Wireless Foundation Model For Network Automation

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CONTENTS

AI Brings New Development Opportunities to 6G

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Productivity Revolution

AI drives productivity transformation for "connectivity"

communication performance

Leap forward

Service Revolution

evolves from simple "connectivity" towards

"connectivity" + "compute" + "Intelligence"

Intelligent Air Interface: network spectral efficiency and energy efficiency

Intelligent Network Control: massive UE access and efficient resource mgmt.

Intelligent Operation & Management: self-optimization for networks with Large Model

Edge Computing: Lower the deployment threshold for AI Apps

Sharing of Data and Models: Accelerate iteration and rollout of AI Apps

AI-Native Service Provisioning: Expand network value and business models

CONTENTS

PHY Aims at Improving Air Interface SE

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Spectrum Efficiency keeps rising with advances in antennas, algorithms and networking technology

Data-link

Channel Estimation **Modulation** **Channel Coding**

$$\boldsymbol{SE} = \frac{N_{data}}{N_{data} + \boxed{N_{pilot} + N_{CP}}} \sum_{c=1}^{N_C} \sum_{s=1}^{N_S} \Phi\left(\boxed{\frac{\left| h_s^H(t,f) w_s\left(\widehat{h_s}(t,f)\right)\right|^2}{\sum_{s' \neq s} \left| h_s^H(t,f) w_{s'}\left(\widehat{h_{s'}}(t,f)\right)\right|^2 + N_0}} \right) \times \boxed{(1 - \mathrm{BLER}(\mathrm{SINR}_{c,s}))}$$

MIMO Pre-coding **Multi-cell cooperation**

Multi-data-link **System Level**

PHY Wireless Foundation Model Motivation

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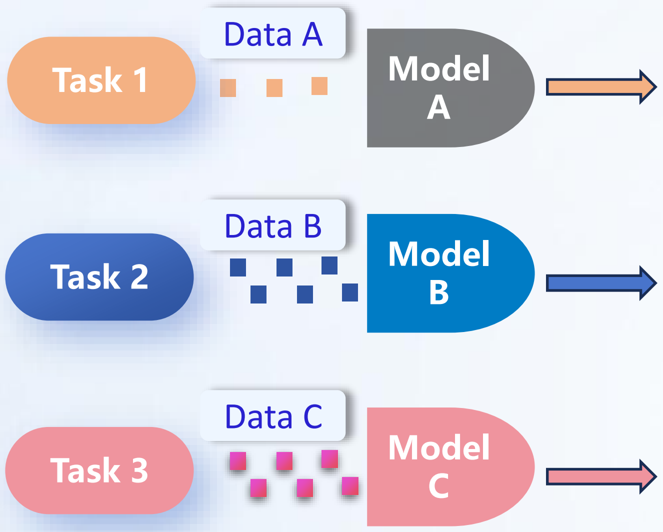
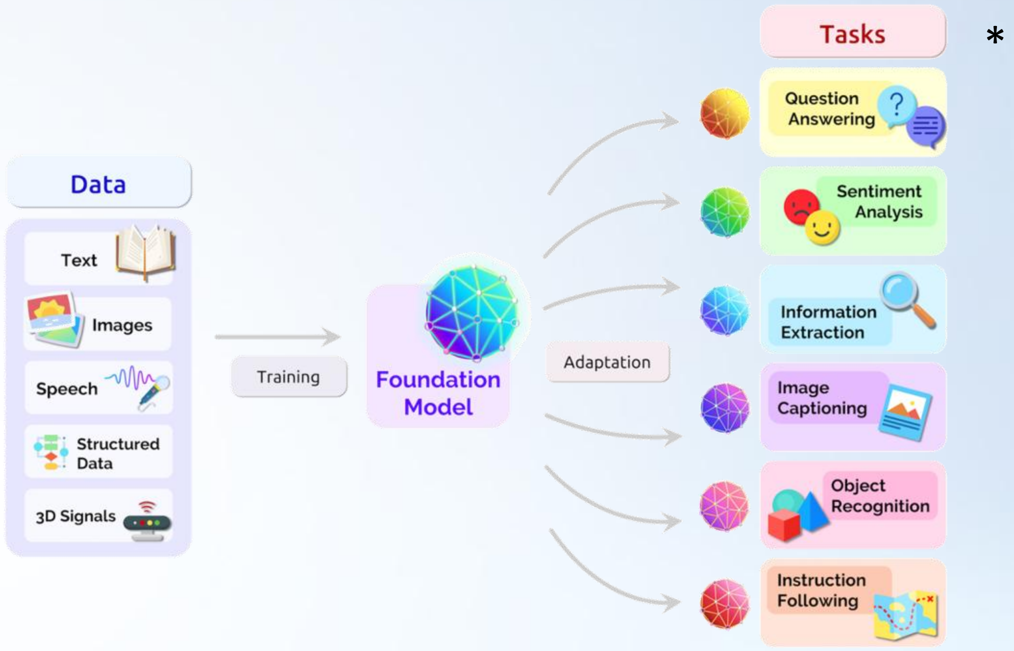
As is



