ENI PoC #19: Space-Ground Cooperative Network Slicing Progress Update

Rapporteur: NDSC

China Telecom, Asiainfo, Huawei, CAICT, CNIT, CNR ISTI

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PoC Goals and PoC member task

Host/Team Leader: NDSC, China Telecom

Team members: CNIT, Huawei, AsiaInfo, Consiglio Nazionale delle Ricerche (ISTI), CAICT

- ✓ **PoC Project Goal #1: Network Slice Data Plane Adaptation Mapping. Demonstrate how to support identity resolution such as VLAN and IP address on the data plane, support precise identification and control for user services, and realize the slicing adaptation between mobile communication network and satellite network.**

- ✓ **PoC Project Goal #2: : Space-Ground Network Slice Cooperative Control. Demonstrate how to exchange the slicing control information with the control plane of ground mobile communication network and satellite network (5GC and SNOCC), optimize the global service quality of network slicing, and ensure the consistency and continuity of slicing service in space-ground cooperative network environment.**

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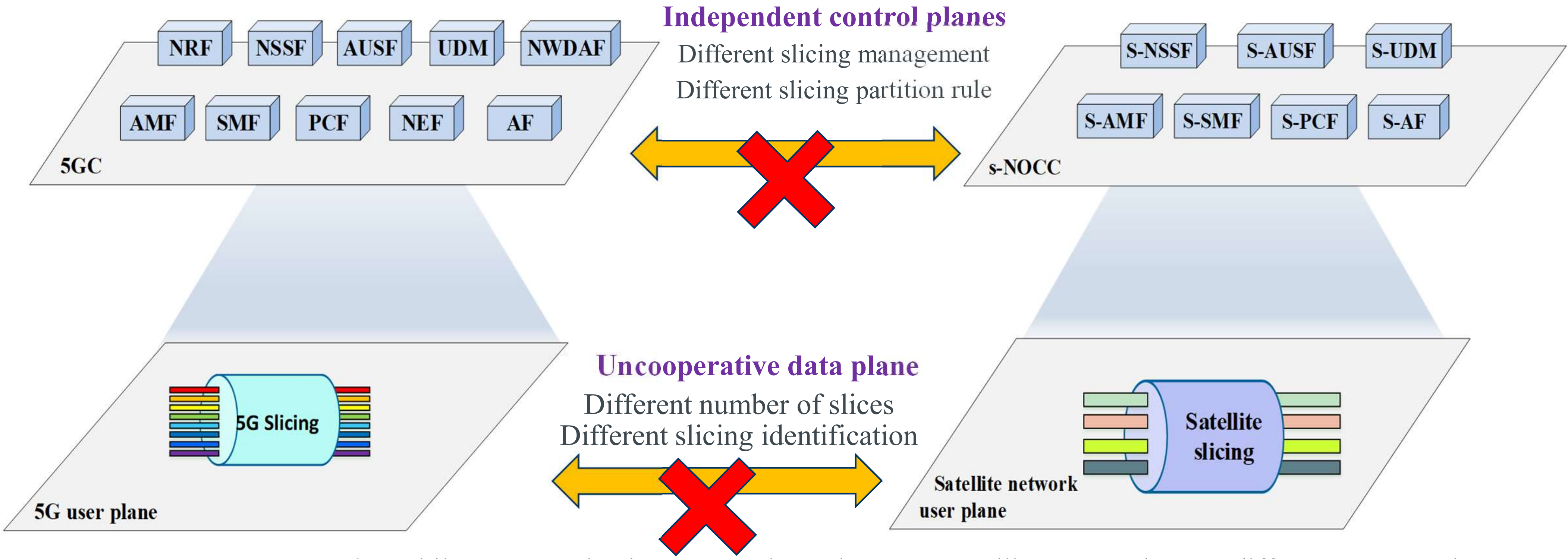
Core problem： Difficulty to interconnect 5G network and satellite network slices



Core problem： Ground mobile communication network and space satellite network are different on service classification of network slicing, number of slices and slicing construction. As a result, the slices of the two networks cannot be directly interconnected.

