Key features and requirements of 5G/IMT-2020 networks

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Outline

• Distinguishing features of 5G/IMT-2020 networks
• High level requirements of 5G/IMT-2020 networks

NOTE 1 – Only a limited set of topics is addressed (see [ITU-T Y.3101] for a wider perspective)

NOTE 2 – Along the presentation some references are provided on relevant achievements and ongoing work items of the ITU-T IMT-2020 standardization initiative (SG13) - see also backup slides
Gaps and challenges towards 5G/IMT-2020

Other network dimensions with gaps for 5G/IMT-2020 expectations:
- business agility (diversity of services and business models)
- operational sustainability (end-to-end management and deployment, flexibility, scalability, energy efficiency)

Source: NGMN 5G White Paper
5G/IMT-2020 as key driver for industrial and societal changes: enabler of a large variety of applications

- Optimization and/or expansion of existing applications (extended coverage, enhanced features)
- New applications (verticals and advanced applications enabled by technology integration)
Diverse application-specific requirements to be supported

5G/IMT-2020 objective:
- to ensure flexibility and adaptation to diverse (and changing) requirements of applications with maximum reusability of (common) network infrastructure capabilities
- and efficient but open integration between application and 5G/IMT-2020 ecosystem (business models diversity)

Source: ITU-R Rec. M.2083
5G/IMT-2020 vision - functional view

- Softwarization
- Flexibility
- Customization

- Service-based architecture and functions interaction
- Modularization of functions
- Separation between Control Plane (CP) and User Plane (UP)
- Network Slicing
- Flexible User Plane
- Fixed Mobile Convergence (through converged Control Plane and simplified User Plane)

Source: China Mobile
Network softwarization

Network softwarization [Y.3100]: *Overall approach for designing, implementing, deploying, managing and maintaining network equipment and/or network components by software programming*

Key drivers of Network softwarization
- pervasive diffusion of ultra-broadband (fixed and mobile)
- increase of performance of HW at lowering costs
- growing availability of Open Source SW
- more and more powerful terminals and smart things
- actionable Big Data and AI/ML advances

Network softwarization is paving the way towards **X-as-a-Service**
- SDN Controllers, Virtual Network Functions and end users’ applications all considered as “services”

**Network functions become flexible**
- New components can be instantiated on demand (e.g. dedicated network dynamic setup)
- Components may change location or size (e.g. deployment at edge nodes, resource reallocation)
- Communication paths may change (e.g. service aware networking, chained user plane functions)

Enablement of network/service architectures (re-)design, cost and process optimization, self-management

**Network programmability** but also increased complexity [network management impact]

See also ITU-T Y.3150
Network Functions Virtualization (NFV): ICT ecosystem disruption

NFV is about implementing network functions in software (programs) running on top of industry-standard hardware (instead of dedicated hardware)

**NFV benefits**
- Reduced CAPEX and OPEX (e.g. power consumption)
- Increased efficiency (several tenants on same infrastructure)
- Flexibility to scale up/down resources
- Agility (improved time-to-market to deploy new network services)
- Lower dependency on network vendors

Some issues to be fully addressed, incl.
- Performance, co-existence, resilience, scalability, vendor integration
Software Defined Networking (SDN)

SDN is a set of techniques enabling to directly program, control and manage network resources, which facilitates design, delivery and operation of network services in a dynamic and scalable manner.

**SDN benefits**
- Faster network business cycle
- Acceleration of innovation and rapid adaptation to demand
- Increase in resource availability and efficiency of use
- Customization of network resources including service-aware networking

**Concept of SDN**

*Source: ITU-T Y.3300*
Separation between Control Plane and User Plane

- Authentication
- Charging
- Policy
- MM
- SM
- ... ...
- Packet Forwarding

- Authentication
- Charging
- Policy
- MM
- SM
- ... ...
- Access Control
- Packet Forwarding

- CP
- Open interfaces (in accordance with SDN principles)

- UP
- UP
- UP

Different User Planes under control of a unified Control Plane

- Scalability
- Independent evolution of both planes
- Flexible network function deployment
Edge Computing: computing and storage resources next to the user

**Low latency applications**

- **Autonomous Devices**
  - Drones
  - Self-Driving Cars
  - Robotics

- **Immersive Experiences**
  - Interactive Environments
  - Virtual Reality
  - Augmented Reality

- **Natural Interfaces**
  - Voice Control
  - Motion Control
  - Eye-Tracking

**Edge Computing benefits**

- **(Ultra-)low latency**: disruptive improvement of customer experience
- **Reduction of backhaul/core network traffic**: cloud services (e.g., big data) near to user
- **In-network data processing**

**Some issues to be fully addressed, incl.**

Resource limitation, more complexity, inefficient application execution, service continuity and mobility
A distributed functional architecture

Distribution of network functions - example

Provisioning of diverse network services by using network functions instantiated at the right place and time
Network slicing: customized support of applications via dedicated logical networks over single infrastructure

**Network slice [ITU-T Y.3100]:** A logical network that provides specific network capabilities and network characteristics.

