.

2 Trends of IMT for 2030 and beyond

2.1 Motivation and societal considerations

The motivation for the development of IMT-2030 is to continue to build an integrating and inclusive information society[1] and to expand its goals towards societal considerations including

[1] RESOLUTION 131 (REV. BUCHAREST, 2022) "Measuring information and communication technologies to build an integrating and inclusive information society"

UN's sustainable development goals (SDGs). To this end, IMT-2030 is expected to be an important enabler for achieving the following characteristics, among others:

– **Inclusivity**: Bridging digital divides by ensuring access to meaningful connectivity to enable the active participation of all.

– **Sustainability**: Sustainability refers to the principle of ensuring that our actions today do not limit the range of economic, social, and environmental options open to future generations. IMT-2030 is envisaged to be built on energy efficient technologies and expected to contribute towards the achievement of the UN's SDGs, e.g., to improve healthcare and learning, combat climate change, and eliminate digital divide.

– **Dependability**: It is expected to provide dependable communication, thereby contributing to a society in which people and industries can grow, deliver value, and thrive safely.

– **Innovation:** Fostering innovation with technologies supporting connectivity, facilitating productivity, efficiency and management of resources.

– **Security, privacy and enhanced resilience:** The future IMT system is expected to be built to be secure and privacy preserving by design. This is fundamental to achieving broader societal and economic goals. Further enhancements to resilience are envisaged to be a key consideration in the design, deployment and operation of IMT systems.

– **Ubiquitous Connectivity:** To connect the unconnected and bridge the digital divide in previously unserved areas, IMT-2030 is expected to include affordable connectivity and, at minimum, basic broadband services with extended coverage, including sparsely populated areas through interworking and interconnecting among various access technologies.

– **Standardization and interoperability**: To achieve wide industry support for IMT-2030, future IMT systems are expected to be designed from the start to use standardized and interoperable interfaces, ensuring that different parts of the network, whether from the same or different vendors, work together as a fully functional system.

We should expect to approach a fully connected world, where the physical world is represented in high detail in the digital domain, where it can be analyzed and acted upon. Innovative networks with both ubiquitous connections among people, machines, and things and efficient interconnection of intelligent agents could be built. New multi-sensor man-machine interfaces and devices leveraging edge cloud computing resources and AI to deliver tactile Internet, ambience awareness and realistic 3D experiences. The network would provide the links between the domains by devices embedded everywhere, as well as provide the infrastructure and the intelligence of the digital domain.

End Change #1

Begin Change #2

2.3.1 Emerging technology trends and enablers

IMT-2030 is expected to consider a new AI-native air interface that uses AI to enhance performance of radio interface functions such as symbol detection/decoding, channel estimation etc. An AI-native radio network would enable automated and intelligent networking services such as intelligent data perception, supply of on-demand capability etc. Radio network to support AI services would be the fundamental design of IMT technologies to serve various AI applications, and

the proposed directions include on-demand uplink/sidelink-centric, deep edge and distributed machine learning.
The integration of sensing and communication functions in IMT-2030 systems would provide beyond-communication capabilities by utilizing IMT systems more effectively resulting in mutual benefit to both functions. Integrated sensing and communication functions would also enable innovative services and applications such as intelligent transportation, gesture and sign language recognition, automatic security, healthcare, air quality monitoring, and solutions with higher degree of sensing accuracy. Combined with technologies such as AI, network cooperation and multi-nodes cooperative sensing, the integration of sensing and communication functions would lead to benefits in enhancing mutual performance and reducing overall cost/size/power consumption of the whole system.

Radio technologies for advanced topology and networking — such as UE cooperative communication, Non-Terrestrial Networks (NTN), and mesh networking — will play more critical roles to support various non-conventional types of connectivity, as well as continuously evolving network topology to adaptively meet the varying traffic demand.

Computing services and data services are expected to become an integral component of the future IMT system. It is expected to include processing data at the network edge close to the data source for real-time response, low data transport costs, high energy efficiency and privacy protection, as well as scaling out device computing capability for advanced application computing workloads.

