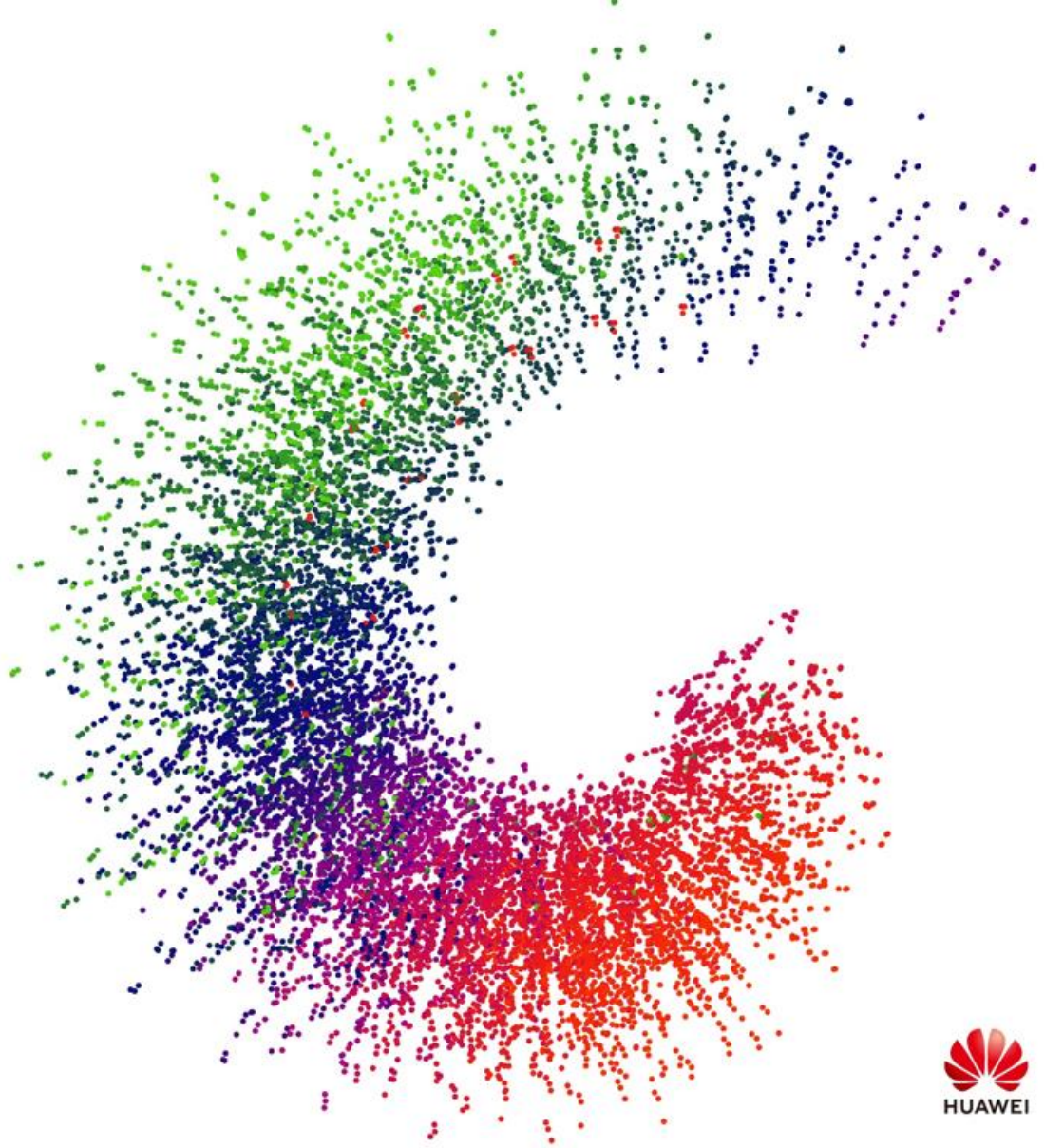
IPv6 Network Slicing

Technologies, Standards and Deployments



Jérémie Leguay (Chief Expert, Dijkstra Lab Director, Paris Research Center)
Jeremie.leguay@huawei.com
07/11/2023

Network Slicing Motivation: 5G and beyond

5G vision: enabling industry digitalization

Key requirements for 5G networks: differentiated network services

Independent service operation

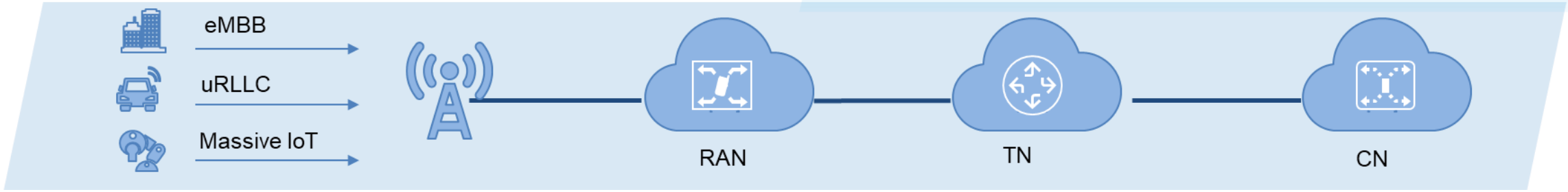
Independent and visible services | Customized services | Independent upgrade | …