**Various dimensions of network slicing:**
- slice types and blueprint (template)
- blueprint information (incl. service requirements, priority, resource isolation level, etc.)
- static versus dynamic slice instantiation
- service assurance and service integration
- recursive slicing (diverse business models)
- end-to-end versus per-domain slice (sub-network slices, incl. radio slicing), inter-domain slice federation
- per-slice network function chaining
- slice-specific and shared network functions
- slice lifecycle mgmt (within globally optimal network mgmt)
- UE-slice interaction (flexible slice selection, ...)
- slice exposure of end-to-end slices to customers

**5G/IMT-2020 network has to support flexible and dynamic management of network slices for various diverse applications, ensuring scalability, high availability and overall resource optimization**
Example of IMT-2020 network deployment from network slicing perspective

**Vertical slicing**

**Horizontal slicing** [can operate in single slice or across multiple vertical slices]

Each slice is architected and optimized for specific application(s)
Each slide can have its own network architecture, engineering mechanisms and network provision

Source: draft ITU-T Y.IMT2020-frame
Application of slicing techniques to 5G/IMT-2020 network transport layer - ongoing study in ITU-T SG15

Source: China Mobile
Network management and orchestration

Softwarization impacts network management
- New types of failure (underlying infrastructure, virtualization)
- Dynamic deployment of components
- Increased accounting options
- Adaptation to required performances
- Wider spectrum of attacks (cloud infrastructure, sharing)

Overall network management and network slice lifecycle management
- Level of isolation between network slices
- Blueprint (Template) based network slices
- Network slice-specific policies and configurations
- Overall orchestration of physical and logical resources
- Integrated management of legacy networks

Sources: ITU-T Y.3110, Y.3111
Heterogenous Access Networks and common Core Network

- Integration of existing and new Access Networks (ANs) (new RATs as well as evolved IMT-advanced RATs, Wireless LANs, fixed broadband, satellite)
- ANs for specific verticals may require specific network functions and technologies
- Minimized AN-CN dependency with access-agnostic common CN (common AN-CN interface and common control decoupled from AN technologies)
- Expectation of unified authentication and authorization framework across different ANs - see also FMC unified user identity

Source: ITU-T Y.3101
**Motivations for FMC**

**Service perspective** (seamless experience and ubiquitous service availability)

- Unified user identity
- Unified charging
- Service continuity and guaranteed QoS

**Network perspective** (mutual coordination and evolution)

- Simplified network architecture (converged functions, flexible operation via AN coordination, resource sharing)
- OPEX & CAPEX reduction (common functions, common user profile data)

**Requirements [ITU-T Y.3130]**

- Traffic switching, splitting and steering between fixed AN and mobile AN on network side
- Traffic switching, splitting and steering on user side
- Other requirements ...
Support of diverse business models will be critical to the successful deployment of 5G/IMT-2020 networks. Investigating key business roles and models of 5G/IMT-2020 ecosystem(s) will benefit technical standardization:

- Identifying relevant use cases where business roles can interact in multiple ways enabling diverse business models promotes linkage between concrete deployments and standardization (network requirements, functional architecture, open interfaces).

**Ongoing draft ITU-T SG13 Y.IMT2020-BM**

- Analyses best practice use cases from different perspectives, building on key features of 5G/IMT-2020 networks
- Identifies key business models and roles (cannot be exhaustive)

**Use cases under investigation**

- Network slicing based services
- Vertical services
- Other services - Device to Device, AR/VR
- For further discussion: Big Data services? Cloud services?

*Source: ongoing draft Y.IMT-2020-BM*
Integrating Machine Learning (ML) technologies in 5G/IMT-2020 networks

ML has potential for network design, operation and optimization
- coping with highly increased complexity (reducing model-reality mismatch)
- enhancing efficiency and robustness of network operations (e.g. by reducing number of measurements and facilitating robust decisions)
- increasing network self-organization feasibility (cognitive network management)
- providing reliable predictions [pro-active strategies] (e.g. adaptive QoS in highly dynamic automotive slices)

Also, ML has potential to enable new advanced applications

Some challenges
- stringent requirements of many applications (latency)
- robust ML with small data sets and under latency constraints
- distribution of data at different locations and diverse data formats
- distributed learning for efficient usage of scarce resources
- (wireless) channel noise, dynamicity and unreliability
- good tracking capabilities
- exploitation of context information and expert knowledge (hybrid data/model-driven ML approaches)

