

6G Network with Native AI: from AI4NET to NET4AI

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Agenda

1 Driving forces of 6G native AI

2 Native AI: from AI4NET to NET4AI

3 Summary

6G Vision

Digital Twin, Ubiquitous Intelligence



G. Liu et al., "Vision, requirements and network architecture of 6G mobile network beyond 2030," in *China Communications*, vol. 17, no. 9, pp. 92-104, Sept. 2020.

Ubiquitous Intelligence: AlaaS

- AI has become the driving force of a new round of society upgrade.
- The digitization and intelligentization of the society require ubiquitous intelligence.

Human needs AI



Voiceprint recognition



Machine translation



Smart Navigation

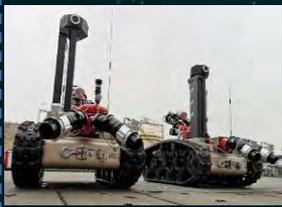


Personalized Recommend.

Vertical industries need AI



Medical Recognition



Robot rescue



Security monitor



Smart Manufacturing

Network autonomy needs AI



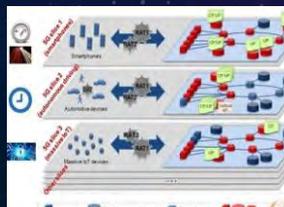
Operation & maintenance



Customized network



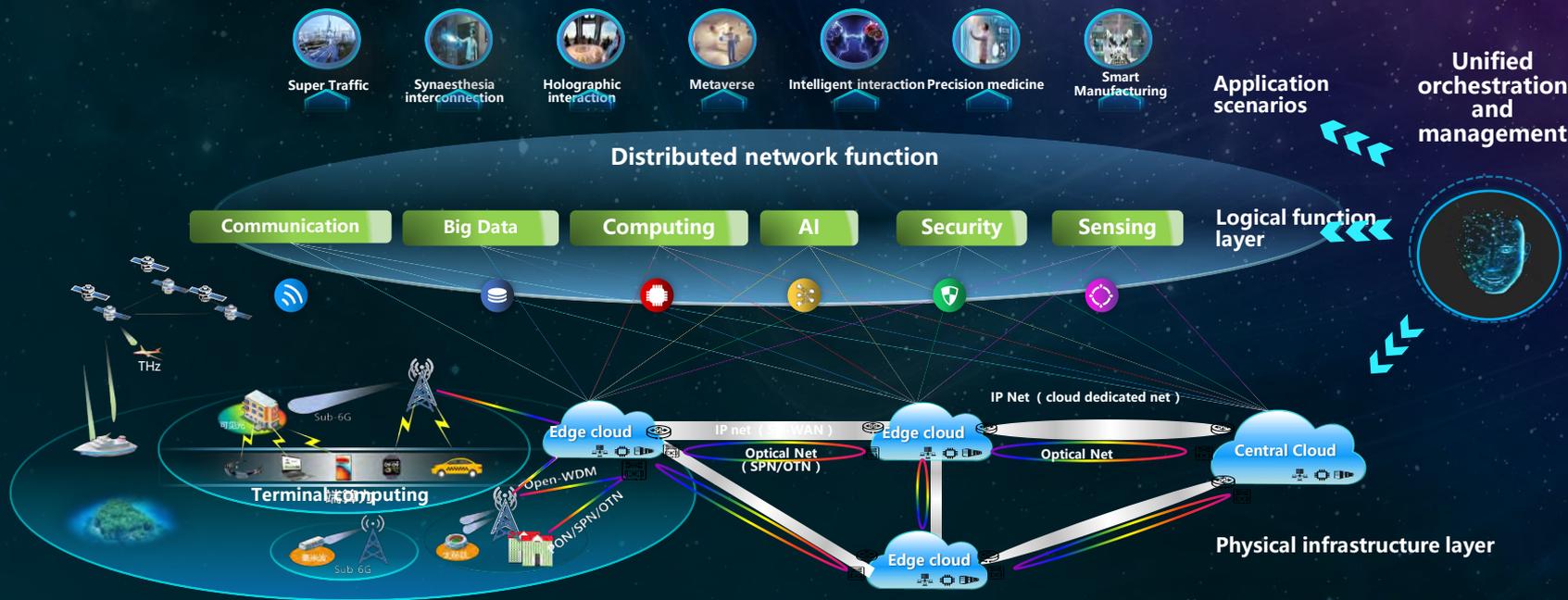
Smart coverage



6G network targets to support AI as a service by native AI design.