Task-specific Model

- Performance ceiling
- Generalization challenge
- Management complexity

To be



Wireless Foundation Model

- Self-supervised pre-training
- One model applies to multiple tasks
- Multi-modal understanding

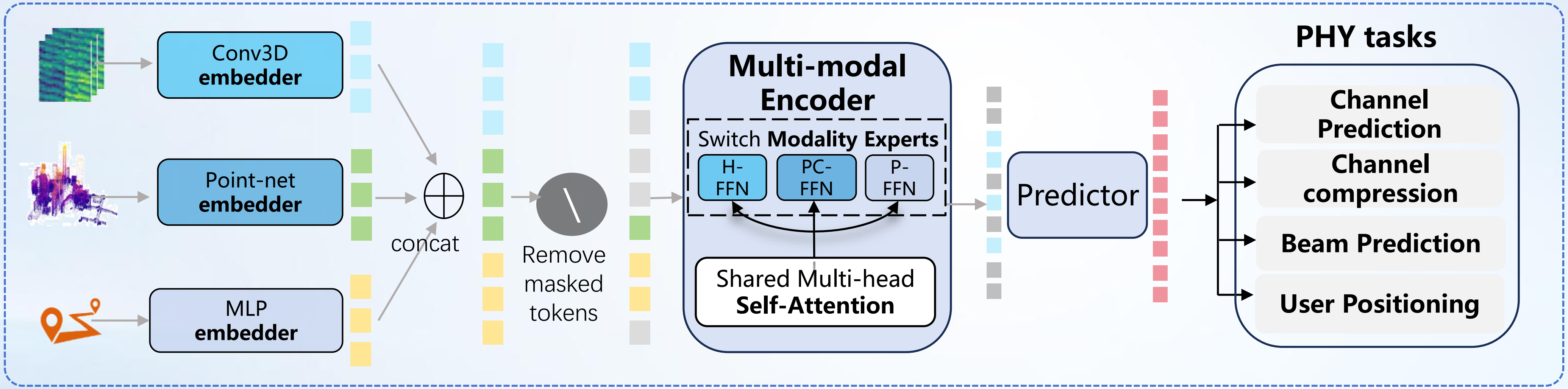
*Bommasani, Rishi, et al. "On the opportunities and risks of foundation models." *arXiv preprint arXiv:2108.07258* (2021).

