"Future technology trends towards 2030"

Geneva, Switzerland, 24 - 25 July 2023

Session 1: IMT-2030 (network aspects)

Takeaways and Conclusions

5 presentations, covering topics for IMT-2030 framework/vision, issues, key technologies, architecture directions and hardware solutions for sub-THz systems.

1. ITU-R framework/vision for IMT-2030: motivations, technology trends, 6 use scenarios, 9 enhanced capabilities, 6 new capabilities
2. Architectural thought on IMT 2030: Limitations of IMT-2020 architecture; initial thoughts on IMT-2030 architecture: disaggregated data plane (for multi-RAT RAN) & control plane
3. IMT-2030 architecture design (3 bodies, 4 layers, 5 planes) and key technologies: AI-native, CNC, FMSC, DTN, …
4. DIG based solutions for sub-THz wave guide: easy to design and fabricate by 3D printers
5. IMT-2030 architecture issues for supporting sustainability, dense deployment, AI-native, immersive communication, sensing integrated communication, etc. and design directions (new RAN, generic API, pub-sub, computing integrated, etc.)

Suggestions to ITU-T

- Making workplan of standardization of architectural component technologies aligning with ITU-R IMT-2030 timeline
- Picking up key technologies of IMT-2030 (network aspects) identified in ITU-R Report M.2516 and framework Recommendation, and initiate studies in coordination with relevant SDOs
- Harmonizing SG13 ongoing studies on component technologies (e.g., FMSC, CNC, digital twin, DLT, AI/ML for network and by network, deterministic communications) with IMT-2030 framework.
- Studying potential new architectural directions, e.g. disaggregated data/control plane functions and interfaces that meet stringent requirements of deterministic communications, etc.
- Participating/leading IMT-2030 (network aspects) standardization coordination activities

Session 2: IMT-2030 (networks aspects)

Takeaways and Conclusions

SG15 support for IMT networks

1. SG15 has supported IMT networks driven by 5G requirements and various technologies under study will be critical also for IMT-2030 such as SDM and enhanced synchronization
2. Large industry participation and ecosystem collaboration are key in the achievements of SG15

AI-native Open RAN for 6G

1. Intelligence and openness are core principles of evolving RAN with RICs (RAN Intelligent Controllers) bringing value in network automation and orchestration
2. O-RAN RIC as practical enabler for AI-native RAN between evolutionary (3GPP) approach and revolutionary (AI-native radio system) approach
3. Autonomous networks and AI-native networks have the potential to revolutionize the way we use and manage networks

Suggestions to ITU-T

- Industry participation and collaboration in the ecosystem are expected to be key also in the IMT-2030 standardization – with the approach and technologies progressed within SG15 to remain essential for the IMT-2030 transport networks

- AI-native networks are expected to be an essential area of study in the IMT-2030 standardization roadmap (building and extending ongoing study areas such as Intent Based Networking, Self Organizing Networks, Autonomous Networks)
- **ITU-T collaboration in the ecosystem is required to investigate and evaluate approaches for the introduction of AI-native capabilities in/across different segments of the network, according to key requirements such as flexibility, interoperability, reliability and performance**

Session 2: IMT-2030 (networks aspects)

Takeaways and Conclusions

AI technologies for IMT-2030

1. AI technologies enhance network intelligence in terms of perception, OAM and orchestration (application example: intelligent customer service)
2. But AI capabilities need to be trustworthy, adhering to basic principles, and agreed metrics, of trustworthiness
3. A holistic AI approach for IMT-2030 – with AI capacity atomization - requires collaboration between large and small models

Next generation distributed edge infrastructure

1. O-RAN nGRG provides a forum to facilitate O-RAN related 6G research (2025-2027 as target of O-RAN 6G collaboration with other SDOs)
2. Major changes, and challenges, will involve the next generation Distributed Edge Infrastructure - 5G Adv /6G use cases and features (3GPP Rel. 17 and beyond) are imposing new requirements
3. Towards an AI (Federated Learning/Cross Domain) infused 6G Edge, sustainable and quantum secure

