6G Research Process in China

-- Establishing the Technical Framework for ‘Intelligent Connection of Everything’

IMT-2030(6G) Promotion Group

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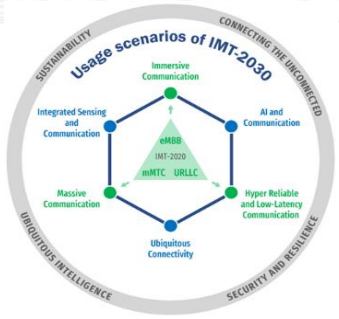
Building technical framework based on 6G vision

6G Vision

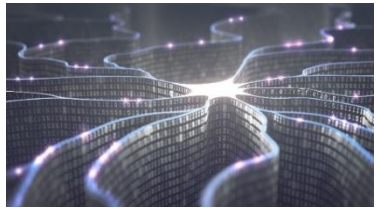
Digital twin, intelligent connection of everything



- **Immersive Cloud XR**
- **Holographic communication**
- **Sensory Interconnection**
- **Intelligent interaction**
- **Communication for sensing**
- **Proliferation of Intelligence**
- **Digital twin**
- **Machine control and coordination**
- **Global seamless coverage**

Integration of AI and Communication: Native AI Design, Implementing AIaaS (AI as a Service)






Integrated Sensing and Communication: Fully utilizing the advantages of communication networks to provide diverse services such as communication, sensing, and positioning



Terrestrial and non-terrestrial integration: ubiquitous access

Immersive broadband: Creating an immersive experience with high realism


Industrial IoT: Further enhancing industrial production and operational efficiency


Research on 6G network system

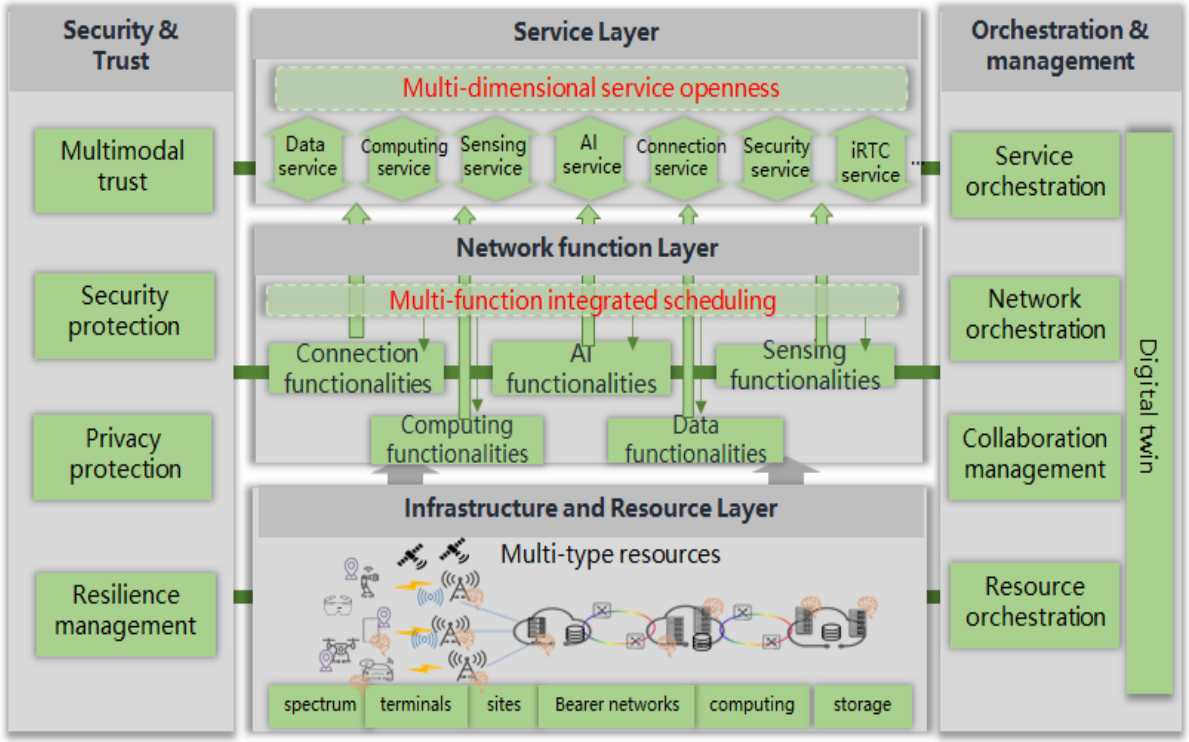
6G system architecture evolves beyond connectivity, expands computing, data, sensing, and AI functions, and continues to deepen new capabilities for 6G network.