Vision for 6G Mobile Network

A new generation mobile information network integrating communication, computing, big data, AI, sensing and security



Agenda

1

Driving forces of 6G native AI

2

Native AI: from AI4NET to NET4AI

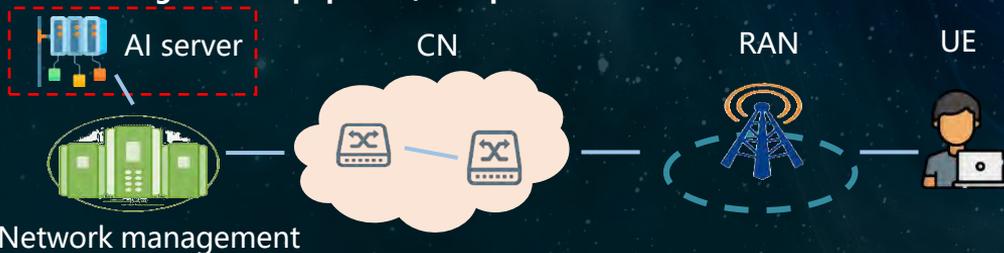
3

Summary

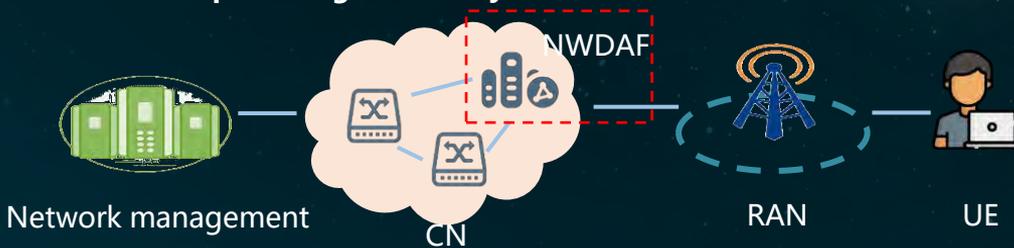
A unified framework to support the fully automatic closed-loop of AI service providing and efficient scheduling of multi-dimensional resources.

External and patched AI

- Mode 1: A server with AI resources is connected to the network management equipment, and provides AI models for the network.



- Mode 2: In the core network, AI is added as a new network function, providing data analysis, such as NWDAF.



Learning from 5G intelligent network:

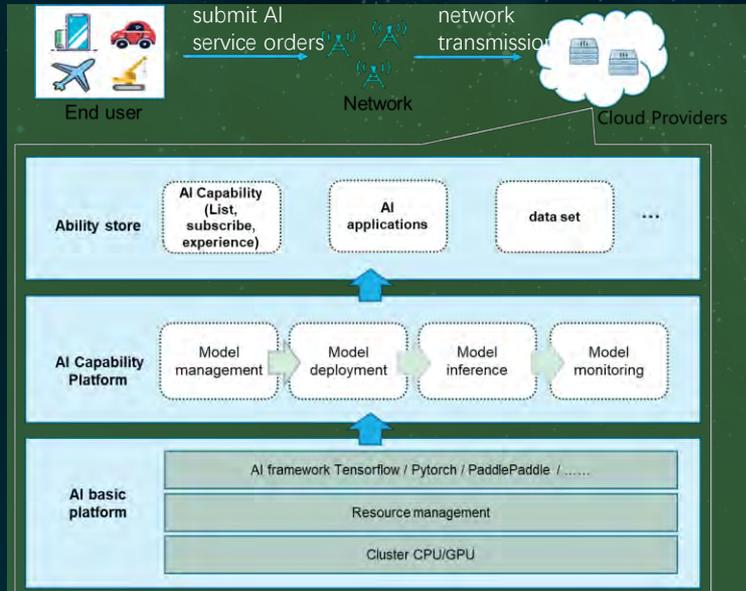
- **Need a unified framework:** to achieve a fully automatic closed-loop of AI pre-validation, online evaluation and optimization.
- **Need the efficient data acquisition and transmission:** to support high performance AI.
- **Need the integration of computing, data, models and connections:** to provide guaranteed QoS, e.g. lower latency.

Learning from Cloud AI Service Providing

6G native AI may need to fully utilize the network resources and ensure the quality of AI service while protecting data privacy and security.

Cloud AI Service Providing

- Cloud AI service providers provide best-effort AI services after users submit orders.