End Change #2

Begin Change #3

2.3.2 Technologies to enhance the radio interface

New advanced modulation methods to overcome RF impairments at high frequencies may be considered to achieve better performance. Technologies may also consider advanced coding schemes such as advanced versions of polar coding, LDPC and other coding schemes, etc. for extreme performance and diverse use cases. Advanced waveform design among orthogonal, bi-orthogonal, non-orthogonal methods would be beneficial in specific scenarios to guarantee desirable performance. For multiple access, technologies including non-orthogonal multiple access (NOMA) as well as grant-based and grant-free multiple access are expected to be considered. Waveform and multiple access technologies are expected to continue evolving to provide improved coverage, improved power efficiency, higher spectral efficiencies, and higher link efficiencies.

Extreme MIMO (E-MIMO) would deploy a new type and a much larger-scale antenna arrays, a distributed mechanism as well as AI assistance, which is expected to achieve better spectrum efficiency, larger network coverage, accurate positioning, accurate sensing, and higher energy efficiency, etc.

Self-interference cancellation (SIC) technology in devices and networks would enable in-band full duplex (IBFD) in future mobile communications to enhance the spectrum efficiency and suppress the interference between co-located heterogeneous systems, especially for high-power and massive MIMO scenarios.

Techniques such as reconfigurable intelligent surfaces (RIS), holographic radio (HR) and orbital angular momentum (OAM) are potential technologies to improve the performance and overcome the challenges in traditional beam-space antenna array beamforming.

Sub-THz and THz frequency resources could potentially provide bandwidths up to hundreds of GHz. Communications using such frequency resources are envisioned as key enablers for many future use cases (e.g. the use cases with extremely high-data-rate, low latency, high-resolution sensing and imaging, and high-precision positioning, etc).

Ultra-high accuracy positioning can be supported by ultra-wide bandwidth and E-MIMO in a millimetre wave or terahertz band, as well as carrier phase positioning (CPP) based on cellular signals, AI/Machine learning (ML) positioning techniques and integrating data communication and device positioning. The use of AI everywhere in the network, where it can be beneficial, i.e., the "AI everywhere" principle, will be used to enhance network performance and to provide AI-as-a-Service in a federated network.

2.3.3 Technology enablers to enhance the radio network

RAN slicing allows multiple independent logical networks to be created on a common shared physical infrastructure. Future IMT is expected configure the slices to satisfy the specific needs of applications, services, customers, or network operators.

QoS requirements vary from one user to another. The future network would need to be resilient and soft in QoS provisioning (e.g., user-centric, service-oriented, flexible and powerful in capabilities, guaranteed in QoS, and consistent in user experience). Technologies such as the QoS guarantee mechanism, deterministic RAN, etc. can be considered.

RAN architecture would be reformed and simplified to achieve the goals of strongest capability, simplest architecture and plug-and-play in future IMT systems. This reform and simplification may be attained from approaches such as data, operation, information, and communication technologies (DOICT), convergence-driven RAN architecture, native-AI enabled RAN functions, a thinner or lite protocol stack design, RAN node cooperation and aggregation and the user-centric network (UCN) architecture, etc. The architecture should be sufficiently flexible and efficient to enable easy integration of everything, i.e., a network of networks, joint communication and sensing, non-terrestrial networks, and terrestrial communication, encompassing novel AI-powered enablers as well as local and distributed compute capabilities.

With real-time interactive mapping between the physical network and virtual twin network, digital twin networks (DTNs) can help efficiently and intelligently investigate, simulate, deploy, and manage IMT-2030 networks.

The interconnection of terrestrial IMT and non-terrestrial communications aims to enable future terrestrial IMT technology to support seamless interconnectivity with non-terrestrial networks (NTN), including satellite communications, high altitude platform stations (HIBS) and unmanned aircraft systems (UASs) as IMT base station platforms.

An ultra-dense network (UDN) is implemented by increasing the densification of transmission reception points (TRxPs). It may be an effective way to fulfil various requirements such as user experienced data rates, connection density, energy efficiency, spectrum efficiency, area traffic capacity, coverage, etc.
New technologies such as trusted data storage, secure sharing, and service-based architecture of RAN would enhance RAN infrastructure sharing in terms of transparency, reliability and rapid response.

End Change #3

Begin Change #4

3 Usage scenarios of IMT-2030: Communication based and beyond communication

[Editor's note: The introductory text needs to be reviewed at the next WP 5D #44 meeting].