➢ Deepen network capabilities

- **Connection:** Based on 5G, optimize existing services and interfaces to support business requirements in new scenarios
- **Computing :** Collaborate with connection functions to optimize the efficiency of new services, such as AI
- **Data:** Provide data service capabilities for new 6G service scenarios (such as AI and sensing)
- **AI:** Provide AI service capabilities for the operation and maintenance of the network itself, and for users or the 3rd parties
- **Sensing:** Collaborate with the connection function to provide the ISAC capability

➢ Enhance platform-based service architecture

- Reduce NF types, simplify unit interaction, and reduce O&M costs
- Fast registration of edge subnets and plug-and-play of new services



Deepen the research on 6G wireless architecture and functionality

6G RAN has the potential to become multidimensional resource carrier of communication, sensing, AI, computing, and data

Intelligent Communication

AI4RAN: Utilizing AI technology to improve network performance, efficiency, scalability, and intelligence level

RAN4AI: Flexibly and efficiently share RAN side AI functions and basic resources, and enhance services performance through UE-edge-cloud collaboration

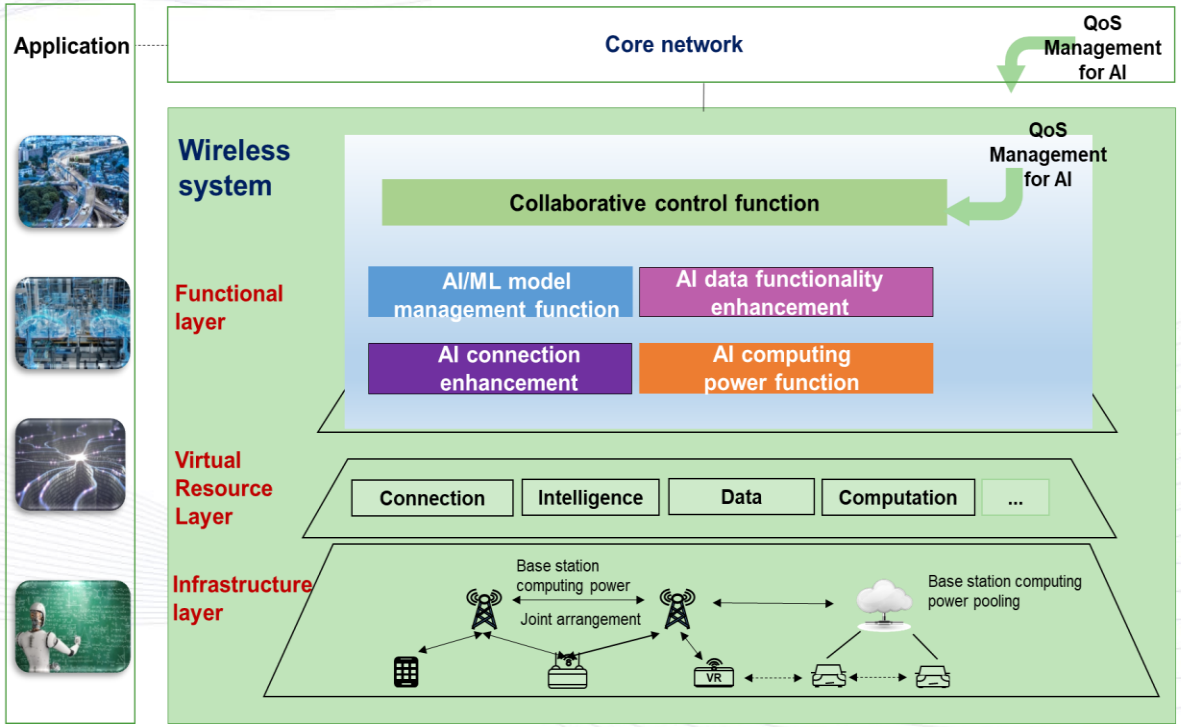


Illustration of integrated intelligent communication functions

- Model storage, querying and selecting
- AI/ML capability registration and reporting
- Model online fine-tuning

AI Lifecycle Management

- Data collection and storage
- Data processing and collaboration
- Data security and privacy

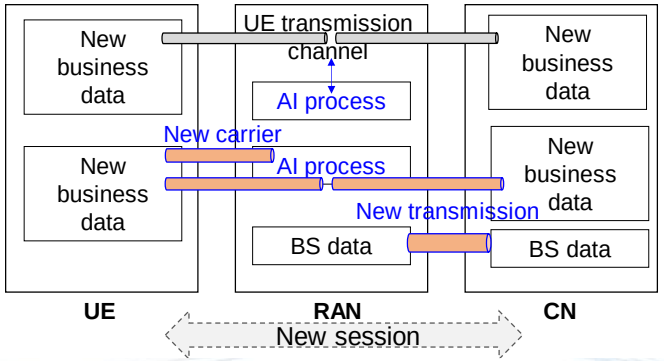
Data Functionalities

- Computing awareness
- Control and Collaboration of computing resources
- Openness of computing resources

Computing functionalities

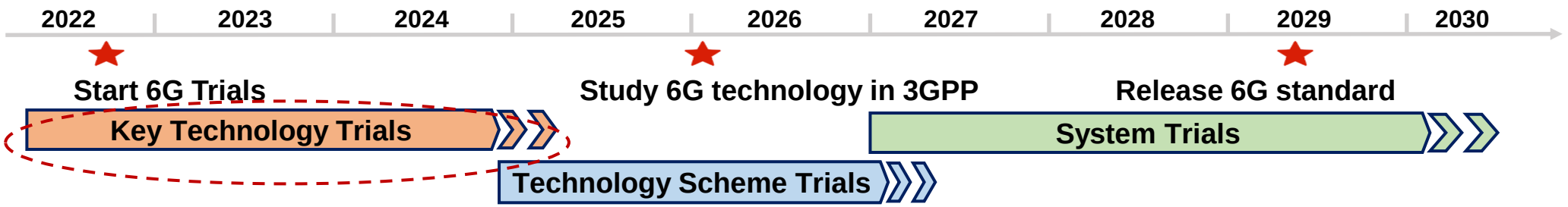
New data, New session

- RAN has the ability to **process** new service data
- UE and RAN can **generate** AI and sensing data
- **Interaction** of data and models between RAN-UE, RAN-RAN, RAN-CN



6G technology trials in China

In Aug. 2022, IMT-2030 PG launched 6G technology trials, which are divided into three phases : **Key Technologies Trials, Technology Scheme Trials, and System Trials**. Key Technologies Trials aim at promoting the development of conceptual prototypes in key technology directions, accelerating technology innovation, and promoting the formation of technical consensus.