Learning from cloud AI service providers:

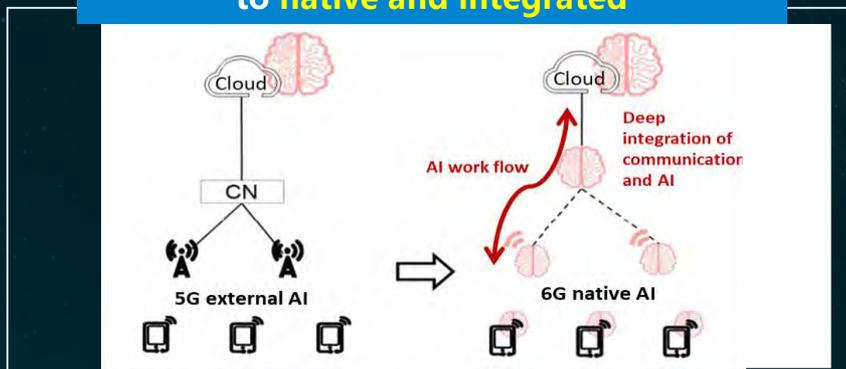
- Need to fully utilize the AI-related resources of the network:** to sense network status and use the widely distributed computing, data, and algorithm resources of the network to provide efficient AI services.
- Need to provide guaranteed QoS for AI services:** to meet the specific requirements of users.
- Need to protect data privacy and security:** to prevent data leakage while providing reliable AI service.

NET4AI: 6G native AI design principles

1. A Unified Network AI Framework for Ubiquitous Intelligence



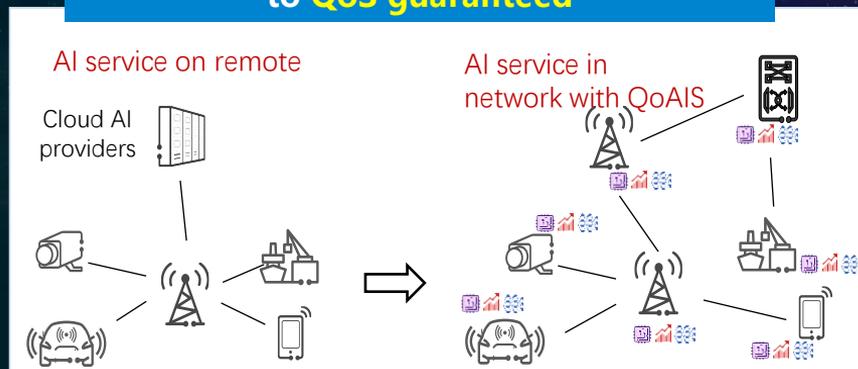
2. Evolve from external and patched to native and integrated



AI lifecycle orchestration and management

Deep integration of multi-dimensional resources

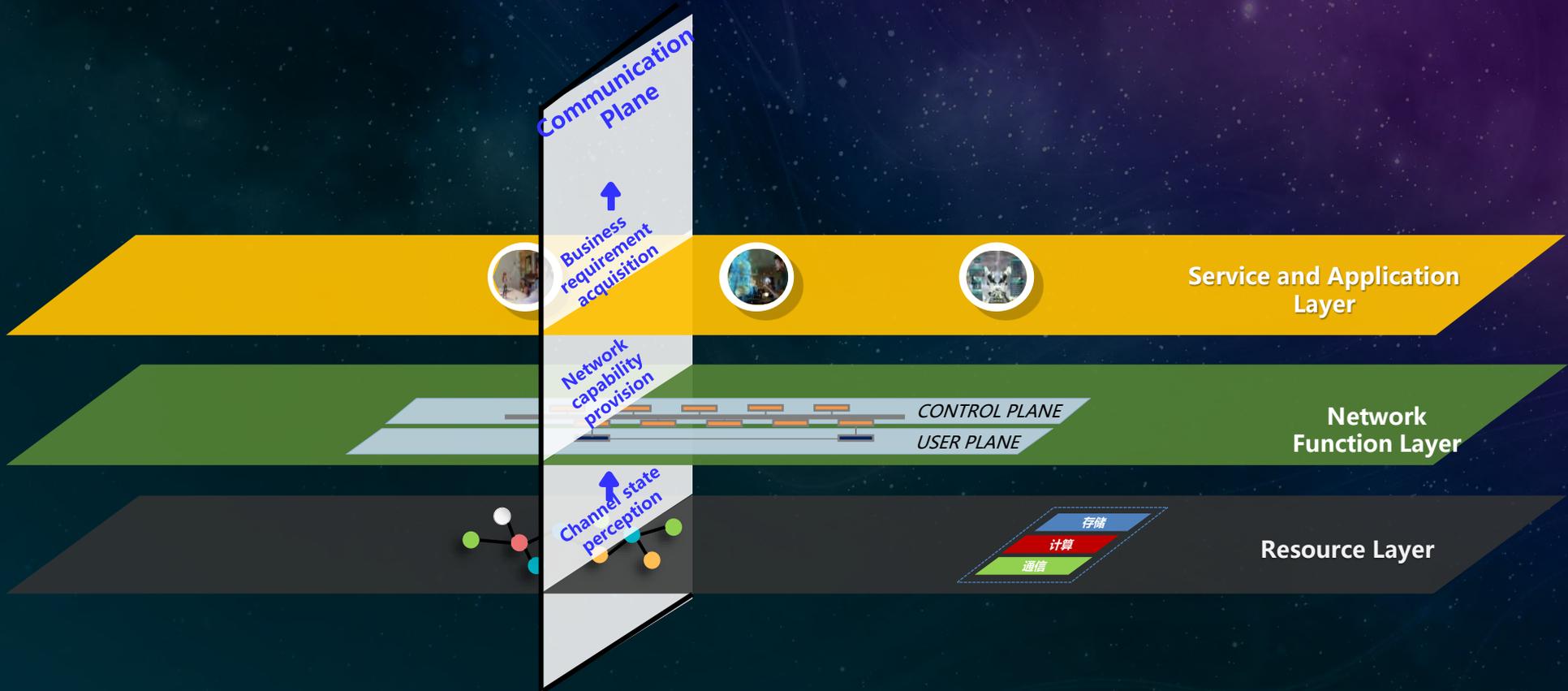
3. Evolve from best-effort to QoS guaranteed