Multi-modal Wireless Foundation Model

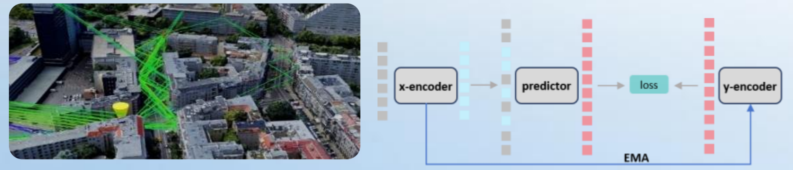
Challenge

Traditional Task-specific Model: small model size, uni-modal input, dedicated to training data, resulting in complex model management and poor generalization

Multi-modal Wireless Foundation Model

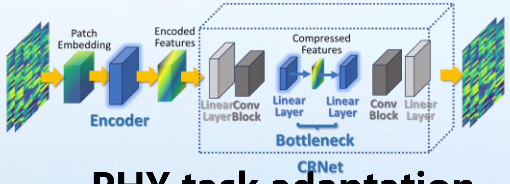


- Multi-modal input
- One model for multiple tasks
- Large-scale pre-training
- Light-weight task head



Ray-tracing pre-training

Real-world fine-tuning



PHY task adaptation

Multi-modal Wireless Foundation Model Result

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Finding

Using Large-scale multi-modal data for pre-training, Network Foundation Model largely improve PHY Layer performance, increasing 28.2% spectral efficiency in E2E simulation

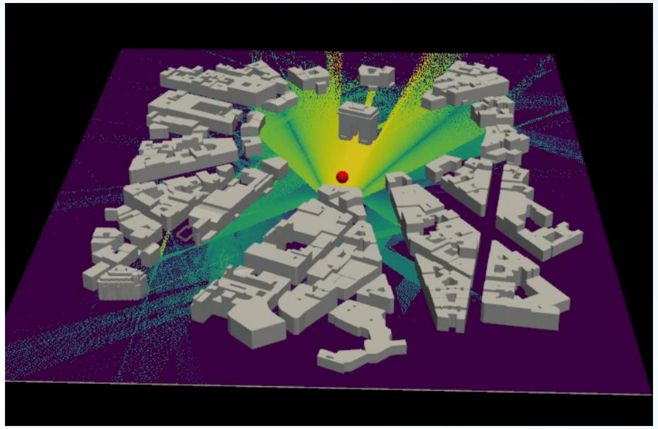
Data Introduction

Dataset Size: 90G training and test samples

Training Data: 4 urban areas (Munich, Paris, Beijing CBD, and the Forbidden City), covering 24 scenarios at speeds of 5, 30, and 60 km/h.
Test Data: Data for evaluating speed generalization and scenario generalization (Amsterdam)

Modalities: Time–frequency–spatial 3D channel data, structural 3D point-clouds, and position coordinates

City structure



Model Introduction

Model Architecture: Multimodal Mixture-of-Experts (MoME)

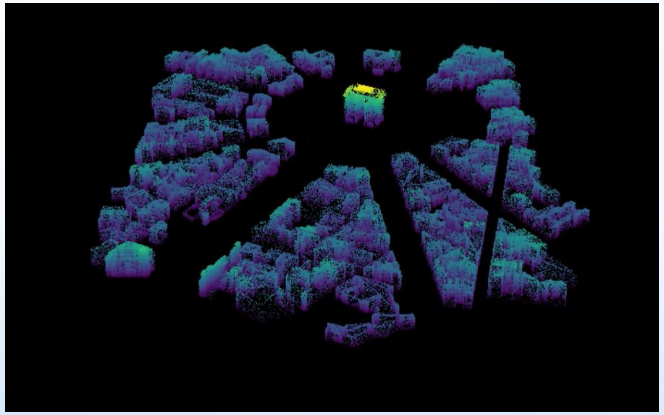
Training Method: Joint-Embedding Predictive Architecture (JEPA)