	6G Wireless Technology Trials					6G Network Technology Trials			
	Terahertz Communication	Integrated sensing and communication	Reconfigurable intelligent surfaces	Wireless AI	Integrated Satellite and Terrestrial Network	Mobile computing network	Data Service	Distributed autonomous network	Network architecture
2022	√	√	√			√		√	
2023	√	√	√	√		√	√	√	
2024		√	√	√	√	√	√	√	

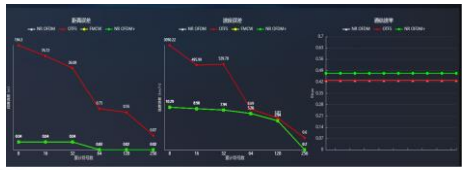
Trial results of ISAC

- **Previous trial review**: verify the performance of prototypes with monostatic sensing and TDM-based ISAC mainly.
- **2024 trial content**: new ISAC waveform, SDM-based ISAC, bistatic sensing, ISAC networking, ect.
- **Technical solutions**: combination of SDMed or TDMed based ISAC, monostatic or bistatic sensing, waveform with LFM/OTFS/OFDM. Sensing bandwidth is 100M-400MHz.

New Waveform

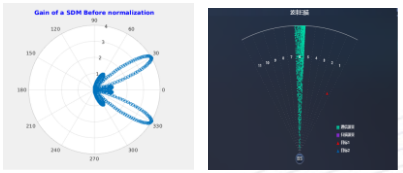
Compared to OFDM, preliminarily verified that：

- **LFM：** larger sensing range
- **OTFS：** no obvious gain
- **Enhanced OFDM：** larger sensing range, better sensing distance accuracy or higher data rate.



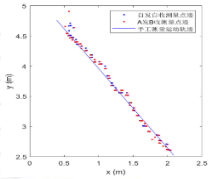
SDM-based ISAC

2 SDM horizontal beams achieved based on digital or analog beamforming, are used for sensing and communication separately, or both used for sensing 2 targets.



Bistatic Sensing

synchronization calibration (<1ns) is achieved based on the stable LOS or NLOS paths between two sensing stations. Sensing accuracy of bistatic sensing is similar to monostatic sensing.



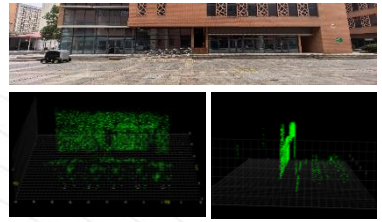
Networking

(1)Field Test： sensing with multi-sites can enhance sensing coverage and support continuous UAV tracking.

(2)Lab Test： sensing interference cancellation method can be adopted to improve the sensing performance.

Environment reconstruction

Outline information such as the door in the wall can be featured in a close sensing situation.



Summary：

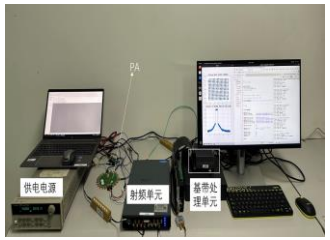
1. **Waveform:** reaching certain consensus, focusing on OFDM waveform and enhancement;
2. **SDMed-based ISAC:** preliminarily verifying SDM horizontal beams can be used for sensing or communication separately.
3. **Bistatic Sensing:** preliminarily verifying the synchronization requirements and the feasibility of bistatic sensing.

Trial results of wireless AI

- **Previous trial review: AI-based physical layer design, focusing on both single-module optimization and multi-module joint optimization, shows significant gains in complex channel conditions**
- **2024 trial content: Generalization enhancement trails and explore more potential wireless intelligent application scenarios**

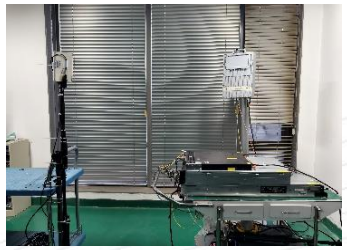
Performance testing

- AI LDPC**: 10%** Performance Improvement in **Throughput**
- AI DPD: **6%** Performance improvement in **EVM**
- Joint optimization: **80% Overhead** Reduction