Quality of AI service (QoAIS)

Learning from Traditional Communication Protocol

Traditional communication network focuses on communication services.



Logic Protocol design for Native AI

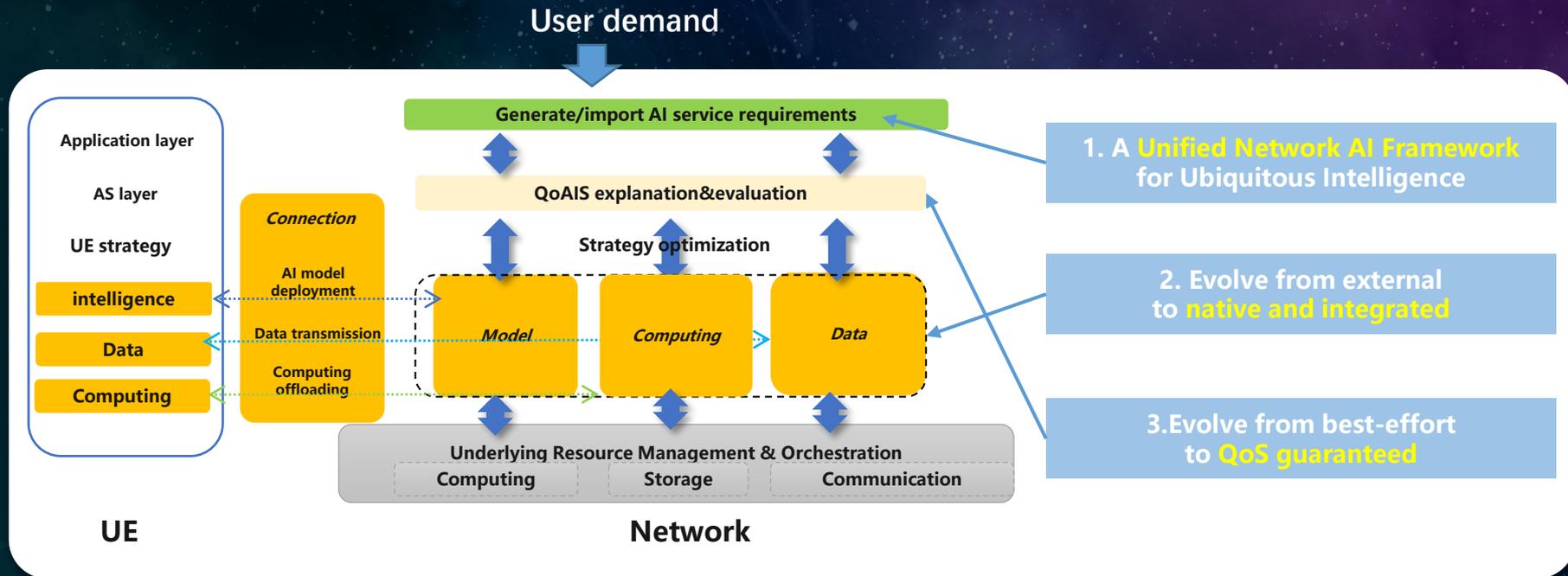
Objective: Orchestrate the necessary resources of data, algorithm/model and computing power for AI service on demand, and guarantee the QoS of AI service through the entire life cycle.



