TOWARDS 6G AND NTN: OPPORTUNITIES FOR SRV6 AND AI

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OUTLINE & AIM

- PART #1
  - INTRODUCTION
  - NTN INFRASTRUCTURE
  - 5G & NTN
- PART #2
  - INTRODUCTION ON SRV6
  - TECHNICAL ASPECTS
  - FINAL CONSIDERATIONS

INTRODUCTION & NTN PRELIMINARIES

Premise:

The evolution of telecommunication technologies, the ever-increasing demand for new services, and the the exponential growth of smart devices fuels the development of Non-Terrestrial Network (NTN) systems as an effective solution to complement terrestrial networks in providing services over uncovered or under-served geographical areas;

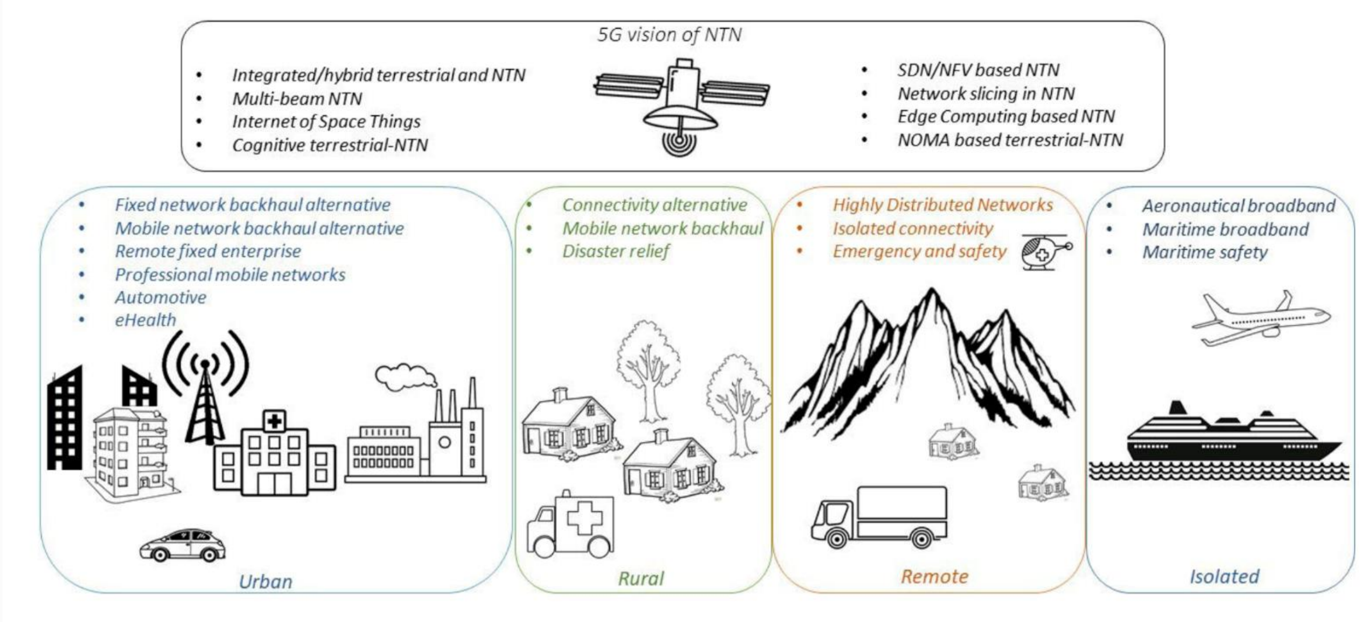
In this context, 5G NTN can help:

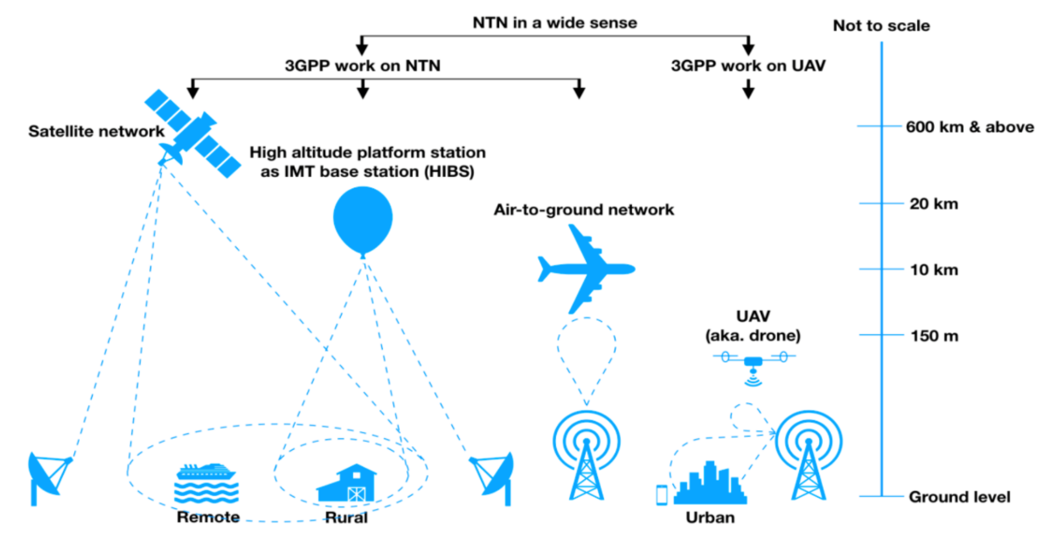
- Satisfying all of the user requests and providing the desired Quality of Service (QoS) anytime and anywhere, even when traveling (maritime cruise, high-speed train, and airplane);
- Providing connectivity service where it is economically challenging to provide coverage with a terrestrial network;
- Guarantying service continuity/availability of Machine-to-Machine (M2M)/Internet of Things (IoT) devices or for people in both critical communications and emerging services;
- Allowing network scalability owing to the provision of multicast/broadcast resources for the delivery of data to network edges and user terminals;

INTRODUCTION & NTN PRELIMINARIES

NTN Usage Scenarios

The NTNs are expected to play an important role in 5G & beyond systems by covering different verticals:





INTRODUCTION & NTN PRELIMINARIES

In support of …

(3GPP) defines an NTN as a network where spaceborne or airborne terminals act either as a relay node or as a base station;

Many releases address NTN integration with NR;