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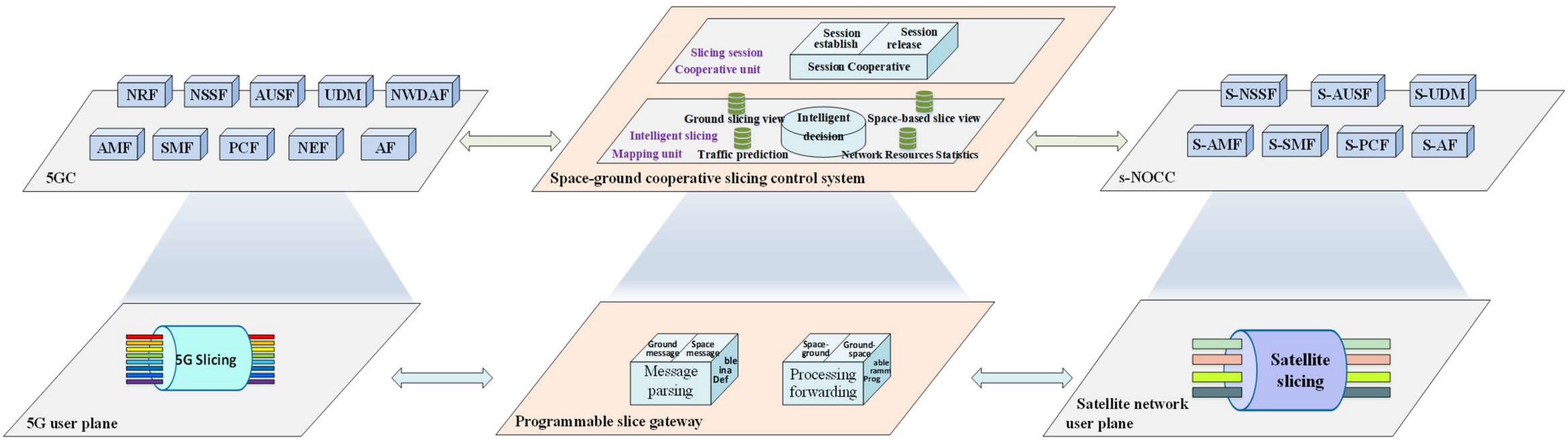
Innovation 1: Architecture of Space-Ground Cooperative Network Slicing



A programmable slicing gateway and a space-ground cooperative slicing control system can be deployed between the ground mobile communication network and the satellite network. On the data plane, it uses definable message parsing and forwarding capabilities to accurately identify and control slicing services, and realize heterogeneous network slicing adaptation. On the control plane, it collaboratively opens the slicing session channel in space-ground cooperative network, and intelligently generates the slicing mapping strategy, to improve the end-to-end slicing service quality of space-ground cooperative network.

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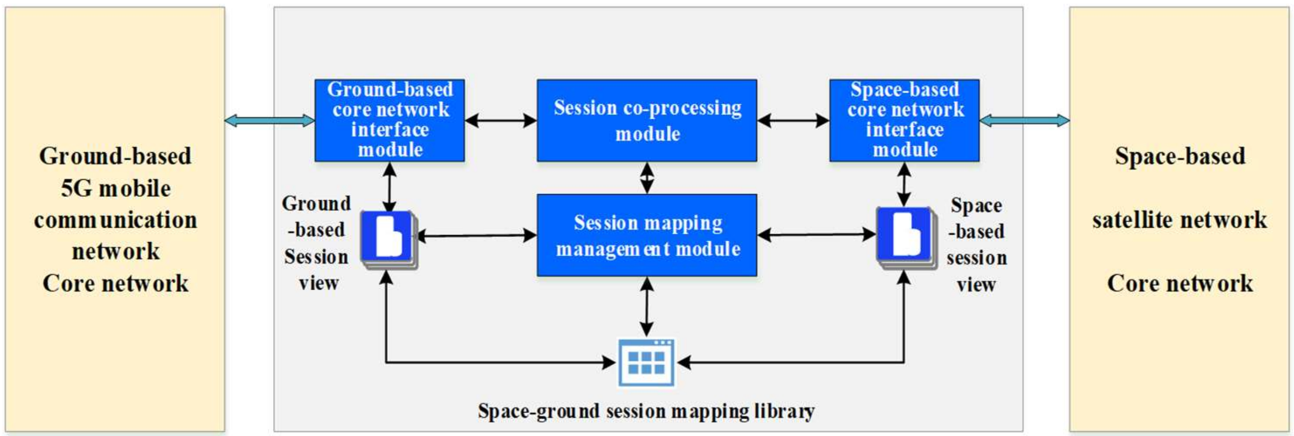
Innovation 2: Space-ground slicing session collaboration (Module introduction)



- **Slice mapping management module** is responsible for maintaining the mapping relationship between ground-based and space-based PDU sessions.
- **Session cooperative processing module** can cooperate with the process of establishing, modifying and releasing sessions of ground-based and space-based networks
- **Ground-based core network interface module** is responsible for the interface with the ground-based mobile communication core network.
- **Space-based core network interface module** is responsible for the interface with the space-based satellite network core network.