Guangyi Liu, Na Li, Juan Deng, Yingying Wang, Junshuai Sun, Yuhong Huang, "The SOLIDS 6G mobile network architecture: Driving forces, Features and functional topology", Engineering, Vol. 8, January 2022.

Functional Design for Native AI Framework

- Native AI framework includes AI use case self-generation, QoAIS guarantee mechanism, entire life cycle AI workflow management and on-demand scheduling of multi-dimensional resources.



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Issue 1: Self-Generation of AI Use Case

Solving problems in a manual, siloed manner often leads to conflicting optimization effects between different optimization cases. So **the network generates AI use case descriptions via data analysis or external import and adjusts AI-related resources.**

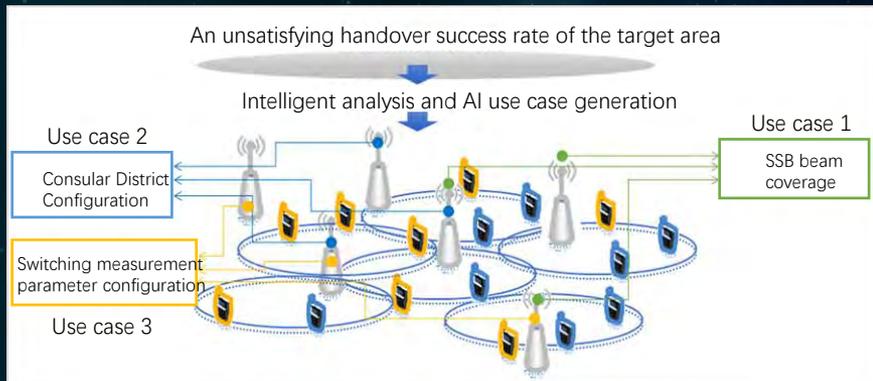


Fig 1. Intelligently generating AI use cases

Table 2 Format of an AI use case description

Attribute	Description
AI implementation scope	A combination of the temporal, spatial and network scope. For example, ID of a cell to be optimized during peak hours.
AI implementation object	Object that uses the intelligence, which can be a user or a function. For example, large-scale antenna weight configuration function.
Problem type	For example, classification, decision-making, and optimization.
Input and output data template	Input and output data attributes of DNN model, and state, action and reward variables of reinforcement learning.
Performance goal	Expected values of performance indicators of the use case
Dataset	Quantity, proportion, and composition of model training datasets and validation datasets; Data requirements on digital twins of model verification scenarios.
Exposure	Data exposure scope; model exposure scope.
Security	Security level.
QoAIS	Quality requirements of the AI service called by the use case.

Challenge

1. How to design the description templates for AI use cases?
2. How to design the efficient data acquisition, storage, governance, and transmission to support AI use case self-generation?

Issue 2: Quality guarantee of AI service (QoAIS)

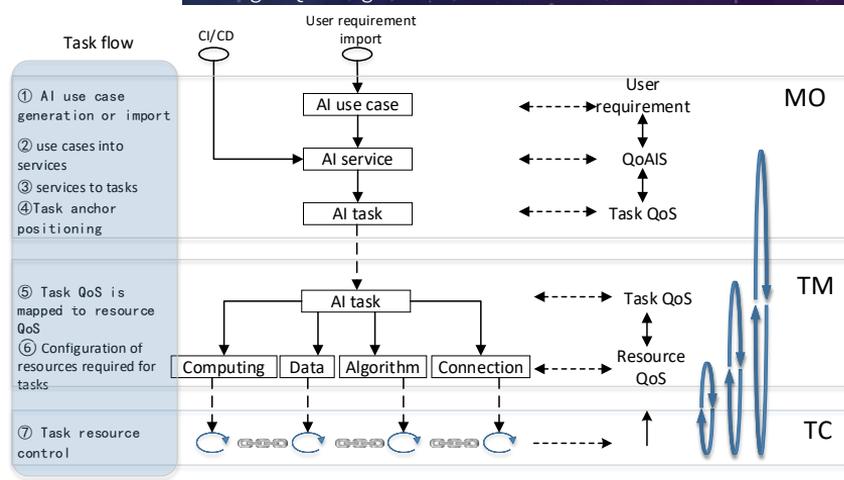
The absence of a unified QoS framework leads to the lack of effect verification and guaranteeing for AI performance. **QoAIS**, in addition to session and connection performance, introduces new evaluation dimensions such as security and autonomy to form a **standardized AI service quality evaluation system**.