Technical Specification Group	Release	Study Item / Work Item	Responsible Groups	Technical Report
RAN (Radio Access Network)	Rel-15	RP-171450: Study on NR to support non-terrestrial networks Objective: study channel model, deployment scenarios, and potential key impact areas.	RAN plenary, RAN1	TR 38.811 [8]
	Rel-16	RP-190710: Study on solutions for NR to support non-terrestrial networks Objective: study a set of necessary features enabling NR support for NTN.	RAN1, RAN2, RAN3	TR 38.821 [9]
	Rel-17	RP-201256: Solutions for NR to support non-terrestrial networks Objective: specify the enhancements identified for NR NTN with a focus on LEO and GEO and implicit compatibility to support high altitude platform station and air-to-ground scenarios.	RAN1, RAN2, RAN3, RAN4	n/a
	Rel-17	RP-193235: Study on NB-IoT/eMTC support for NTN Objective: identify scenarios and study necessary changes to support NB-IoT and eMTC over satellite.	RAN1, RAN2	TR 36.763 [10]
SA (Service & System Aspects)	Rel-16	SP-170702: Study on using satellite access in 5G Objective: identify use cases and the associated requirements.	SA1	TR 22.822 [11]
	Rel-17	SP-180326: Integration of satellite access in 5G Objective: specify stage 1 requirements.	SA1	n/a
	Rel-17	SP-181253: Study on architecture aspects for using satellite access in 5G Objective: identify key issues of satellite integration in 5G system architecture and provide solutions for direct satellite access and satellite backhaul.	SA2	TR 23.737 [12]
	Rel-17	SP-191335: Integration of satellite systems in the 5G architecture Objective: produce normative specifications based on the conclusions identified in TR 23.737.	SA2	n/a
	Rel-17	SP-190138: Management and orchestration aspects with integrated satellite components in a 5G network Objective: identify key issues associated with business roles, service and network management, and orchestration of a 5G network with integrated satellite component(s) and study the associated solutions.	SA5	TR 28.808 [13]
	Rel-18	SP-191042: Guidelines for extra-territorial 5G systems Objective: study use cases of extra-territoriality, identify relevant features, technical aspects, and applicable types of regulations.	SA1	TR 22.926 [14]
CT (Core Network & Terminals)	Rel-17	CP-202244: CT aspects of 5GC architecture for satellite networks Objective of study phase: study the issues related to PLMN selection and propose solutions. Objective of normative phase: support the stage 2 requirements, and the requirements and solutions for PLMN selection for satellite access.	CT1, CT3, CT4	TR 24.821 [15]

NTN INFRASTRUCTURE

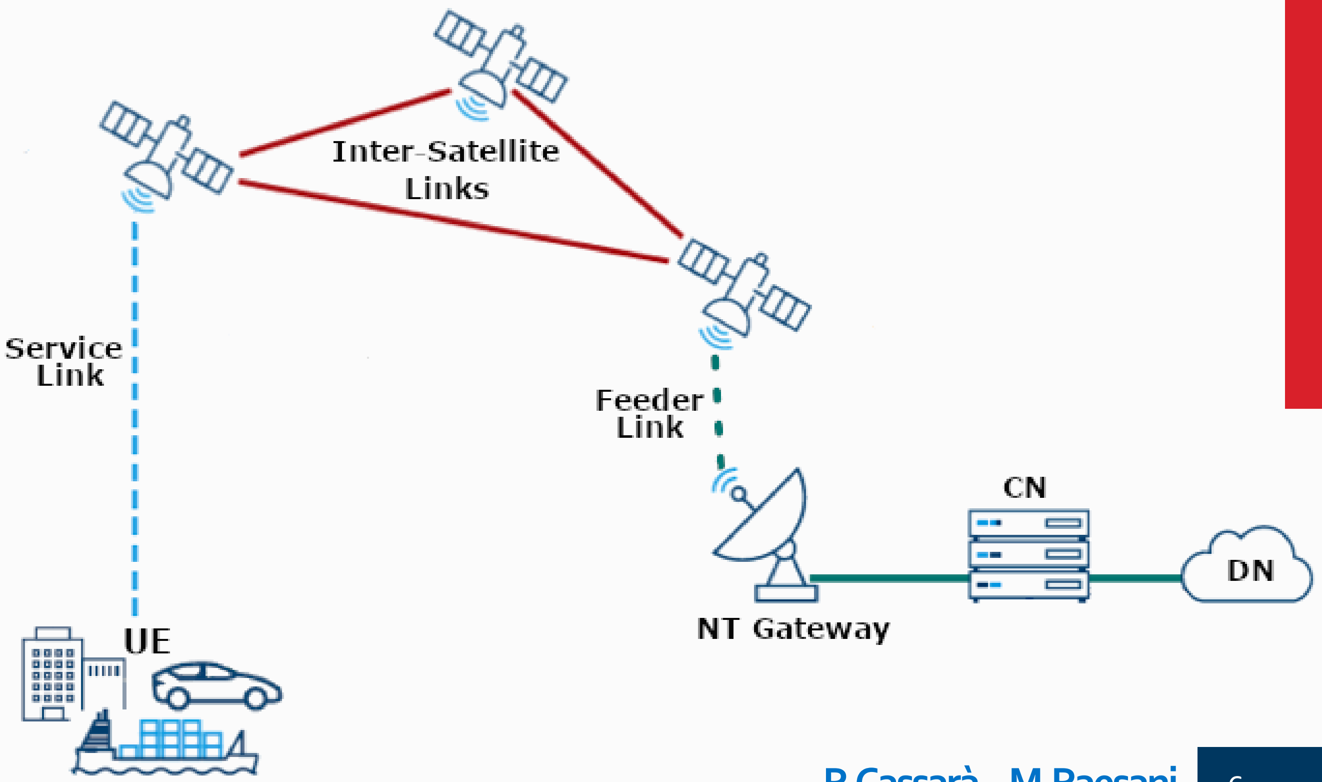
NTN Access Components:

- NTN terminal refers to the 3GPP User Equipment (UE) or a specific platform.
Note that Very small aperture terminals operate in the radio frequency of the Ka-band (i.e., 30 GHz in the uplink and 20 GHz in the downlink), whereas handheld terminals operate in the radio frequency of the S-band (i.e., 2 GHz);

- NTN gateway is a logical node connecting the NTN platform with the 5G core network;

- The service link is the radio link between the NTN terminal and the NTN platform;

- The feeder link is the radio link between the NTN gateway and the NTN platform;



NTN INFRASTRUCTURE

NTN Multi-Connectivity Scenarios

Multi-connectivity can guarantee continuity and scalability in 5G and beyond systems by integrating NTNs and terrestrial networks;

Benefits of multi-connectivity:

- Reliability and Broadband services in urban and rural areas;
- Connectivity among densely crowded areas (such as concerts, stadiums, city centers, and shopping malls);
- Connectivity for mobile users (high-speed trains, airplanes, and onboard cruises);

