ENI PoC #17: Intelligent Satellite-Terrestrial Integration Network Architecture Progress Update

Rapporteur:

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ENI PoC project #17: Intelligent Satellite-Terrestrial Integration Network Architecture

PoC Goals and PoC member task

Host/Team Leader:

Team members:

- ✓ **PoC Project Goal #1: Hand-and-Arm based Architecture. Demonstrate the architecture design with inherent wide-area coverage capability and the unified management of user access with ubiquitous signaling coverage.**
- ✓ **PoC Project Goal #2: Intelligent On-demand Coverage. Demonstrate the intelligent on-demand coverage technology to provide dynamic resource allocation for traffic steering to meet diversified user demands.**

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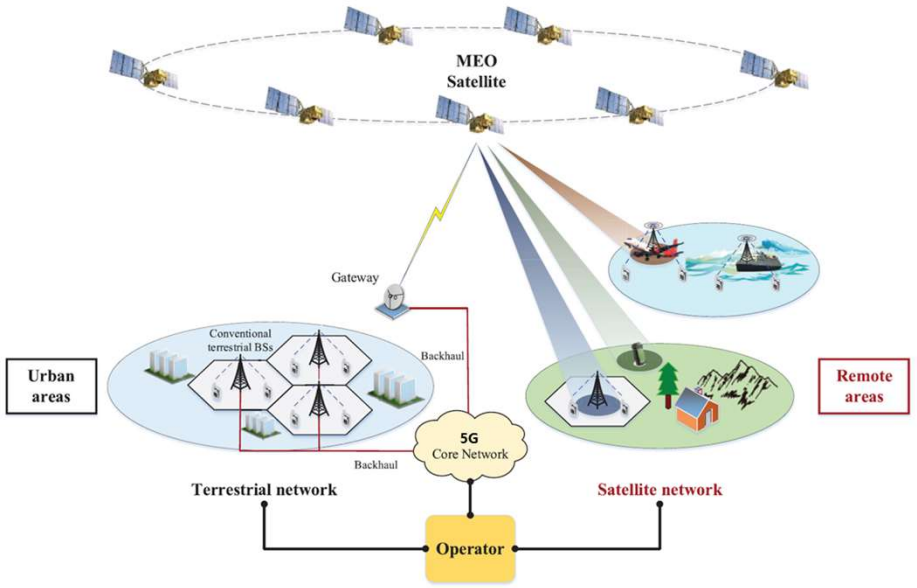
The integrated satellite-terrestrial network architecture to achieve high effective network efficiency

The integration architecture is composed of the MEO satellite network and the terrestrial network, both of which are connected to the 5G core network of the operator. To provide unified and continuous communication service, the MEO satellite network and the terrestrial network are integrated at the air interface level. In this way, unified terminal devices can seamlessly access either the satellite network or the terrestrial cellular network according to different service scenarios. For users located in the coverage of terrestrial networks, generally in urban areas, the users will access the terrestrial network for broadband services. For users in areas without terrestrial networks, such as rural areas, sea areas, and airspace, the users will access the satellite network for communication.



The integrated satellite-terrestrial network architecture

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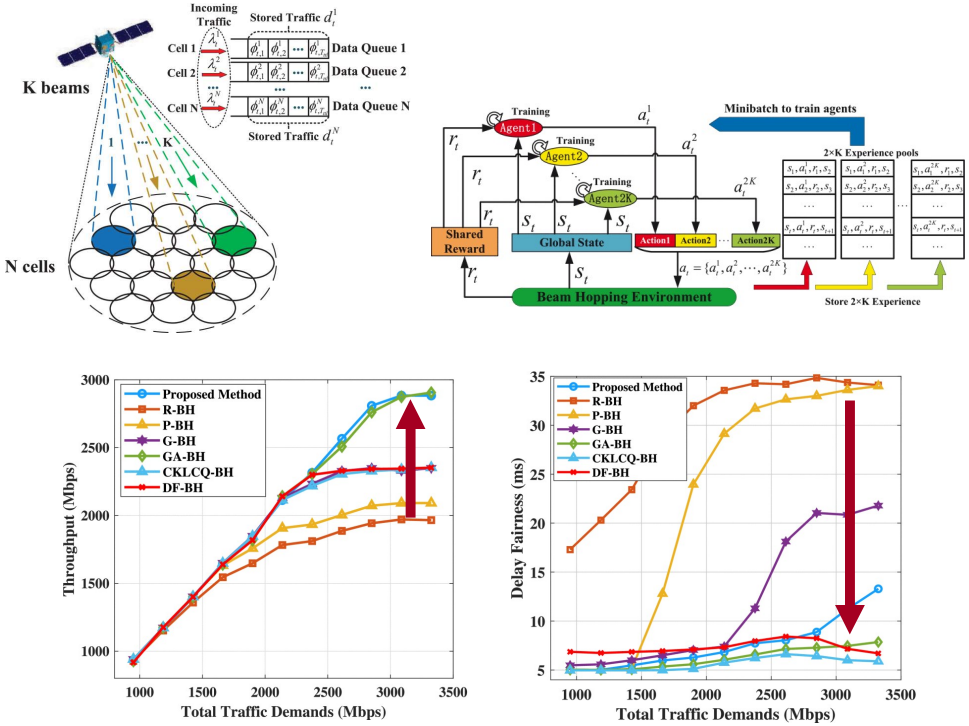
Intelligent On-demand Coverage