Table 1: QoAIS indicators of AI training service

Types of AI Services	Evaluation dimension s	QoAIS indicators
AI training	performance	Performance bounds, training time, generalization, reusability, robustness, interpretability, consistency between loss function and optimization objective, fairness
	overhead*	Storage overhead, computing overhead, transmission overhead, energy consumption
	Safety*	Storage security, computing security, transmission security
	privacy*	Data privacy level, algorithm privacy level
	autonomy	Fully autonomous, partially manually controllable, and fully manually controllable

Note*: Common evaluation indicators between different types of AI services

Fig.1 QoAIS guarantee mechanism

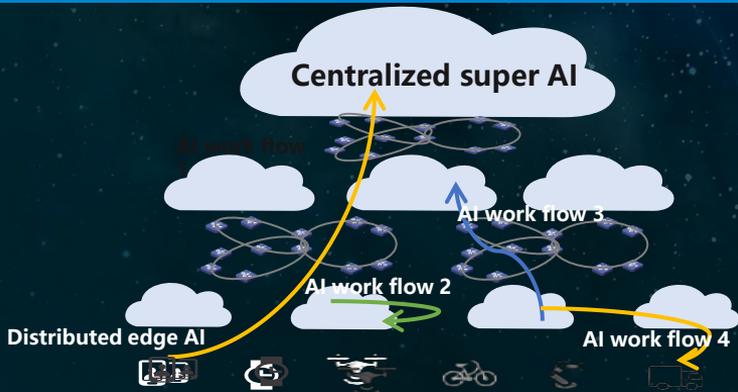


Challenge

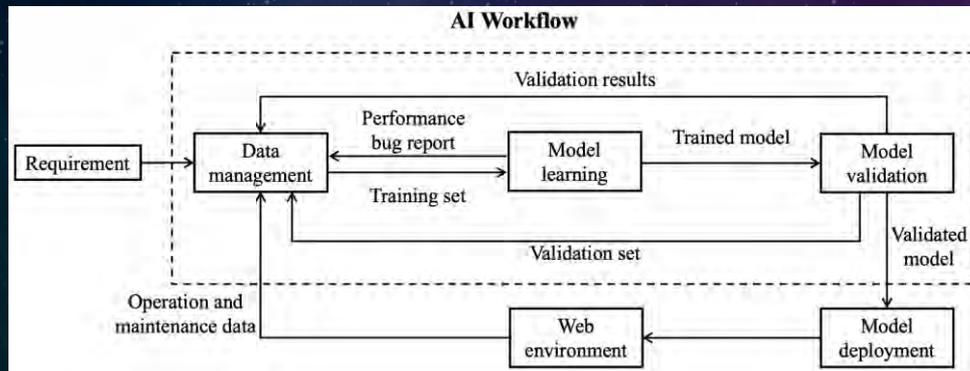
1. There is no mature quantitative evaluation method for some QoAIS indicators (such as generalization, interpretability, and reusability of models).
2. How to realize the automatic analysis and mapping of AI service requirements to QoAIS indicators that can be executed by the network?

Issue 3: Lifecycle Orchestration & Management of AI service

- Most of the AI workflows in 5G are implemented offline and independent from the network operating environment, which lead to low efficiency and high cost.
- 6G network with native AI targets to provide a **complete operating environment for all aspects of the end-to-end AI workflow** to provide AI services of different qualities for various scenarios.



- Combining centralized and distributed: centralized super AI, distributed edge AI

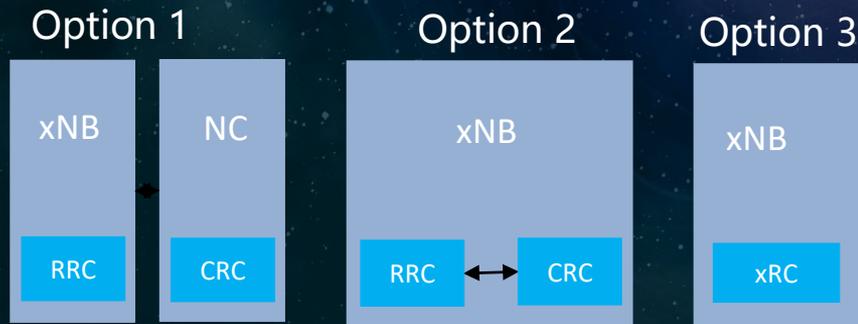


- End-to-end flexible orchestration of AI lifecycle workflows

Challenge

1. In order to ensure the continuous satisfaction of QoAIS, how should the management plane orchestrate resources required by the workflow? how should the control plane be involved?
2. How to design open AI capability interfaces?