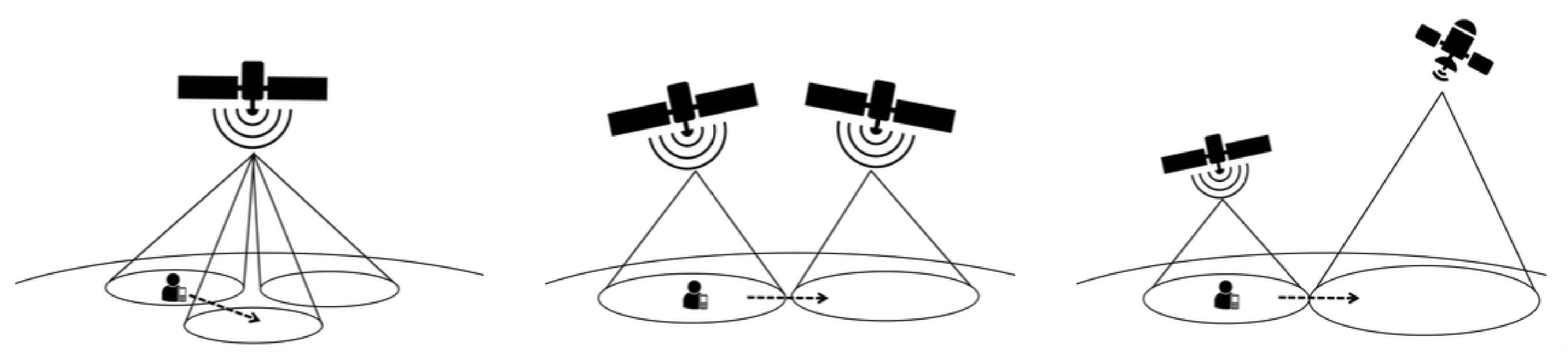
In 3GPP TR 38.821 investigated multi-connectivity architectures involving NTN and terrestrial NG-RANs or two NTN NG-RANs;

NTN INFRASTRUCTURE

NTN Mobility Management & Scenarios

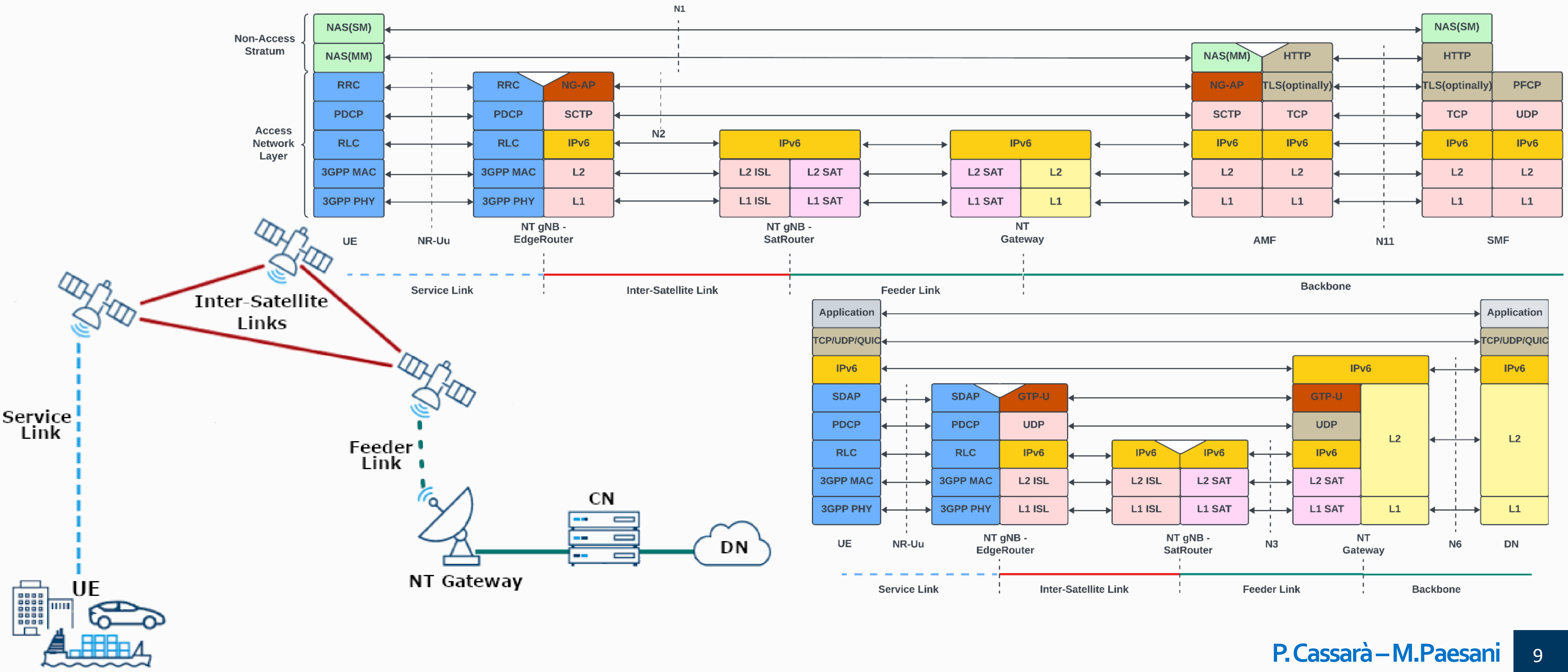
Handover categories:

- Intra-satellite handover occurs between satellite beams;
  Note: for NGSO satellites, frequent intra-satellite handovers are related to high beam footprint speeds on the ground;
- Inter-satellite handover occurs between satellites due to the limited geographical coverage of NGSO satellites;
- Inter-access network handover, or vertical handover, occurs between satellites belonging to different access networks or from the NGSO satellite to the gNB (or vice versa) in integrated terrestrial-NTN systems;