(SG13-launched) New ITU-T Focus Group on “Machine Learning for Future Networks including 5G” (FG-ML5G)

https://www.itu.int/en/ITU-T/focusgroups/ml5g/Pages/default.aspx
Thank you very much for your attention
Backup information
## Existing ITU-T standards related to IMT-2020

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<th>Domain</th>
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<td><strong>General</strong></td>
<td>Y.3100: Terms and definitions for IMT-2020 network</td>
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| **Services, Architecture and Management** | Y.3011: Framework of network virtualization for future networks  
Y.3012: Requirements of network virtualization for future networks  
Y.3300: Framework of software-defined networking  
Y.3320: Requirements for applying formal methods to software-defined networking  
Y.3321: Requirements and capability framework for NICE implementation making use of software-defined networking technologies  
Y.3322: Functional Architecture for NICE implementation making use of software-defined networking technologies  
Y.3101: Requirements of the IMT-2020 network  
Y.3110: IMT-2020 Network Management and Orchestration Requirements  
Y.3111: IMT-2020 Network Management and Orchestration Framework  
Y.3130: Requirements of IMT-2020 fixed-mobile convergence  
Y.3150: High level technical characteristic of network softwarization for IMT-2020  
Y.3100-series Supplement 44: Standardization and open source activities related to network softwarization of IMT-2020 |
| **Data**                      | Y.3031: Identification framework for future networks  
Y.3032: Configuration of node IDs and their mapping with locators in future networks  
Y.3033: Framework of data aware networking  
Y.3034: Architecture for interworking of heterogeneous component networks in FNs  
Y.3071: Data Aware Networking (Information Centric Networking) – Requirements and Capabilities |
| **Environmental aspects**     | Y.3021: Framework of energy saving for future networks  
Y.3022: Measuring energy in networks |
| **Socio-Economic aspects**    | Y.3013: Socio-economic assessment of future networks by tussle analysis  
Y.3035: Service universalization in future networks |
| **Smart Ubiquitous Networks** | Y.3041, Y.3042, Y.3043, Y.3044, Y.3045 |
FG-ML5G working groups and objectives – 1/3

WG1

Specific questions to be addressed include:

- What are the relevant use cases and derived use cases requirements for ML?
- What are the standardization gaps?
- What are the liaisons activities?

Tasks include, but are not limited to:

- Specify important use cases.
- Derive minimum requirements regarding those use cases to be shared with WG2 and WG3.
- Analyze technical gaps related to the use cases and its ecosystem

Deliverables

- Use cases
- Ecosystem, terminology and services
- Requirements and standardization gap

NOTE – FG-ML5G meetings:
- 1st meeting: 29 Jan -1 Feb 2018 (Geneva) (Workshop on Machine Learning for 5G and beyond, 29 Jan 2018)
- 2nd meeting: 24, 26 -27 April 2018 (Xi’an, China) & Workshop on Impact of AI on ICT Infrastructures, 25 April 2018
FG-ML5G working groups and objectives – 2/3

WG2

Specific questions to be addressed include:

• How should data be collected, prepared, represented and processed for ML in the context of communication networks?
• What are the privacy and security implications on data formats and ML?
• Categorization of ML algorithms in the context of communication networks, i.e., how do different ML methods fit to different communications problems?
• How can current ML technology be used in a distributed setting (e.g., efficient representation of ML models, efficient at-terminal computation, distributed learning with reduced overhead)?
• What are the standardization and technology gaps?

Tasks include, but are not limited to:

• Analysis of ML technology and data formats for communication networks, with special focus on the uses cases of WG1.
• Providing input to WG3 on data formats and ML technology, and incorporate output from WG3 on ML-aware network architectures.
• Identification of standardization and technology gaps.
• Liaisons with other standardization organizations.

Deliverables

• ML algorithms in communication networks: categorization, terminology & implications
• Data formats including privacy and security aspects for ML in communication networks
• Standardization and technology gaps
FG-ML5G working groups and objectives – 3/3

WG3

Specific questions to be addressed include:

• What are the implications of ML (including distributed ML) on network architectures?
• What are the requirements imposed by ML on network architectures in terms of computational power, energy, storage, interfaces, communication resources (e.g. which interfaces are needed to support ML-based network optimization)?
• What are the standardization gaps?
• What are the liaisons activities?

Tasks include, but are not limited to:

• Analysis of implications of ML (including distributed ML) on network architectures
• Incorporate output from WG1 on use cases and requirements and WG2 on data formats
• Analysis of functions, interfaces, resources imposed by ML on network architecture
• Gap analysis based on the tasks of different standard organizations
• Other topics can also be studied as appropriate, based on contributions.

Deliverables

• Analysis of communication network architectures from the viewpoint of ML
• Description of ML-related functions, interfaces and resources for communication network architectures
• Standardization and technology gaps