Generalization testing

- Generalization validation on intelligent demodulation, intelligent channel estimation, and intelligent receivers
- Fine-tuning boosts model generalization with minimal field data



Adaptation testing

- **Identical model** structures: **18%-25%** throughput gain
- **Different model** structures: **15%-20%** throughput gain

Summary:

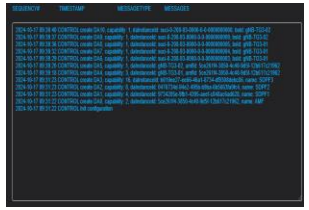
1. AI-based physical layer **multi-module joint optimization** design improves performance by **10%-18%.**
2. **Model fine-tuning** and **hybrid data augmentation** significantly enhance generalization.
3. **20% throughput** boost from independent bilateral model training, with greater gains for **identical structures.**

Trial results of data service

- **Previous trial review**: focused on fundamental functionalities, while further testing of the collaboration between data service and the network is needed.
- **2024 trial content**: the **collaboration between data service functionalities and the network functionalities**, efficiency of the new data service protocol.

Capability Discovery & Request Identification

- UE, RAN, CN NF can report their data service capabilities.
- The requests from RAN, CN NF or AF can be identified.



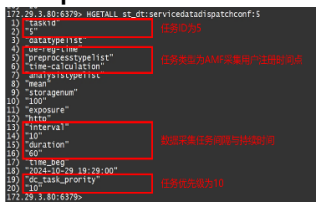
Data Service Protocol & Efficiency

- The application of TCP, QUIC, HTTP3.0, self-developed air interface data service protocol for data service transmission.
- Efficiency verification

protocol	Data volume (GB)	0% packet loss configuration	
		latency(s)	data rate(MB/s)
http2.0	1.1	60.5	17.98
http3.0	1.1	53.7	20.26

On-demand Data Collection & Data reusage

- On-demand data collection based on collection frequency, priority, etc.
- Determine whether the data can be reused for two requests to avoid duplicate collection.



Summary:

1. Verify the collaboration capability between data service functionalities and the network based on the mobile network architecture and protocols.
2. In a simple networking environment, use TCP, QUIC, HTTP3.0, self-developed air interface data service protocol as the data service transmission protocol and test the data transmission efficiency.

Trial results of mobile computing network

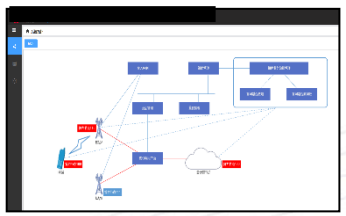
- **Previous trial review**: the capabilities of computing and network awareness, joint control and scheduling, and service deployment can be achieved, while the testing of the enhanced capabilities is still needed.
- **2024 trial contents**: align basic computing and network evaluation indicators, and focus on the collaborative scheduling capability of UE-edge-cloud computing resources in mobile networks.

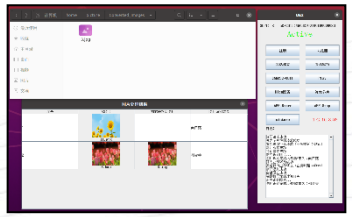
Computing and Network Indicators

- Computing performance indicator: type, resource demand.
- Network performance indicator: bandwidth, delay.

UE-Edge-Cloud Collaborative Computing

- Select appropriate UE-edge/UE-cloud/UE-edge-cloud collaborative computing strategies based on computing and network indicators





Service Continuity Assurance

- When the wireless channel quality deteriorates, all tasks can be turned back to the UE for execution
- When BS switch occurs, the scheduling strategy can be dynamically changed

Summary:

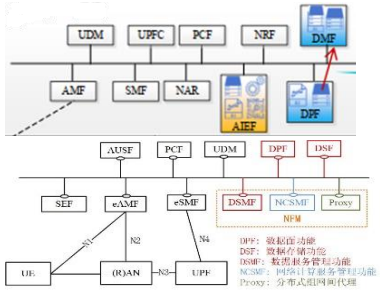
1. The prototype can identify basic computing and network indicators.
2. Preliminarily realize the collaborative computing of UE-edge-cloud, while the collaboration mechanism is not flexible.
3. Some companies verifies the collaborative capabilities of data, computing and network functionalities for AI services.