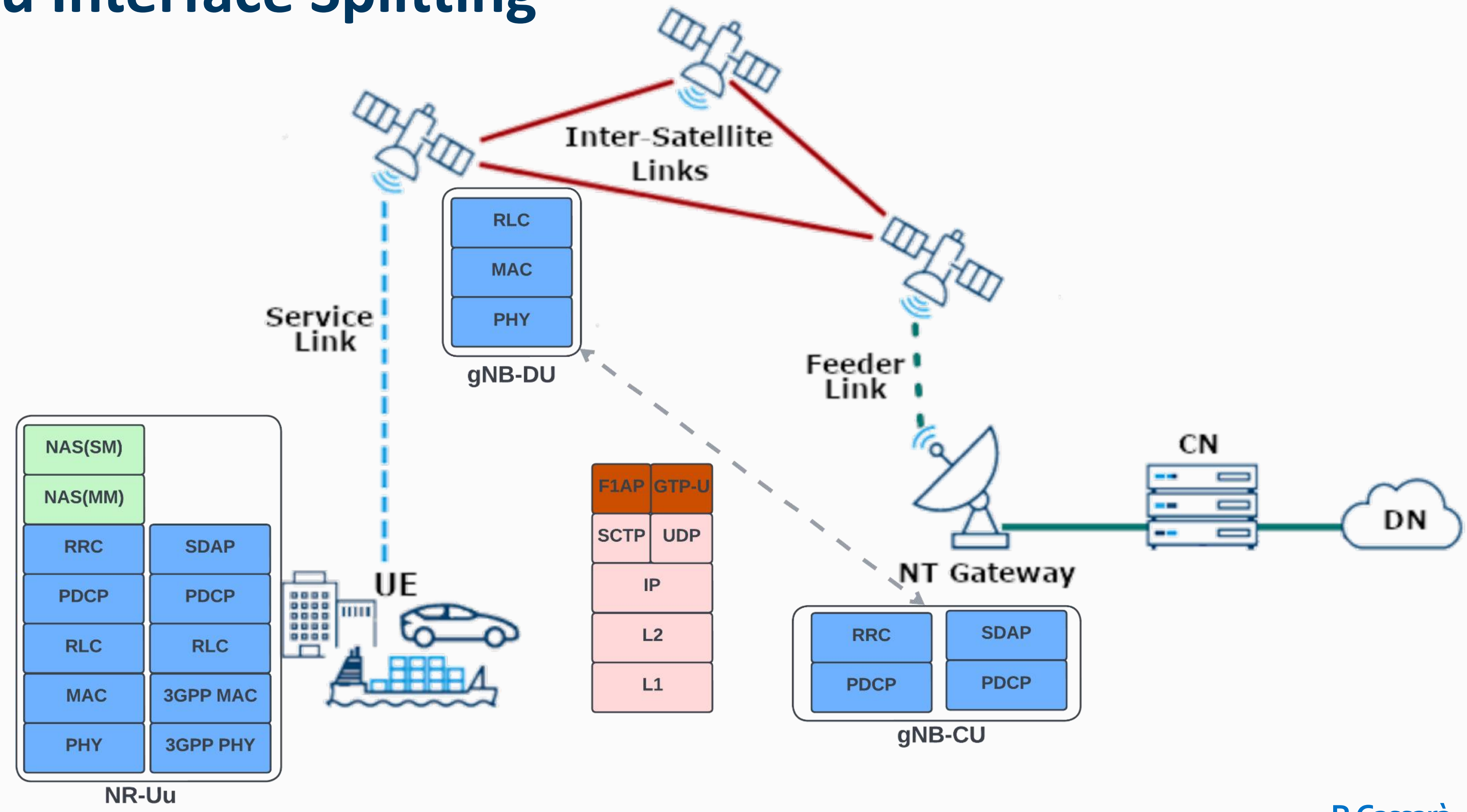
5G-NT ECOSYSTEM

User Plane and Control Plane



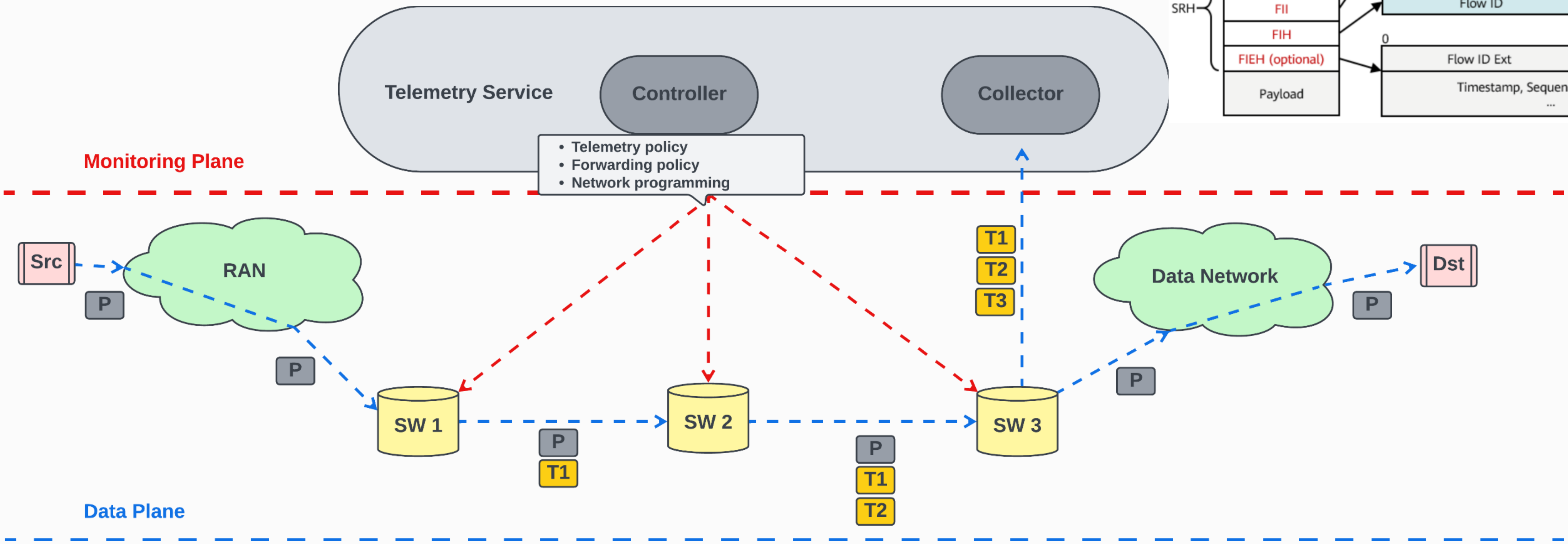
5G-NT ECOSYSTEM

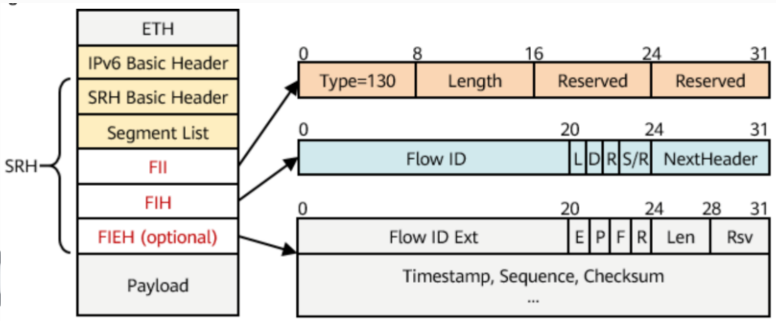