A dynamic beam pattern and bandwidth allocation scheme based on DRL is proposed, which flexibly uses three degrees of freedom of time, space and frequency. And a cooperative multi-agent deep reinforcement learning framework is proposed to solve the explosion of action space, where each agent is only responsible for the illumination allocation or bandwidth allocation of one beam. The agents can learn to collaborate by sharing the same reward to achieve the common goal, which refers to maximize the throughput and minimize the delay fairness between cells. Simulations have proven that the proposed method has better performance of data throughput and the delay fairness than existing beam hopping approaches.



Performance of the intelligent on-demand coverage

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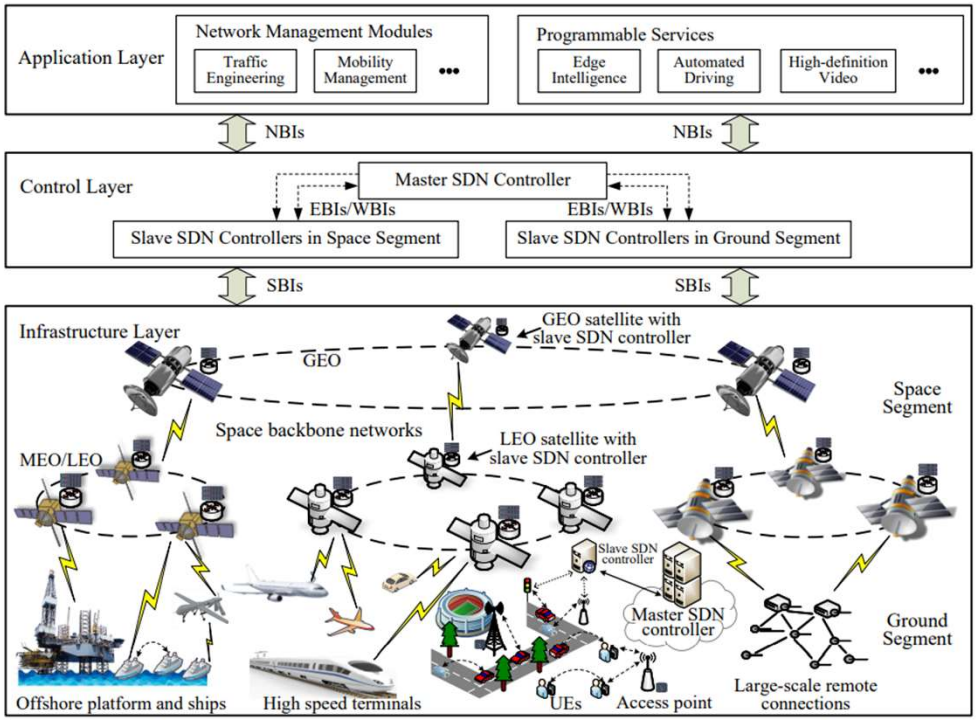
Software defined intelligent satellite-terrestrial integration

In order to dealing with the poor flexibility of network architecture, low adaptability to dynamic environments and low resource utilization, the software defined intelligent satellite-terrestrial integrated networks architecture can be used. This architecture can be used to realize agile and effective network management and control.