IMT-2030 is expected to expand and support various user, application and technology trends as described in § 2, while providing prospects towards digital transformation.
IMT-2030 is envisaged to encompass both communication-based and beyond communication usage scenarios, which are use cases enabled by a common set of capabilities.

[IMT-2030 is envisaged to provide an interactive and immersive communication experience for mobile users, be massively scalable, and handle critical and secure communication. It will extend/enhance AI and sensing capabilities with ubiquitous but graded computing where real time data processing is required.]

IMT-2030 is expected to be built on overarching aspects which act as design principles commonly applicable to all usage scenarios. These distinguishing design principles of the IMT-2030 system are including, but are not limited to, sustainability, [connecting the unconnected/Global connectivity,] security/privacy/resilience and ubiquitous intelligence for improving overall system performance.

[Connecting the unconnected or Global connectivity includes providing affordable connectivity at minimum basic broadband services with extended coverage, including remote and sparsely populated areas thus contributing to achieving the UN SDGs such that all human beings independent of the location of the user are provided universal and affordable access as targeted by SDG-9.]

3.1 Communication-based usage scenarios

Usage scenarios of IMT-2030 are envisaged to encompass usage scenarios which expand the usage scenarios of IMT-2020 (i.e., eMBB, URLLC, and mMTC) into broader use requiring evolved and new capabilities.

The usage scenarios of IMT-2030 are:

[Immersive Communication]

[This usage scenario extends the enhanced Mobile Broadband (eMBB) of IMT-2020 and covers use cases which provide a rich and interactive video (immersive) experience to users, including the interactions with machine interfaces.

This usage scenario covers a range of environments, including hotspots, urban and rural, which come with additional and new requirements compared to those of eMBB from IMT-2020.

[Editor's note: The use cases of industrial robots could be integrated in Usage Scenario B.]

Typical use cases include communication for immersive extended reality (XR), remote multi-sensory telepresence, and holographic communications, etc. Supporting mixed traffic of video, audio, and other environment data in a time-synchronized manner is an integral part of immersive communications, including stand-alone support of voice.

[Editor's note: The capabilities related to usage scenario "Immersive Communication" need to be reviewed together with section 4 on "Capabilities"].

Capabilities that aim for enhanced spectrum efficiency and consistent service experiences along with leveraging the balance between higher data rates and increased mobility in various environments, are essential. Certain immersive communication use cases may also require high reliability and low latency for responsive and accurate interaction with real and virtual objects, as well as larger system capacity for simultaneous connecting numerous devices.]

Extreme[/critical] Communication // Extremely Reliable Low-Latency Communication

This usage scenario extends the Ultra-Reliable Low-Latency Communication (URLLC) of IMT-2020 and covers specialized use cases that are expected to have more stringent requirements on reliability and latency. This is typically for time-synchronized operations, where failure to meet these requirements could lead to severe consequences for the applications.

[Editor's note: This text on typical use cases of Usage Scenario B to be reviewed together with Usage Scenario E on typical use cases].

Typical use cases include communications in a factory among machines for full automation, control and operation. These types of communications can help in realizing various applications such as robotics interaction including tactile feedback and monitoring, drone operation, remote medical assistance, energy transmission and distribution, etc. Communication in the event of natural disasters as disaster-resilient infrastructures characterized by the situations where failure or unstableness of the communication service could lead to severe consequences for the applications, including safety-related applications are to be targeted.

End Change #4

Begin Change #5

5.1.2 Relationship between IMT-2030 terrestrial network and non-terrestrial network, as well as other access systems

Mobile users want to access services anytime, anywhere. To achieve this goal, interworking is expected to be necessary among various access technologies. While each access system would fulfil its own role, it could also be interworking with other access systems to achieve service and operational goals among which to provide ubiquitous coverage.

The ongoing development of non-terrestrial network within IMT-2030 is expected to support the interconnectivity between terrestrial network and non-terrestrial network (including satellite communications, high altitude platform stations (HIBS) and unmanned aircraft systems (UASs) as IMT base station platforms) to offer service continuity, expand accessibility and improve reliability in network connectivity. Space-Terrestrial Integration for ubiquitous coverage provides an opportunity to plug the gaps in coverage of rural hinterland and ensure that all have broadband connectivity no matter where they are.

IMT-2030 is also expected to interwork with other radio systems, such as RLANs, broadband wireless access, broadcast networks, and their possible future enhancements.

End Change #5