gNB’ Uu Interface Splitting



NETWORK PERFORMANCE MEASURING

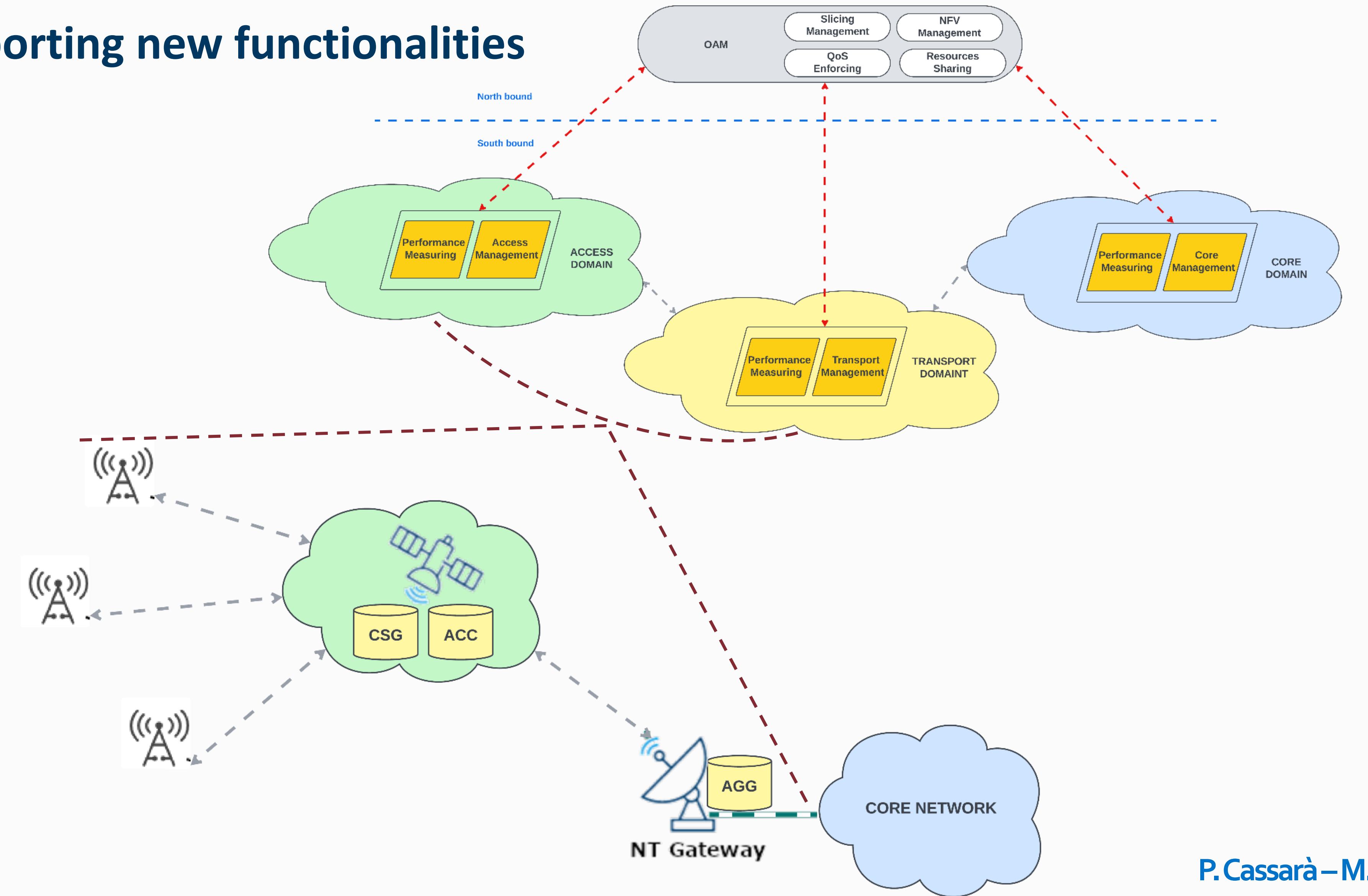
A brief overview of the in-band telemetry: SRv6 an IFIT tools