1.Communications on the Move
2.Internet of Things (IoT) in Remote Areas
3. Communications among Non-Terrestrial Platforms



Architecture of software defined intelligent satellite-terrestrial integrated networks

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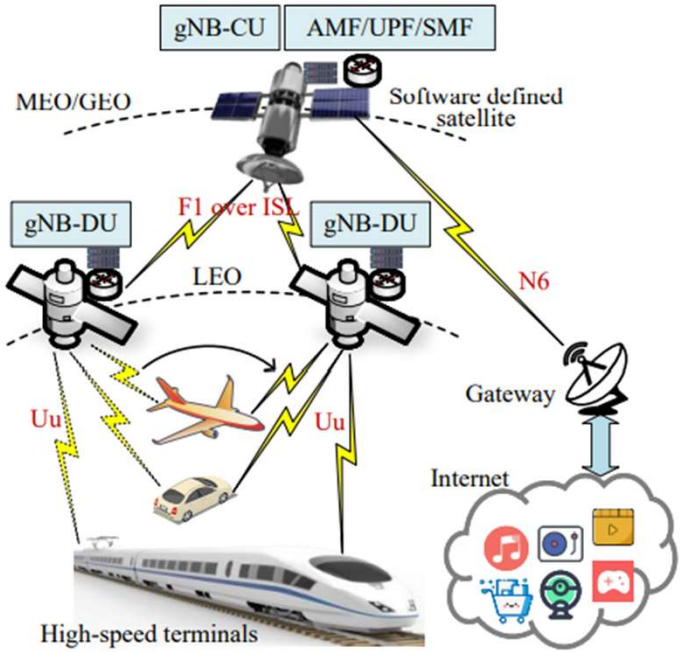
1.Communications on the Move

gNB-CU and core network functions are deployed on the MEO/GEO satellite, and gNB-DU is deployed on the LEO satellite. Thus, the terminals on the move are able to establish direct and/or complementary (need the relay node) connections with satellites. Meanwhile, terminals are able to be handed over between gNB-DUs that are centrally controlled by one gNB-CU, which reduces the signaling overhead and handover latency. Satellites will forward the data received from terrestrial terminals through the satellite feeder link to the terrestrial gateways connected to the Internet



Communications on the Move

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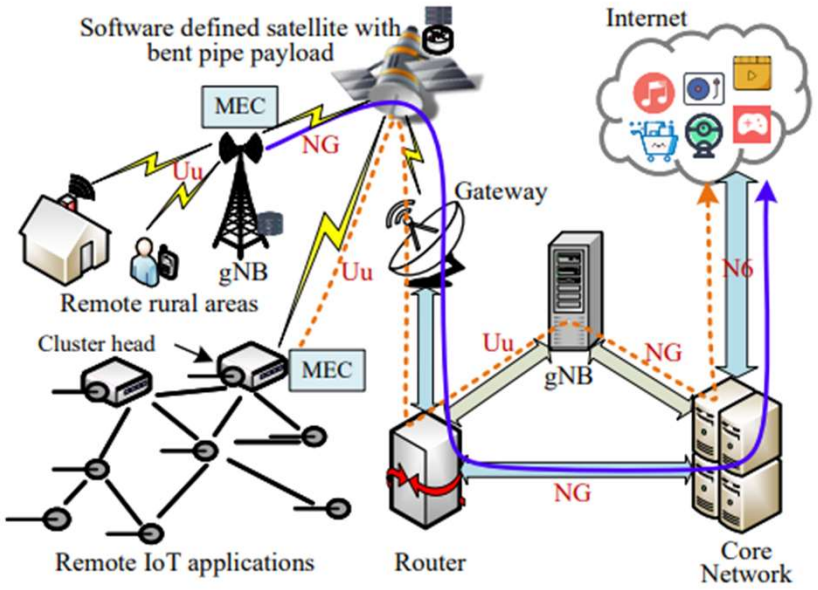
2. Internet of Things (IoT) in Remote Areas

the IoT devices can establish direct or complementary connections with satellites by cluster heads or terrestrial relay nodes, and use satellites as the mobile backhaul to forward data to the terrestrial core network. there are two radio access methods in this network. The solid line denotes that users access nearby base stations and utilize the satellite as mobile backhaul to access the core network, and the dashed line denotes that users use satellites as relay nodes to access the base station. the intelligent analysis for sensing data can be performed at the edge of the network to reduce the burden of satellite-to-earth links. the module of MEC with computation and storage resources can be equipped at terrestrial base stations for IoT data processing. By uploading only processed data or analysis results, the occupied satellite-earth link resources can be reduced.