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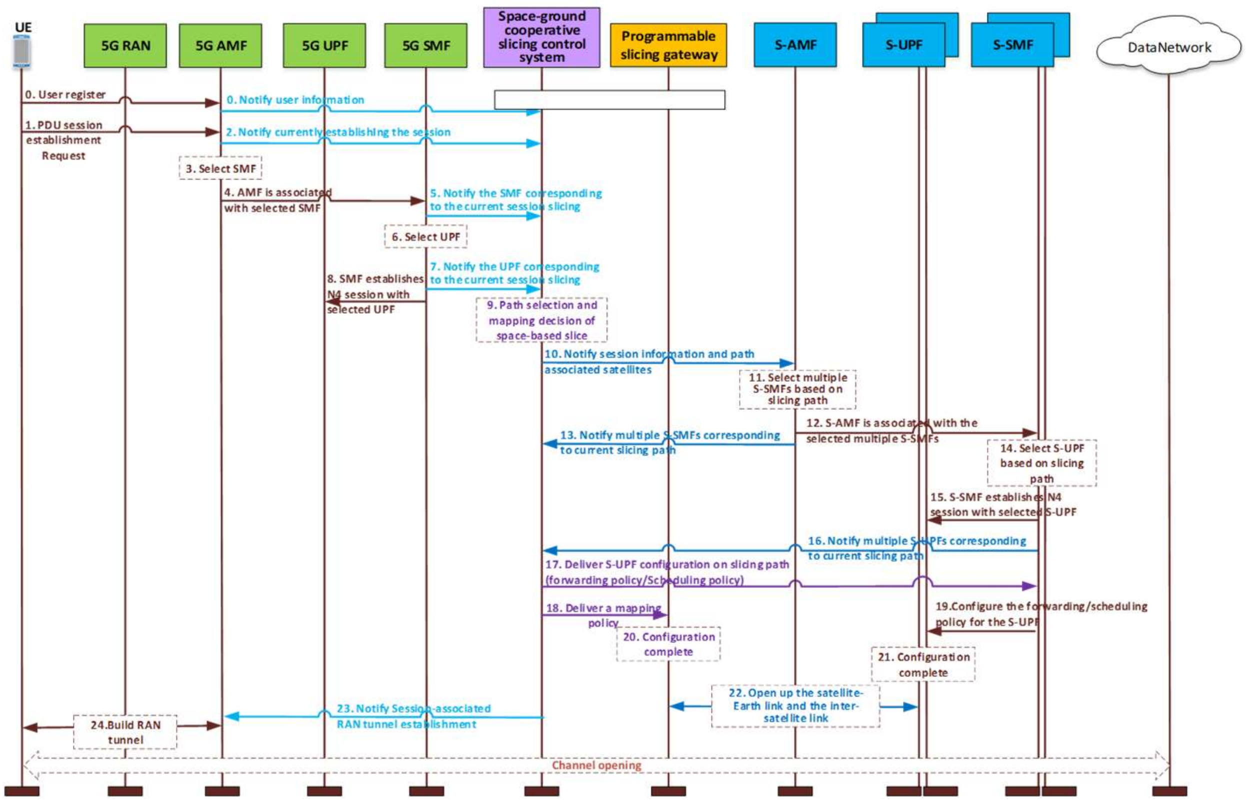
Innovation 3: Space-ground slicing session collaboration (PDU session establishing)



The space-ground cooperative slicing control system interacts with the space and ground network slicing control planes respectively to maintain the mapping relationship between ground-based PDU sessions and space-based PDU sessions. So the establishing, modifying and releasing sessions of ground-based network and space-based network can be cooperated with each other. The programmable slicing gateway receives configuration policies and establishes PDU session channels from UE to ground-based 5G mobile communication network, space-based satellite network and up to Data Network.