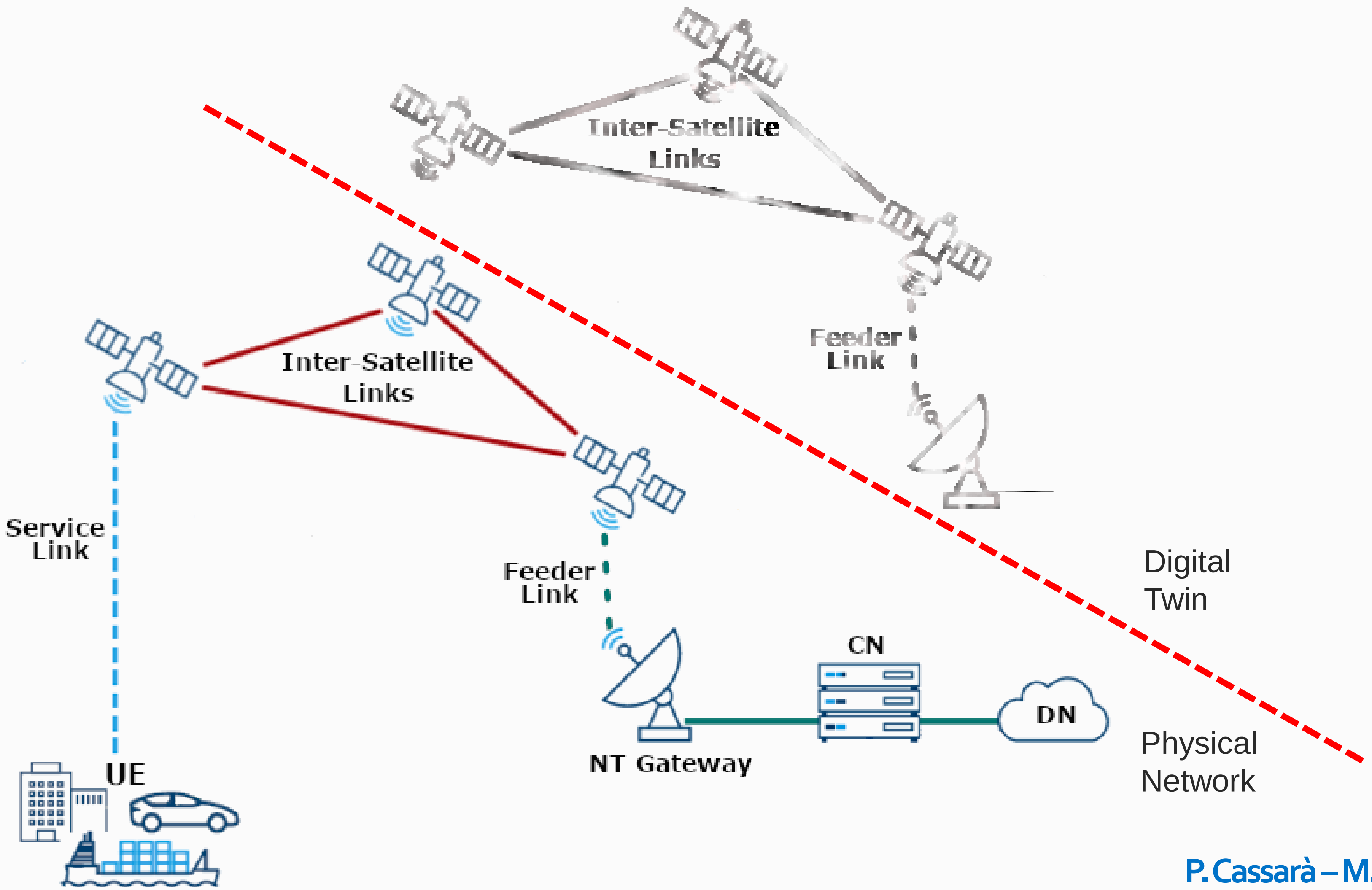
OAM ARCHITECTURE

IPRAN for supporting new functionalities



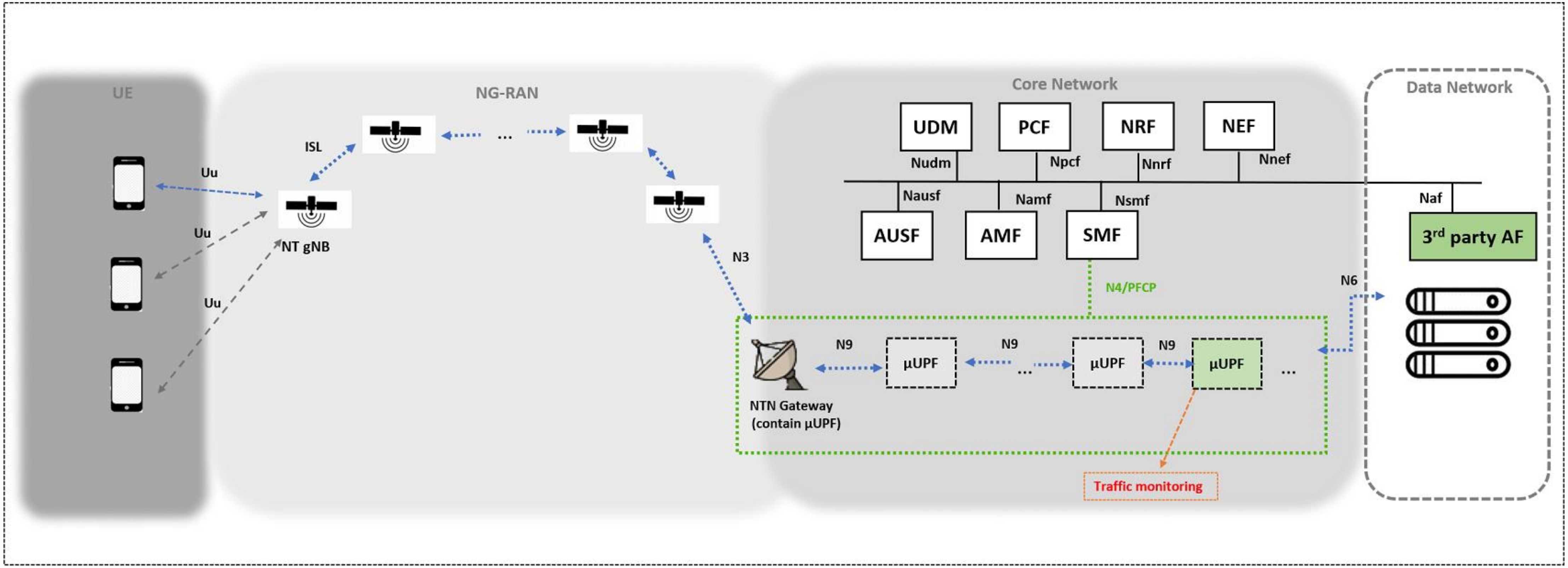
DIGITAL TWIN

Generative models to reproduce the behavior of networks



QOS ENFORCING

RL-based approaches for QoS Controlling



SRV6 DEEP DIVE

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Our future network will be Intent-Driven/Based Network (IDN/IBN)

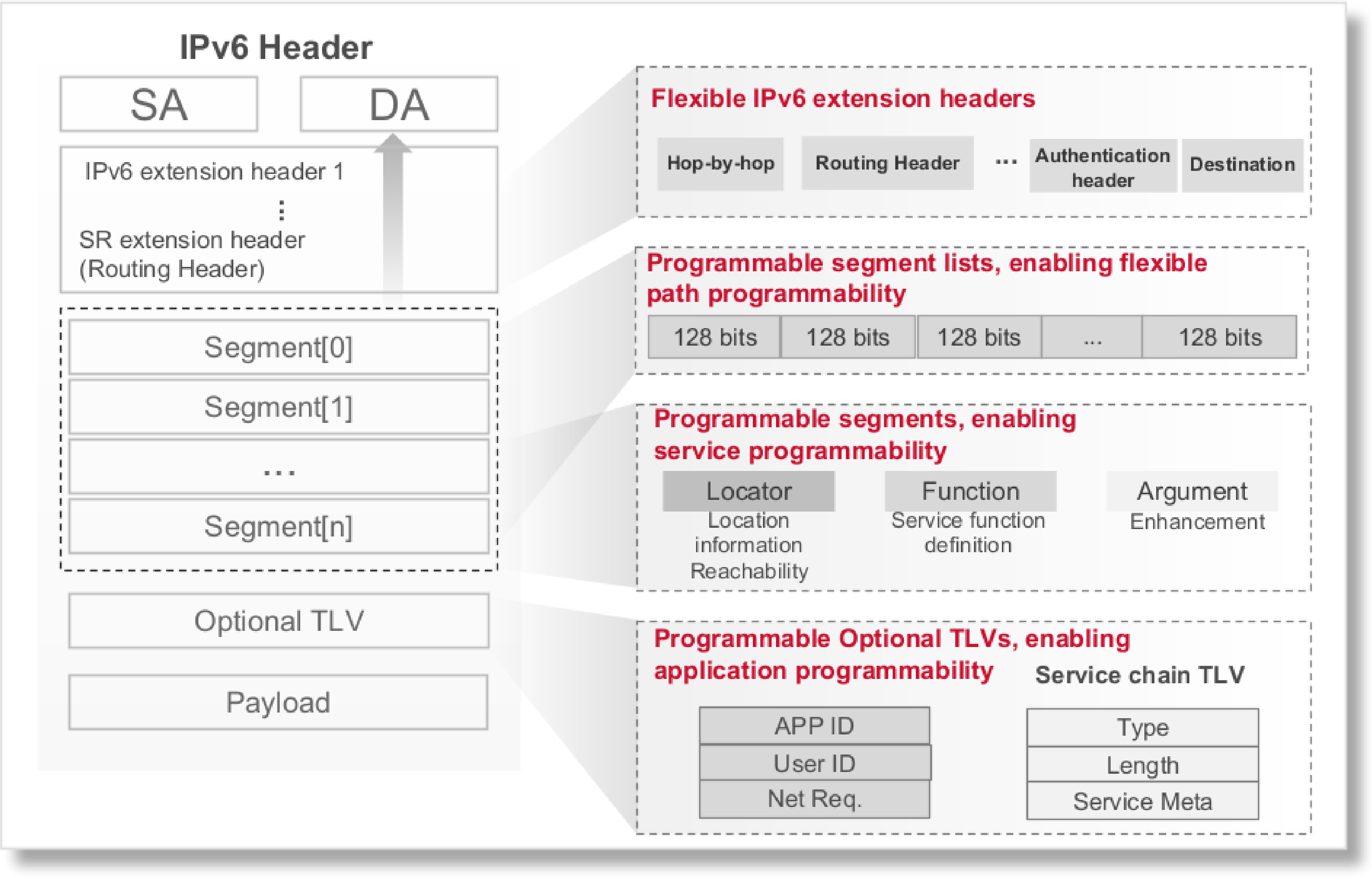
- Elastic architecture (Fabric)
- Dedicated network experience (Slicing)
- **Any2any connection (SRv6)**
- Intent driven (SDN)
- Highly Intelligent (AI)