Model Backbone: Vision Transformer

Hidden Dimension: 384	**Layers:** 12	**Attention Heads:** 6

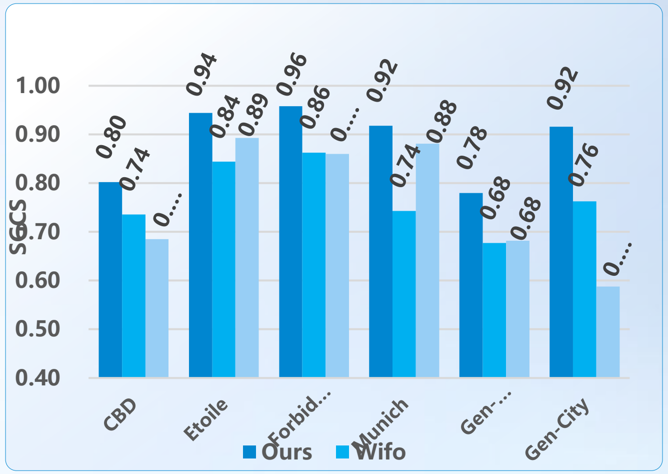
Model Size: 78 million parameters

3D Point-cloud

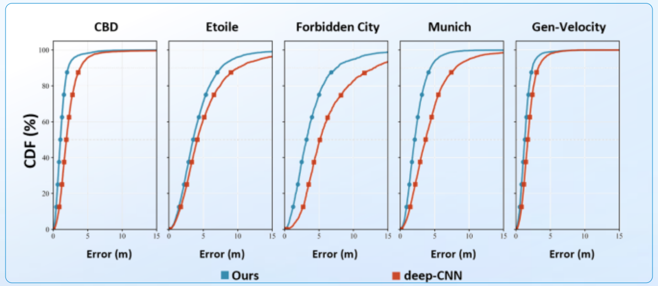


Simulation Result

CSI Temporal Prediction Performance Comparison



User Localization Performance



CONTENTS

From Physical Layer to High-Level Foundation Model

Physical Layer

The physical layer focuses on **mining, prediction and fitting**.

It characterizes the variation law of wireless channels.

Its main **objectives** are to extract channel features and achieve optimal prediction, classification and fitting.

Past / Known → **Fitting** → **Future / Unknown**

Final target: Output fitting results

Feature: Pre-trained Foundation Model

Higher Layer

The high-level layer focuses on **learning, prediction and control**.

It characterizes the impacts brought by base station behaviors.

Its main **objective** is to learn state transitions of users and base stations after actions are applied.

Action

Current State → **Fitting** → **Future State**

Final target: Output optimal actions

Feature: World Action Model (WAM)

MAC Layer World Action Model (WAM)

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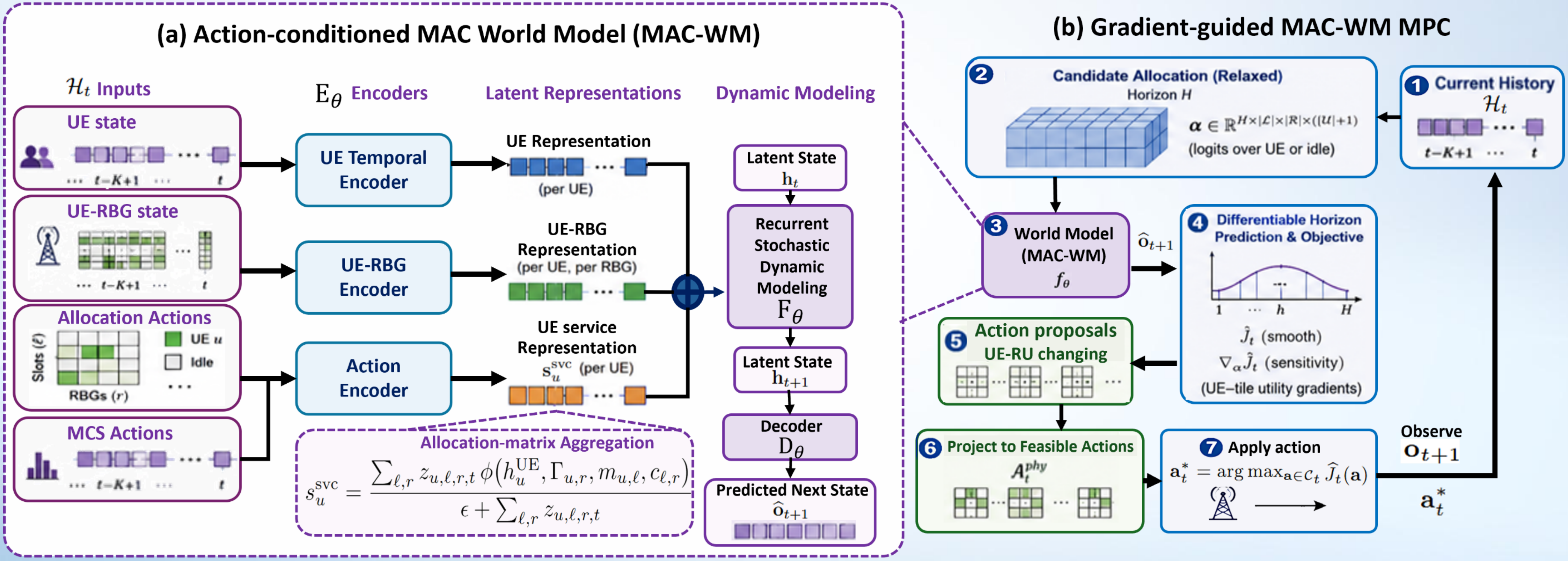
Using WAM to Solve Complex User Scheduling Problem in MAC Layer