Suggestions to ITU-T

- Studies on collaborative (distributed) AI atomized capacities in the network should be progressed forward for a holistic integration of AI technologies in IMT-2030
- On the other hand, this implies that AI trustworthiness studies need to be developed further to ensure ubiquitous trustworthy AI capabilities in the network

- IMT-2030 use cases and features impose the evolution of the different network components: it is necessary that the IMT-2030 architectural studies ensure the flexibility to accommodate different use cases and associated requirements

Session 2: IMT-2030 (networks aspects)

Takeaways and Conclusions

Speaking same language in 2030

1. Collaboration on standards – with commitment and common timelines - helps ensure that important topics such as energy efficiency, sustainability, inclusion, human rights, and safety and privacy regulations are discussed alongside technical aspects such as radio spectrum allocation
2. To shape 6G standards to support interoperability (cross-domain interoperability is key) and innovation, and encourage a healthy and transparent service environment (FRAND patents and standards incentivize a healthy ecosystem)
3. One Global 6G, avoiding fragmentation, regional solutions and unnecessary complex options

Suggestions to ITU-T

- Speaking same language in 2030 is a call for action for ITU and the global standardization community
- The proven collaboration between ITU and 3GPP has fundamentally followed an approach which should have a central role for IMT-2030 too, with government-lead ITU defining vision and framework, industry-lead 3GPP developing the basic technical standards, and ITU conforming against requirements
- An interoperable metaverse is a key driver for network evolution and ITU is required to play a leading role in its framework setting

Session 3: The next Web (Emerging Web technologies)

Takeaways and Conclusions

1. Many technical issues exist for standardization of the emerging web technologies
   - Identifier (ID), Digital assets, Distributed Ledger Technology (DLT), Trust, Privacy, etc.
2. Make, manage, utilize, and trade digital assets
   - Privacy-preserving vs. raw data
   - Define Model, Protocol, Incentive in technical level
3. DLT as application and infrastructure
   - Network infrastructure with DLT, DLT Interoperability
4. Spatial Web and Metaverse
   - Other view on the emerging Web (New models, protocols, standards, etc.)
5. Various views on trust
   - Trust provisioning and Trust level based approaches
   - Zero Trust based approaches
     - zero knowledge vs. with knowledge

Suggestions to ITU-T

1. Consider how to embrace emerging Web technologies as a lead group on future networks, cloud computing, and machine learning
   - Extracting key technical standardization items on the emerging Web technologies
   - Narrow down the scope to meet SG13 mandates
     - Emerging Web technologies as application vs. infrastructure level approaches
2. Collaborate with Focus Group on Metaverse
   - Extracting useful inputs for supporting spatial web and metaverse (e.g., use cases and requirements)
3. Trust issues are still important
   - SG13 has continuously developing “trustworthy networking and services” work items (ITU-T Y.305X series) - Keep encouraging activities

Session 4: The next Web (Emerging Web technologies)

Takeaways and Conclusions

1. Novel way to governance AI frameworks that depend on factors such as intelligence capabilities, autonomy levels, and trust and go from centralized to federated to distributed AI governance
2. Use a holistic and adaptive approach to governance in managing the interoperability of autonomous AI systems and various governance frameworks
3. Decentralize trust boundaries (grant autonomy) entity to be able to focus on security and performance
4. Use a prospective approach to measuring trust by using Trust Indicators (TIs) that are feasible that cover different aspects of trust instead of the direct trust approach
5. Implementing a Zero Trust Architecture using blockchain technology with smart contracts

Suggestions to ITU-T

- Examine the possibility to develop multi-dimensional standards for AI and Autonomous Intelligent Systems that also integrate technical, social, legal, and physical factors
- See the possibility to use blockchain technology to establish trust between network slice stakeholders and implement the Zero Trust Architecture using blockchain technology with two smart contracts
- Implement Multiparty Zero Trust (Networks) under Zero Knowledge (MZTZK)
- Develop the TrustFlow module that processes real-time date and quantifies the trust of an entity using the deterministic-based Quantification and the Machine Learning-based Quantification.