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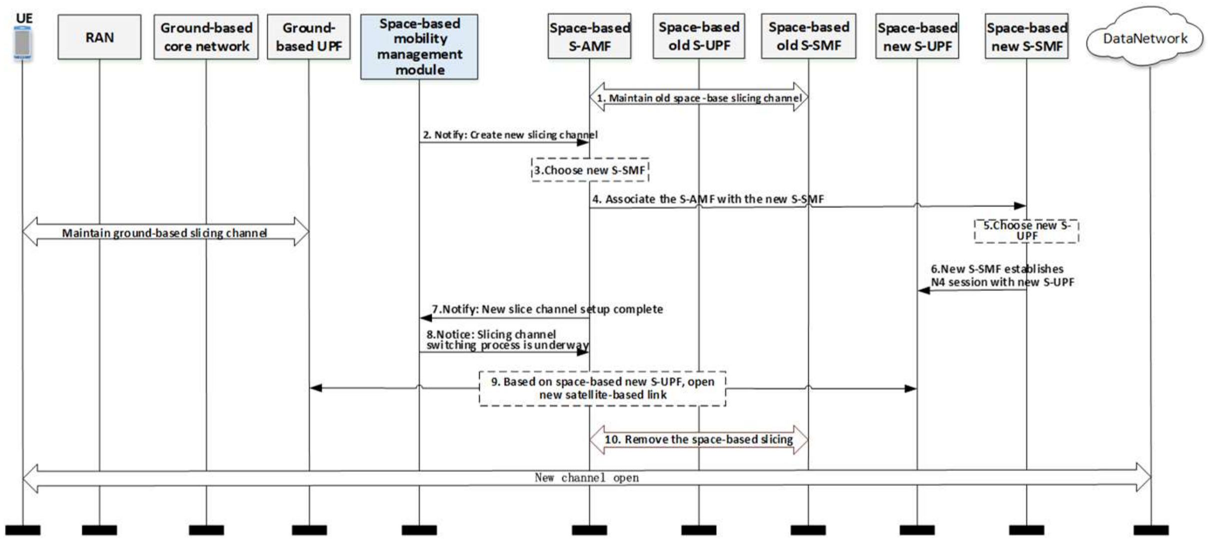
Innovation 4: Space-ground slicing mobility management (satellite movement)



For the satellite movement events, the space-based mobility management module informs the space-based core network in advance of the deployment of a new slicing channel, which is based on a new satellite construction serving the satellite-based link, and then performs the satellite switching process to open the new space-based slicing channel and the old ground-based slicing channel. Inform the space-based core Network to remove the old space-based slicer channel and recover related resources.

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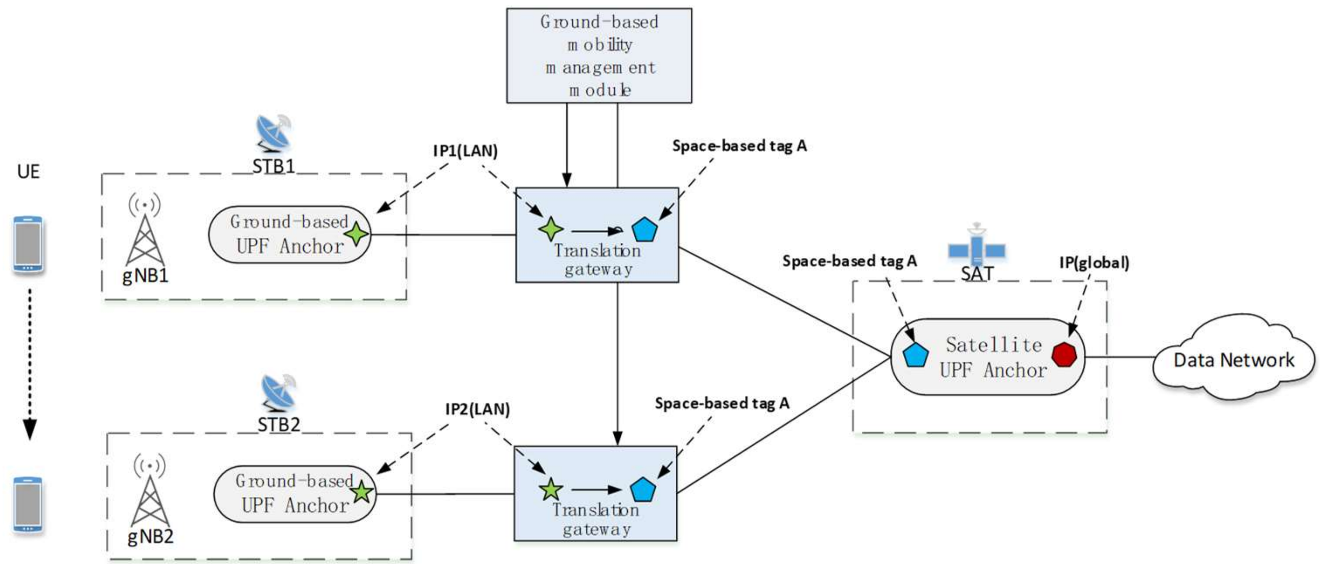
Innovation 5: Space-ground slicing mobility management (UE movement)