Trial results of network architecture

- **Previous trial review**: reach consensus for distributed network, mobile computing network and data service. It is necessary to further verify the multi-dimensional function collaboration capability
- **2024 trial content:** Verify the functionalities of the 6G network architecture in a prototype
- **Technical solutions:** preliminarily realizes **the basic network functionalities, the integrated control and scheduling of multiple elements, distributed network, and trustworthy network**

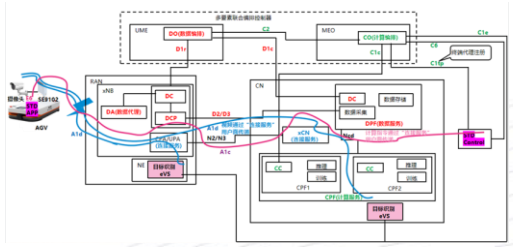
Network function

- Verify that the basic network functions have the ability of connectivity, computing, data, and AI



Control and scheduling

- Different scenarios that realize the collaboration of multiple elements in "connectivity + computing + data + AI"

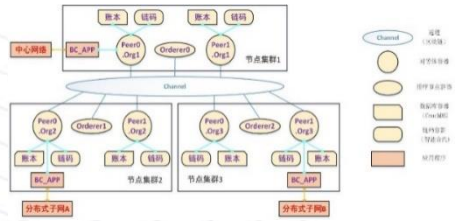


Distributed network

- Support on-demand subnet generation, topology hiding, differentiated registration and service continuity

Identity management

- Support distributed ledger establishment and scaling
- Supports identity credential generation, storage, verification and revocation



Summary:

1. **General consensus on the capabilities of connectivity, computing, data, and AI elements in the network architecture is formed and preliminarily verify the function and scheduling process of these four elements.**
2. **Preliminarily verify the capability of integrated control and scheduling of multiple elements, while the collaboration of multiple elements still needs further research.**
3. **Use a distributed ledger to implement the identity credential function, but the deployment of blockchain is different.**

Released publications

IMT-2030(6G) Promotion Group released over 60 research reports/white papers.

Vision & Requirements 10+

- **6G use cases**
- **Security Technologies for Integrated Terrestrial and Non-Terrestrial Network**
- 6G vision and candidate technology
- 6G usage scenarios and key capabilities
- 6G AIaaS requirements
- 6G requirements and usage scenarios on sensing
- 6G immersive service requirements
- The vertical industry demands

System architecture 5

- 6G network architecture outlook whitepaper
- 6G trustworthy and secure network architecture
- 6G Network Architecture Vision and Key Technology Outlook
- **6G Wireless System Architecture and Functions**
- Design principles and typical features of 6G wireless system

Network technology and security technology 20+

- **Security Requirements and Technologies for 6G Integrated Sensing and Communication**
- **Design and Key Network Technologies of Integrated Sensing and Communication Architecture**
- **6G Distributed Autonomous Network Architecture and Key Technologies**
- **Scenario-customized 6G distributed network architecture and technology**
- **Security Technologies for Integrated Terrestrial and Non-Terrestrial Network**
- **…..**

Wireless technology 30+

- **Key Technologies of Cooperative Sensing for 6G ISAC**
- **Key Technologies of 6G ISAC air interface**
- **Channel Measurement and Modeling for 6G**
- **Novel Multiple Access Technology**
- **Performance requirements and evaluation methods for coding and modulation technology**
- **6G ISAC Simulation Evaluation and Method**
- …….

THANKS