MAC WAM Data Model and Results

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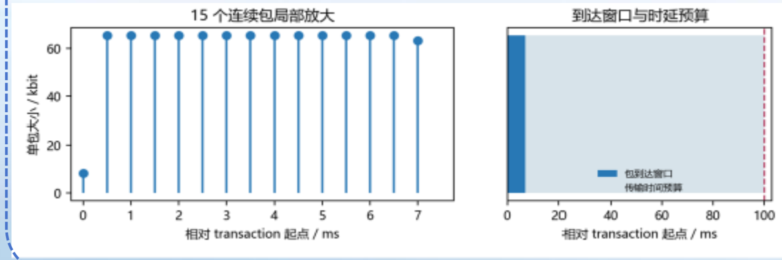
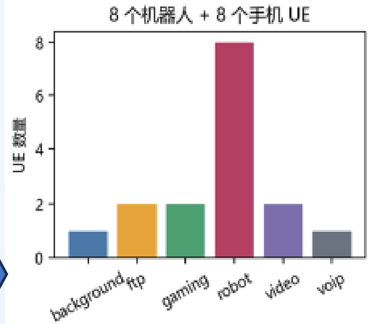
Data Simulation

Nvidia Isaac（Unitree G1+GR00T)

Grab data with Wireshark

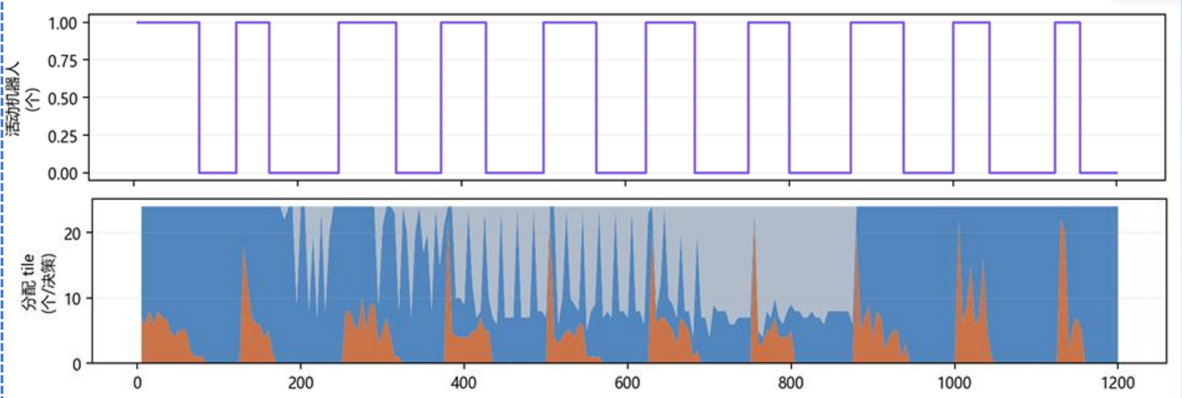




Combine data of 8 robots + 8 phones

Scheduling result

WAM MAC Scheduler Target:
within robot delay constraint，
higher **throughput** and **fairness**