Internet of Things (IoT) in Remote Areas

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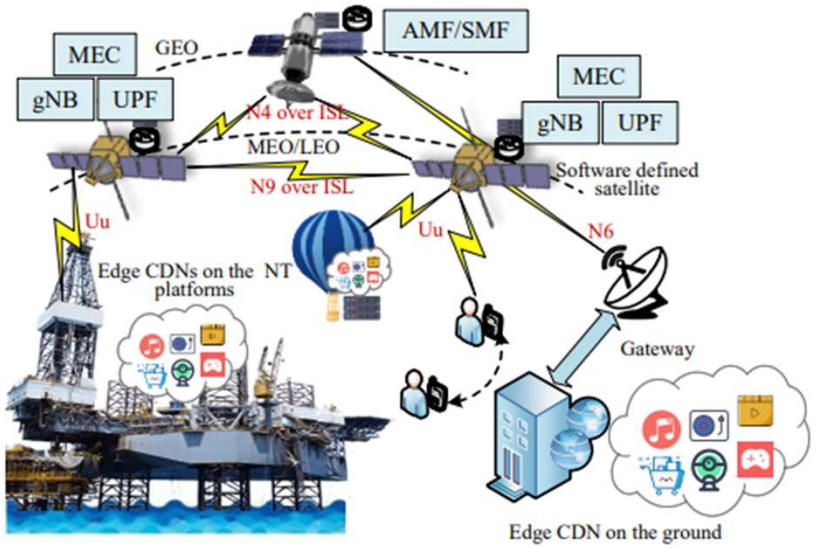
3. Communications among Non-Terrestrial Platforms

Networking without the terrestrial core network can be achieved by reconstructing the core network functions on the GEO satellite and cooperating with the space backbone network. the base stations and various relay nodes with satellite access capabilities in these platforms form a hybrid satellite access network with satellite base stations to provide access selection services for terminals. Thus, a satellite Internet can be formed among these non-terrestrial platforms. Moreover, the terrestrial Content Delivery Networks (CDNs) and the CDNs on platforms can be connected through satellites and provide various services on the satellite Internet.



Communications among Non-Terrestrial Platforms

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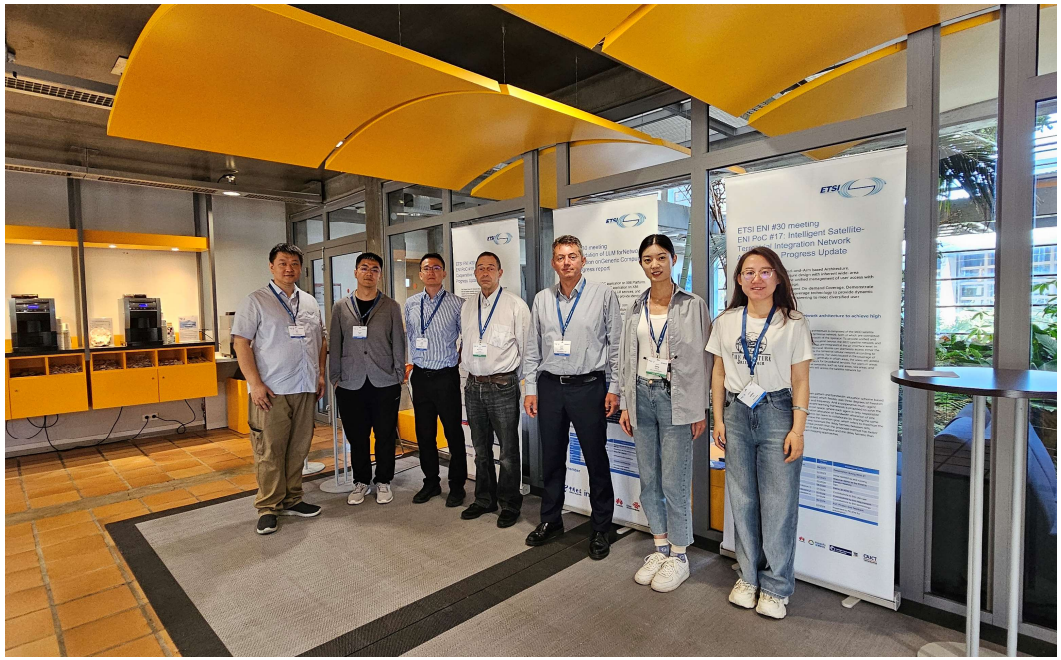
PoC Milestones and Current Progress

Demo at ENI#30 June 2024



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PoC Milestones and Current Progress

PoC Milestone	Stages/Milestone description	Target Date	Additional Info
P.S	PoC project submission	09/2023	Presentation during #ENI 27
P.TP.1	PoC Test Plan 1	12/2023	Initial testbed up and running
P.D1	PoC Demo 1	12/2023	Webinar demo at the ENI#28 plenary meeting
P.D2	PoC Demo 2	06/2024	Demo at ENI#30
P.D3	PoC Demo 3	09/2024	Demo at ENI#31
P.C1	PoC Expected Contribution 1	10/2024	Contributions to ENI use case
P.C2	PoC Expected Contribution 2	10/2024	Contributions to ENI requirement
P.R	PoC Report	10/2024	PoC-Project-End Feedback
P.E	PoC Project End	12/2024	Presented to ISG ENI for information