For the UE movement events, the ground-based mobility management module manages network identifiers used by ground-based and space-based networks in a unified way to realize cooperative allocation and mapping of network identifiers, including space-based network labels and global IP addresses for accessing data networks. At the same time, a conversion gateway is deployed behind the ground-based UPF anchor of the satellite base station. The translation gateway is managed by the ground-based mobility management module and performs the identity translation operations.

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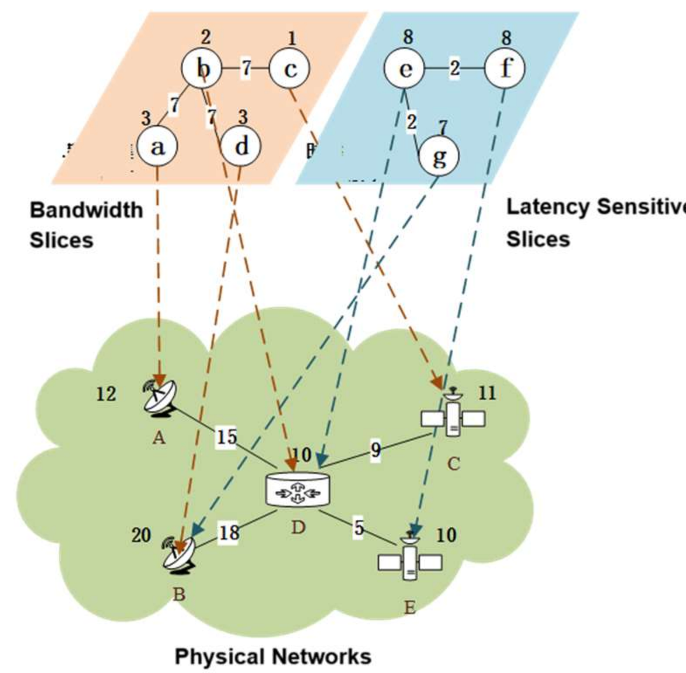
Innovation 6: Mathematical model generation based on the slices of the optimal weighted graph matching

Based on the principle of adjacency matrix feature vector decomposition, the fast matching of network weighted graphs is carried out to reduce the computational complexity of network resource slicing. The adjacency matrix element substitution mechanism is used to reduce the minimum bandwidth requirement of network resource slicing. Finally, the balance of load and bandwidth is further optimized through the virtual network mapping optimization based on the hill climbing algorithm.

During the mapping of virtual links, neighboring functions can be matched to both neighboring and non-neighboring nodes. It is necessary to replace the matrix elements representing the link bandwidth in the physical topological adjacency matrix, select an optimal path for each pair of nodes, and update the matching weight. In this PoC, a path is calculated for any pair of nodes, so that the ratio of the minimum bandwidth to the transmission hop number of the path is maximized, and the bandwidth hop ratio is updated to the link matching weight.