- Robot QoS：**100%**
- BS Total Throughput：**+11.4%**
- Phone SE：**+10.5%**

* Compared with RL

CONTENTS

Wireless Foundation Model UC in M&O

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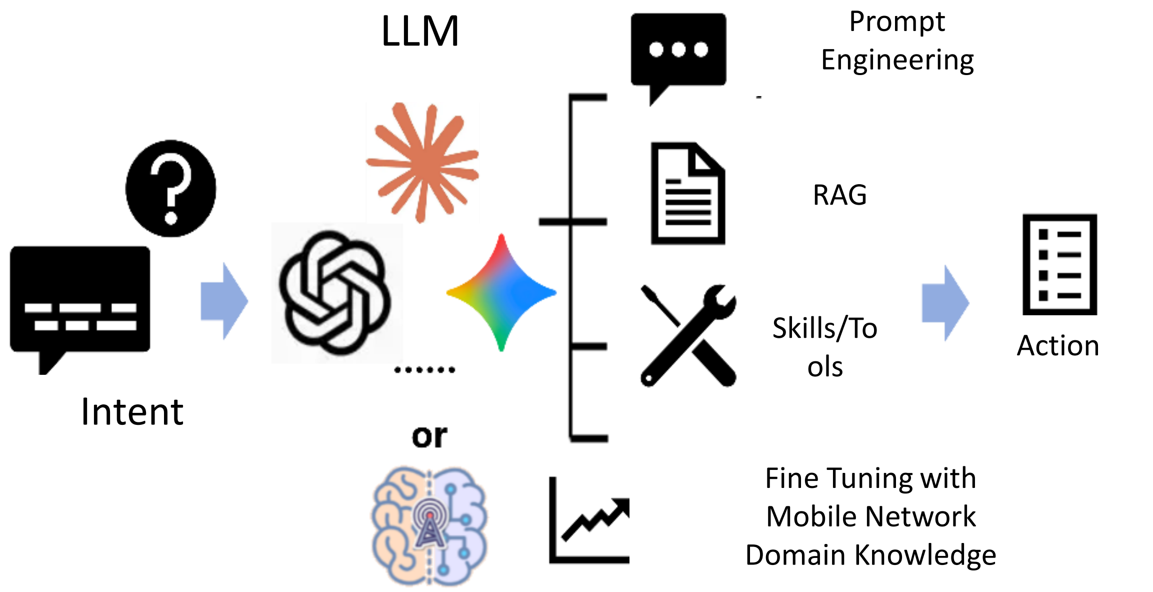
China Mobile is actively exploring Network Foundation Model in both network management and operation

Case1： Intent-Driven Fault Diagnosis for 5G Private Networks

Case2： Industrial Network Quality Management

Intelligent Network Maintenance and Optimization

Agentic AI as Main Solution for Network M&O



LLM+Fine Tuning+Prompt Engineering+RAG

Enhance LLMs with domain knowledge and Agent harness:

- Network specific knowledge-base
- Intent-based AI Agent design utilizing network MCP
- Recursive network monitoring and optimization

1. Intent-Driven Fault Diagnosis for 5G Private Networks

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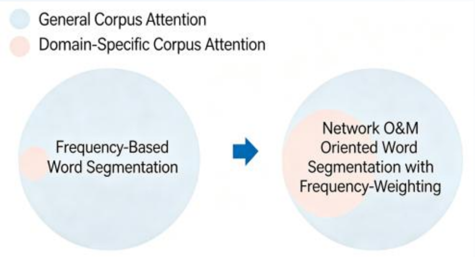
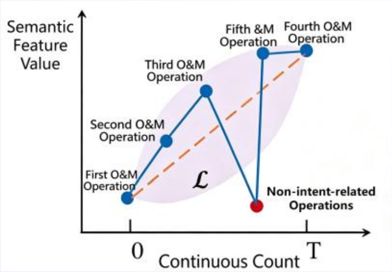
Challenge