- In 5G MEC, the communication and computing are loosely coupled.
- Native AI requires computing with high performance, high power efficiency and low latency.
- The "integration" protocol design is more efficient and flexible to adapt to ubiquitous requirements of heterogeneous intelligent scenarios.



CRC: Computing resource control;
RRC: Radio Resource Control;
NC: Node of Computing; xNB: Base station;

Challenge

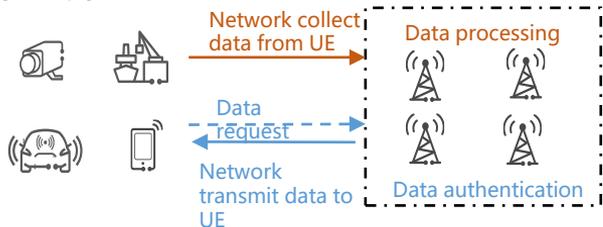
1. How to support efficient heterogeneous computing power awareness and discovery in protocol design?
2. What is the coupling relationship between the communication protocol and the AI protocol on the management plane, control plane, and user plane?

Potential AI service of 6G network

The 6G native AI network can provide four types of AI services: data, training, inference and verification.

1. AI data service

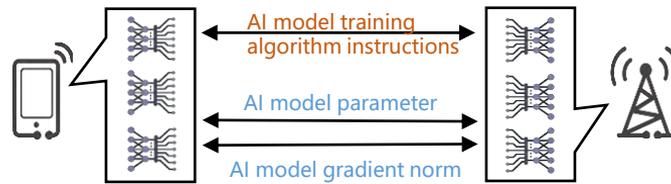
- Including AI-related data acquisition, processing, authentication with privacy protection.



e.g. AI-related data acquisition between terminal and network

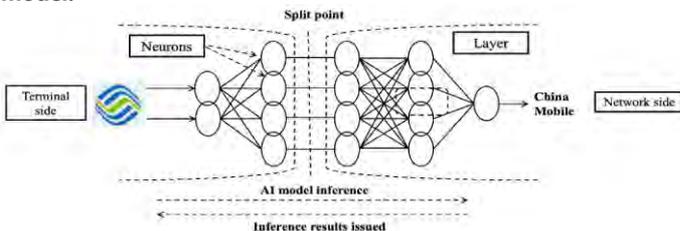
2. AI training service

- Utilizing distributed multi-dimensional resources deployed on the network and terminals to perform AI model training.



3. AI inference service

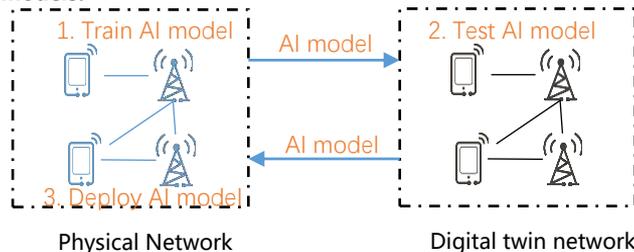
- Utilizing distributed multi-dimensional resources deployed on the network and terminals to obtain conclusions from the AI model.



e.g. AI model inference with terminal and network collaboration

4. AI verification service

- Build a network of digital twins to verify the performance of AI models.



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Summary

- **Native AI of 6G network targets to guarantee the QoAIS by providing the resources of data, algorithm/model and computing power on demand;**
- **A native AI framework provides AI use case self-generation, QoAIS guarantee mechanism, entire life cycle AI workflow management and on-demand scheduling of multi-dimensional resources to serve ubiquitous intelligence.**

Future research:

- **SLA and QoAIS requirement guarantee:** What SLAs do users really need? How are user requirements represented through AI use cases? How to resolve the conflict between performance and security in QoAIS?
- **Deep integration of multi-dimensional resources:** Considering real-time requirements on AI service, mobility and dynamic channel condition in wireless networks, how can computing, algorithms, connections, and data be coordinated and scheduled to ensure the QoAIS?
- **Security and privacy guarantee:** Training high-performance models and generating powerful inference capabilities require data sharing. How to protect data privacy while sharing data?