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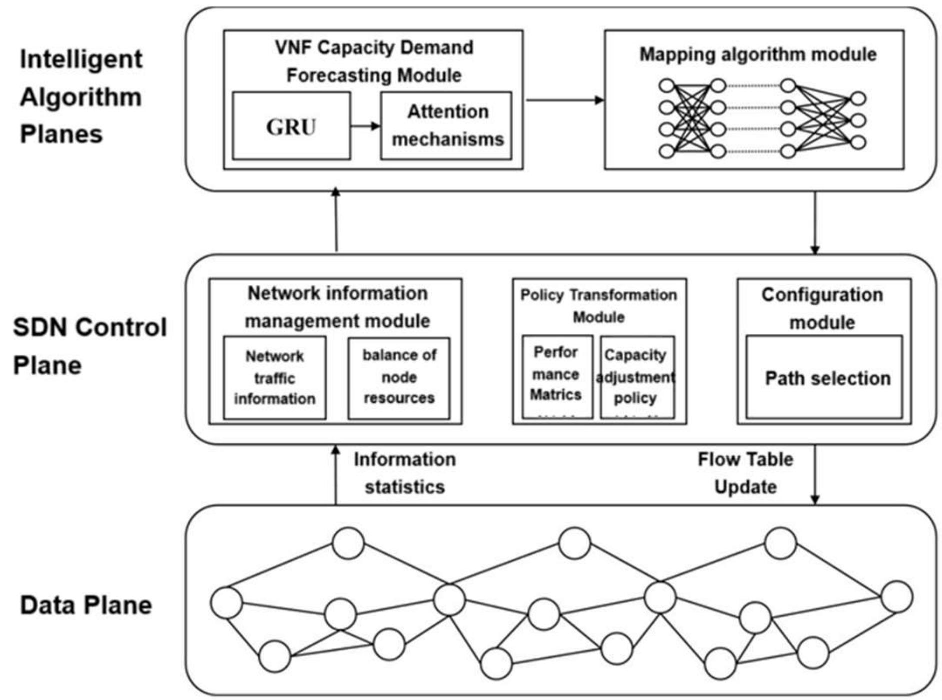
Innovation 7: Dynamic migration mapping of network resource slices

Dynamic migration mapping (DMM) of network resource slices is mainly implemented based on the SDN architecture, The core of DMM is the implementation of intelligent algorithms at the upper layer of the SDN controller, and the interaction between the algorithm and the SDN controller is completed through the SDN northbound interface. The functional modules loaded in the SDN controller include: the network information management module, which is responsible for the collection and collation of traffic data and node resource margin data; The policy conversion module is responsible for receiving the control strategy of the DRL intelligent algorithm and converting it into a VNF centralized placement strategy; The underlying configuration module is responsible for converting VNF centralized placement policies into configuration information for the physical network.



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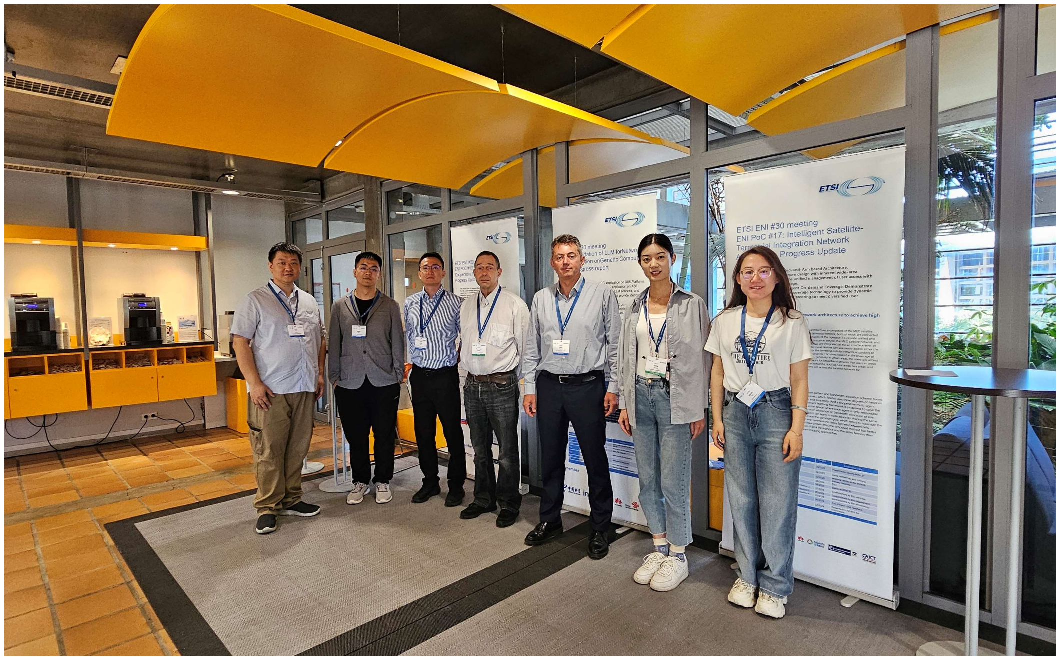
PoC Milestones and Current Progress

Demo at ENI#30 June 2024



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PoC Milestones and Current Progress

Current

Target

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	11/2024	PoC-Project-End Feedback
P.E	PoC Project End	12/2024	Presented to ISG ENI for information