Heavy Reliance on Expert Experience: Fault diagnosis depend on O&M expertise, with staff turnover causing knowledge gaps and inconsistent diagnostic performance

1. User Complaint Understanding
Restricting Intent Scope to Private-Network O&M Scenarios

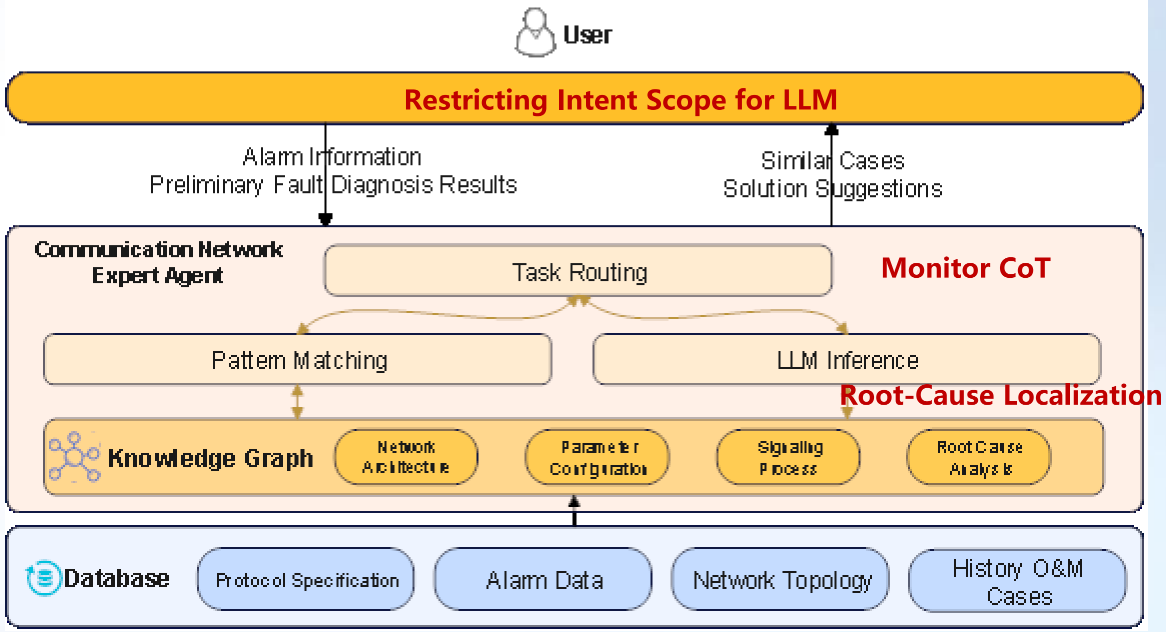


2. Task Routing for Network Troubleshooting
Monitoring CoT Coherence and Operational Context



3. Experience-Based Root-Cause Localization
Verifying Intent-to-Network-Issue Matching via Advanced Knowledge Graphs

Advanced Knowledge Graphs
- ✓ IE Structures and Values 6,045 entries
- ✓ Signalling Procedures 1,733 entries
- ✓ ...