6G Native AI Architecture and Technologies White Paper

(2022)



China Mobile Research Institute (CMRI)

White papers:





6GANA

6G ALLIANCE OF NETWORK AI (6GANA)

- Initiated in Nov. 2020 by China Mobile, Huawei, China Telecom, China Unicom, CAICT, Tsinghua University, Zhejiang University, UESTC, ZTE, etc.
- Formally set up in April 2021





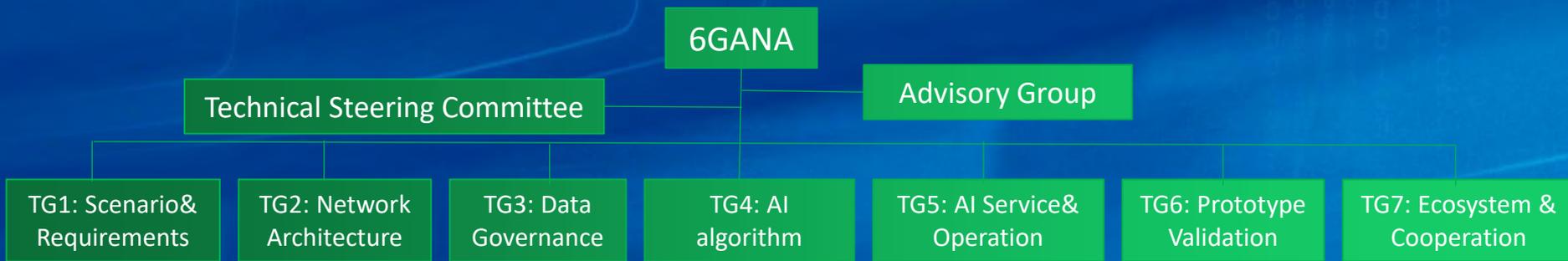
ROLE AND MISSION

- A domestic or none-official platform
- Promote AlaaS by native AI design for 6G, from technology and ecosystem perspective
- organize the members to study the scenarios, requirements, network architecture, data, theory and algorithms, prototype validation for network AI or native AI of 6G
- Build the consensus on network AI or native AI among academies and industries, and promote its standardization and industrialization



6GANA

6GANA ORGANIZATION



- Advisory Group: Hequan Wu, Ping Zhang, Quan Yu, Xiaohu You, Wen Tong, Yuhong Huang, Yunqing Chen, Shanzhi Chen, Jinkang Zhu, Zhishen Niu, Yingchang Liang
- TSC (Technical Steering Committee): Guangyi Liu, Jianjun Wu, Zhenqiang Sun, Jingyu Wang, Changle Li, Shuguang Cui, Honggang Zhang, Yang Yang



6GANA

6GANA MEMBERS

The image displays a collection of logos for 6GANA members, arranged in a grid-like fashion. The logos include:

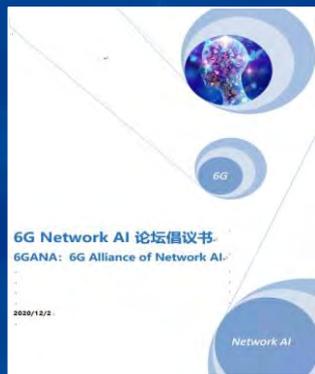
- Industry and Tech:** HUAWEI, 中国移动 China Mobile, China unicom 中国联通, CHINA TELECOM, Tencent 腾讯, Alibaba.com, 大唐电信 大唐电信科技产业集团, PML, oppo, vivo, ERICSSON, NOKIA 上海贝尔, ZTE 中兴, inspur 浪潮, intel, mi, TIJ Technology Innovation Institute, 5*6G INNOVATION CENTRE UNIVERSITY OF SURREY.
- Academic and Research:** 重庆邮电大学 CHONGQING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS, 上海科技大学 ShanghaiTech University, 之江实验室 ZHEJIANG LAB, GDCNI, and several university seals including Tsinghua University, Fudan University, and others.



6GANA

6GANA WHITE PAPERS

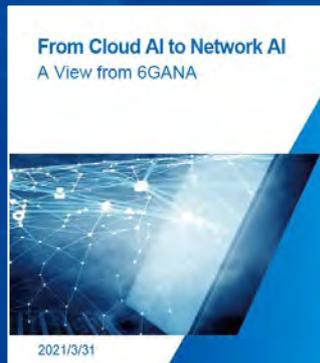
Dec. 2020, Initiative white paper



June 2022, technical white papers



June, 2021 white paper in EuCNC



More details are available at Web site:
<http://www.6G-ANA.com>



Thanks!