Session 5: Quantum Network – Research status

Takeaways and Conclusions

1. Quantum Network has actively been developed
   - Entanglement is a key aspect
   - Packet-switching approach is also considered for cost effectiveness and user scalability
2. Quantum Network needs new protocol
   - Multiple approaches to quantum repeater
   - Various proposals for protocol stack
3. Quantum Network will be the next ICT infra
   - Entanglement-based QKDN system is feasible
   - QKDN (including satellite) is the primary form
   - How to integrate QKDN into existing and upcoming infrastructure should be considered

Suggestions to ITU-T

1. Standardization of Quantum Network
   - Meets the mandate of SG13 “future networks and emerging network technologies”
   - Will be one of key study items for NSP (Next Study Period)
2. Encouraging activities are,
   - Understanding of quantum physics
   - Collaboration among SGs and SDOs
     (i.e., Roadmap-based approach)

Session 6: Quantum Network – Panel discussion

Takeaways and Conclusions

1. QKDN has successfully developed in ITU
   - Q.16/SG13 – QKDN general
   - Q.6/SG13 – QKDN QoS
   - Q.2/SG11 – QKDN protocols
   - Q.15/SG17 – QKDN security
   - FG on QIT4N (including CCSA)
   - JCA-QKDN

2. QKDN will continuously be active study items
   - Entanglement-based QKD network
   - Interfaces, security, QoS, etc.

Suggestions to ITU-T

- **Consistency among Docs. And SGs**
  - **Collaboration each other under the leadership of JCA-QKDN**
  - **Consideration of updating the standardization roadmap**

- **Following FG QIT4N, further quantum-related study items should be activated.**

Session 7: Deterministic Communications and Services

Takeaways and Conclusions

1. Clocks and synchronization are fundamental for deterministic communications/services and URLLC. New time synchronization mechanism introduced with proof of concept demonstrations.
2. Latency and Jitter upper bound guarantee for large scale networks is also critical for deterministic communications/service. Completed and on-going Wis are introduced.
3. 3GPP standardization efforts for supporting deterministic communications and services, especially collaboration with IEEE and IETF on TSN well elaborated.

Suggestions to ITU-T

1. Currently SG13 is develop a number of deterministic communications and service standards for IMT-2020 networks but do not address time synchronization issues.

2. Considering the importance of the topic, SG13 needs to consider the impact and how it can be addressed in association with the existing WIs or future Wis.

Session 8: Deterministic Communications and Services (Part 2)

Takeaways and Conclusions

1. TSN for industrial applications as a core enablers. Impacts and benefits introduced in details.
2. 5G-TSN integration pros and limitations introduced. Deep reinforcement learning based 5G-TSN joint scheduling solution is introduced to overcome limitation. Industrial application demonstration is verified the proposed solution
3. Issues for differentiated QoS of diversified deterministic communications introduced.
4. 3 talks all well addressed the importance of deterministic communications for industrial applications from TSN, 5G, 5G-TSN perspectives and limitations are identified and ways of improvement are proposed.

Suggestions to ITU-T

1. Currently SG13 is develop a number of deterministic communications and service standards for IMT-2020 networks are not enough to address the results of gap analysis provide by the 3 presentations.

2. Additional work items to fill the gaps are proposed

3. Need more intensive gap analysis with other related SDOs such as IEEE TSN, IETF DETNET, and 3GPP and more tighter collaboration need to be addressed.

Wrap Up

Takeaways and Conclusions

1. Visions for Future Telecommunication Infrastructure and Services
   - The next Web (Emerging Web technologies)
2. Emerging Networks
   - IMT-2030 (networks aspects)
   - Quantum Network
3. Enhancement and Improvement of Fundamental Technologies
   - Deterministic Communications and Services

Suggestions to ITU-T

- **Preparing the next 10 years for the 2030 timeframe and beyond**
  - Next Study Period – Restructuring of Qs
  - Focus Groups
  - JCA
- **Towards Digital Economy Infrastructure**
  - Expanded roles of networks
  - Paradigm shift – Decentralization, User-centricity
- **Integration of multiple existing technologies**
  - AI/ML, Blockchain/DLT, Quantum, Trust
  - Innovative Services