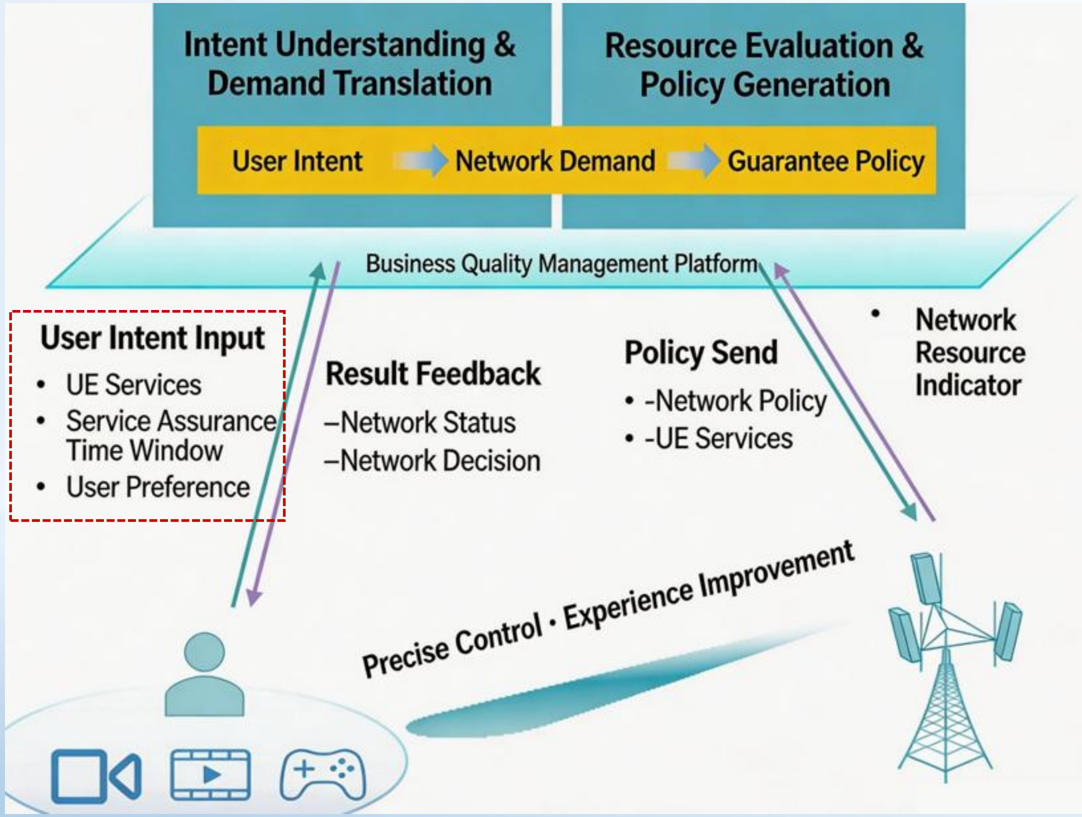


Intent recognition accuracy >95%
Fault-analysis time reduced by 75%

2. Industrial Network Quality Management

Challenge

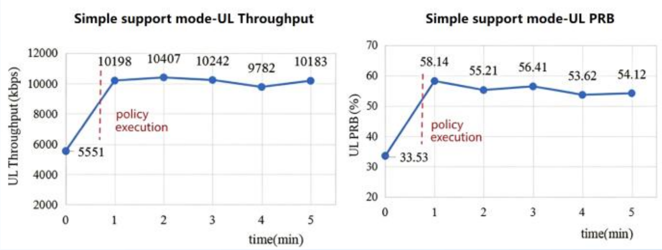
Limitations of Network Element Monitoring Mode: Existing network monitoring only captures device-level alarms and KQIs, failing to directly characterize E2E user service experience



For robot VLA services

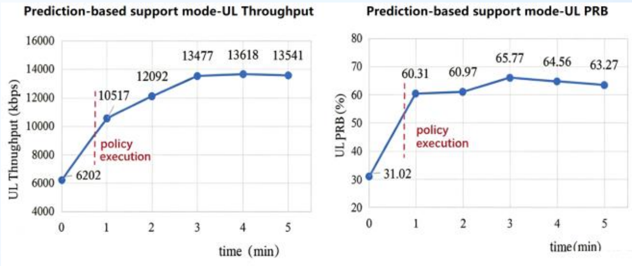
Simple support mode:

One-shot policy deployment



Prediction-based support mode:

Adjust the policy repeatedly based on network changes after policy deployment



The DL RTT is reduced by 54%
The UL throughput is increased by 69.6%.

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THANK YOU