Gradually Maturing SRv6 Standards

Service	Description	Status
Base	SRv6 Arch-Network Programming	RFC 8986
	IPv6 Segment Routing Header	RFC 8754
EVPN	SRv6 EVPN	RFC 9252
IGP	ISIS & OSPFv3 for SRv6	RFC 9352 & WG
OAM	SRv6 OAM	RFC9259

Mainstream Vendor already support SRv6: Arista, Broadcom, Cisco, Huawei, Juniper, Marvell, Nokia
(more info on EANTC Intop-test 2023)

SRV6 DEEP DIVE



Programmable Paths

Flexible segment list orchestration provides definable service paths

Programmable Services

VPN, VAS, and SFC service information can be flexibly defined

Programmable Applications

Extension header + Optional TLV enables networks to be aware of applications.

SRV6 DEEP DIVE

Control Protocols

5+ >> 2

IGP, LDP, BGP RSVP-TE, LDP	IGP, BGP

Encapsulation Protocols

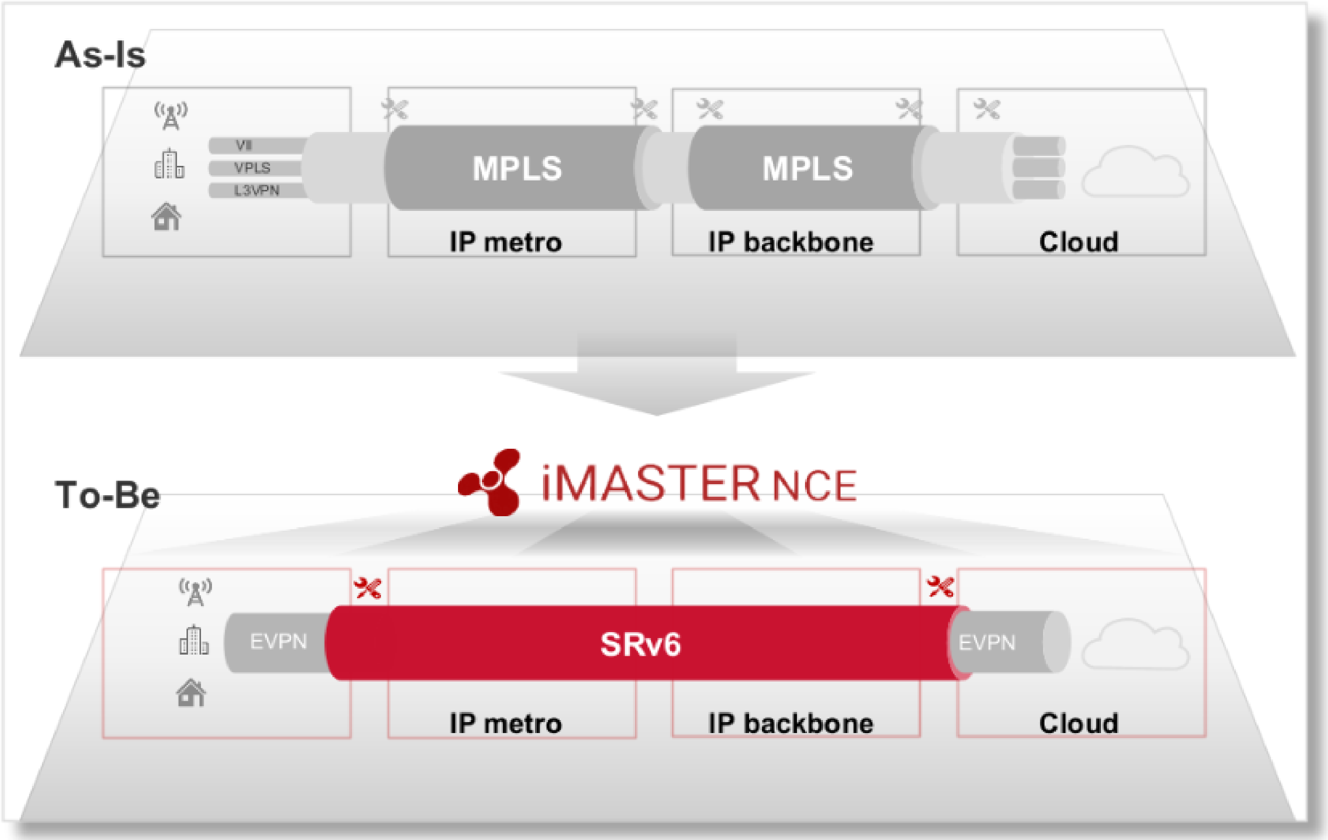
4+ >> 1

MPLS, VXLAN GRE, L2TP, IP	IP

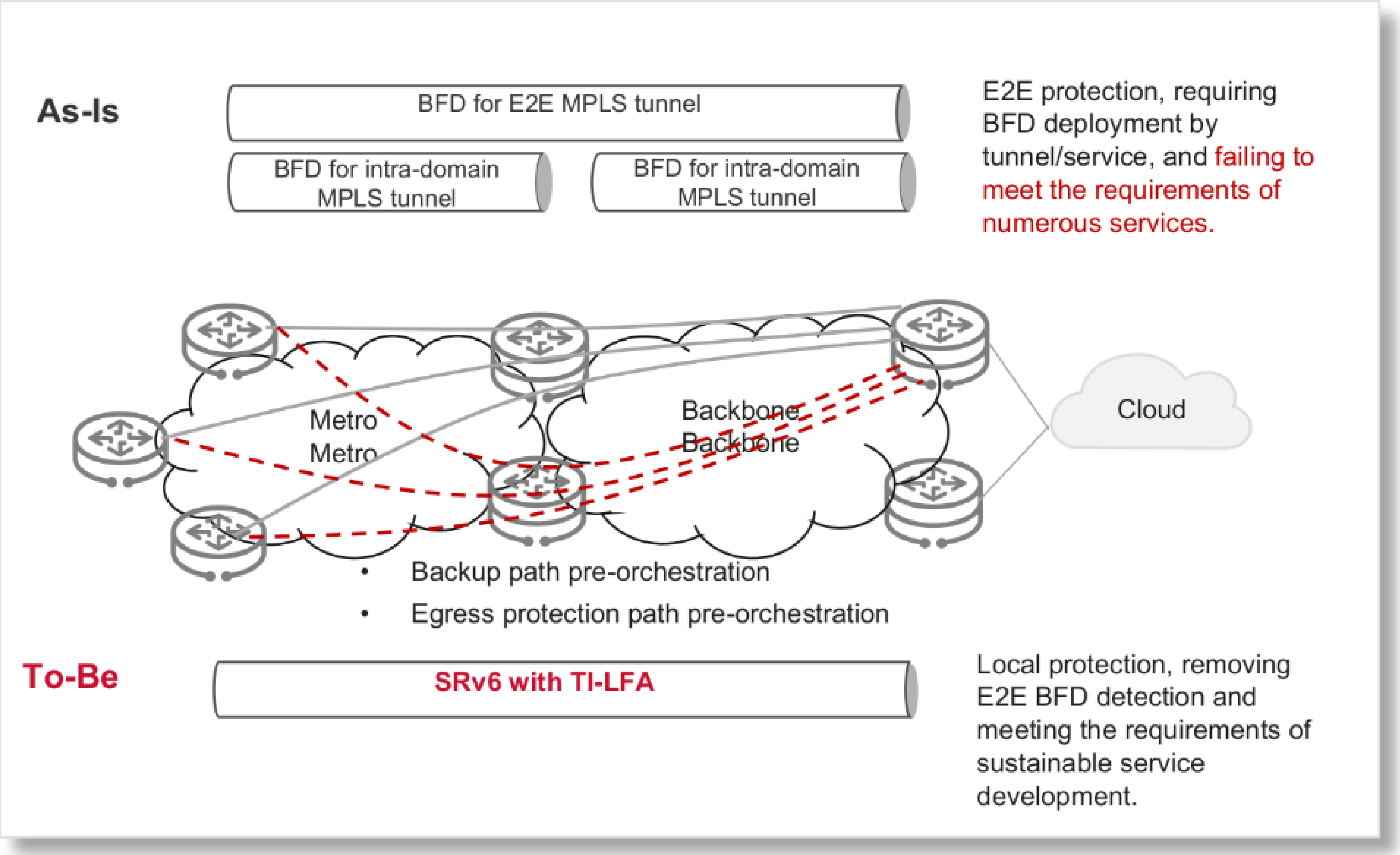
Service Configuration

6+ >> 2

Segment-by-segment, device-by-device	Service end nodes only



SRV6 DEEP DIVE



Recovery Within 50 ms

Local protection, fast detection, and fast recovery

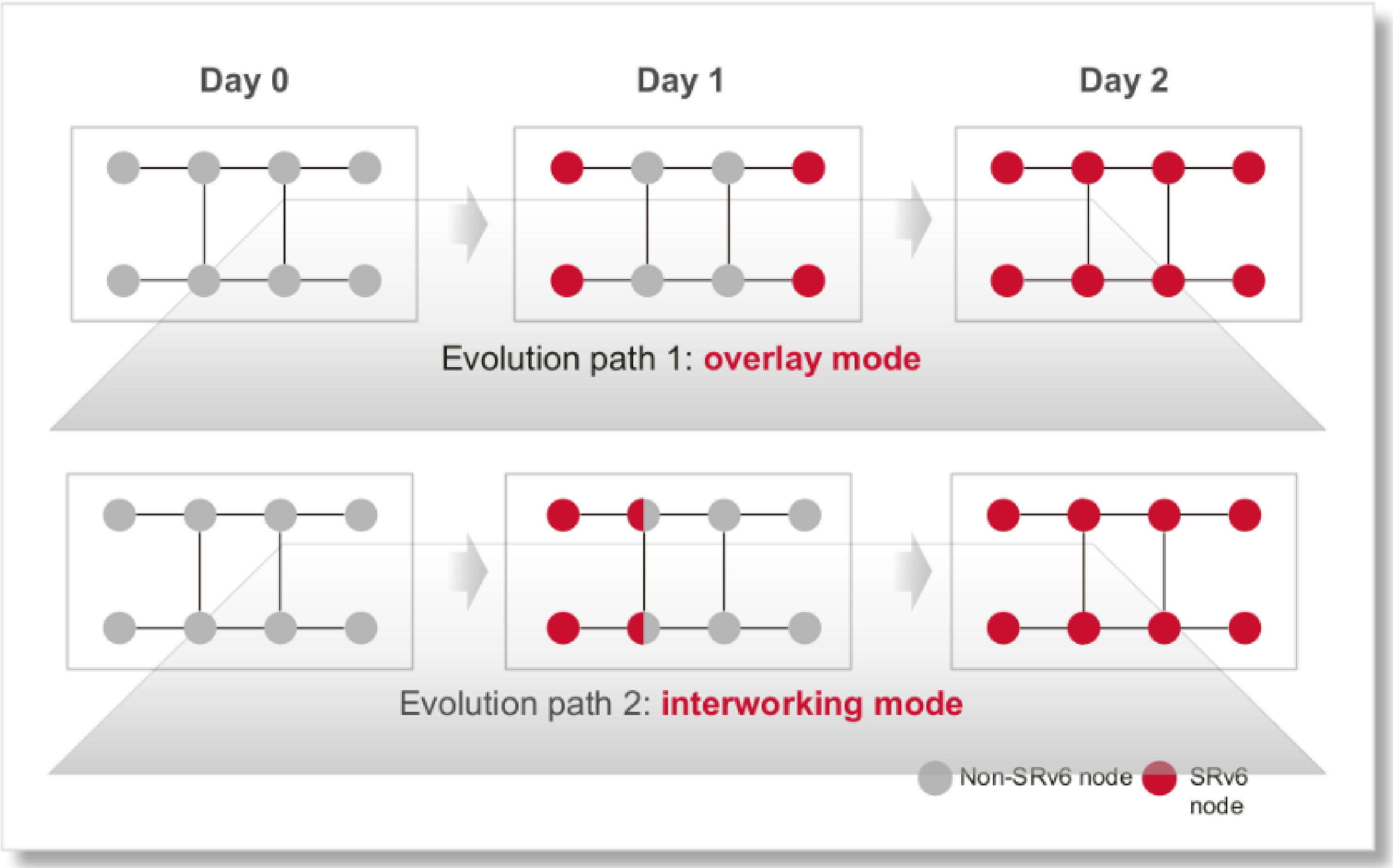
Any Topology

Unified protection for any topology

Numerous Services

One-time simple deployment, irrelevant to the number of tunnels or services

SRV6 DEEP DIVE



Fast Deployment

Incremental deployment, on-demand reconstruction, and fast SRv6 introduction

Reduced Investment

Network devices can be flexibly reused, minimizing one-time investment

Easy Evolution

Multiple evolution paths, supporting flexible and on-demand selection

Why you need SRv6 ?

- Forwarding plan is only SRv6 SRH IPv6 (no label)
- Network scalability independent from network elements
- Easier: Only IPv6, Less configuration, Easy Planning
- Load balancing is native flow label on IPv6
- Artificial Intelligence ready: path programming & application aware programming

Thanks for your the attention

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