Secure isolation

Smart grid | Industrial control | Autonomous driving | …

Guaranteed SLA

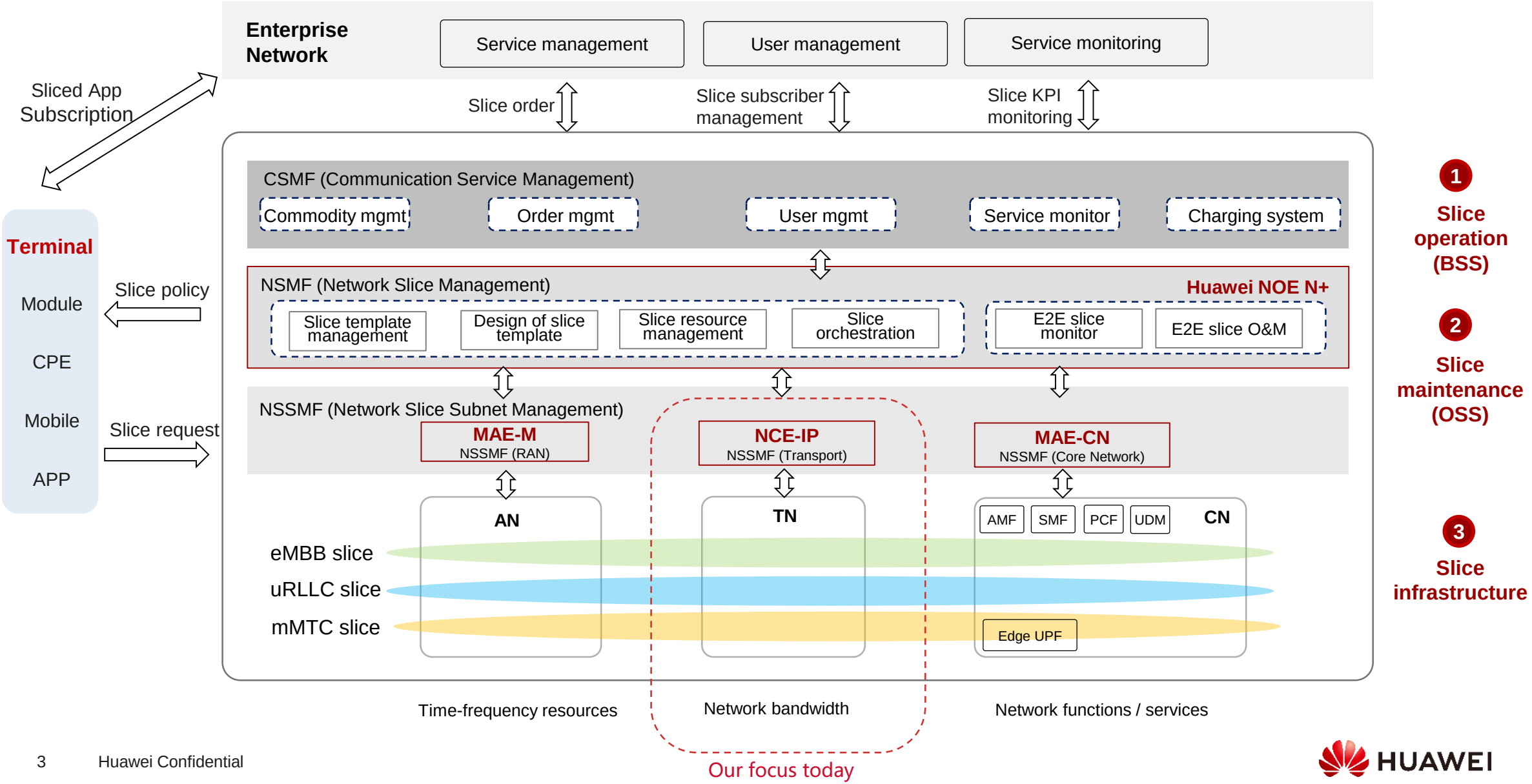
Ultra-high bandwidth	Ultra-low delay	Massive connections	Ultra-high reliability	…
10 Gbit/s	< 1 ms	1 MB connection/km^2	99.999%	



Network slicing needs to be **end-to-end** to meet the SLA of diverse services & customers (B2C, B2B)

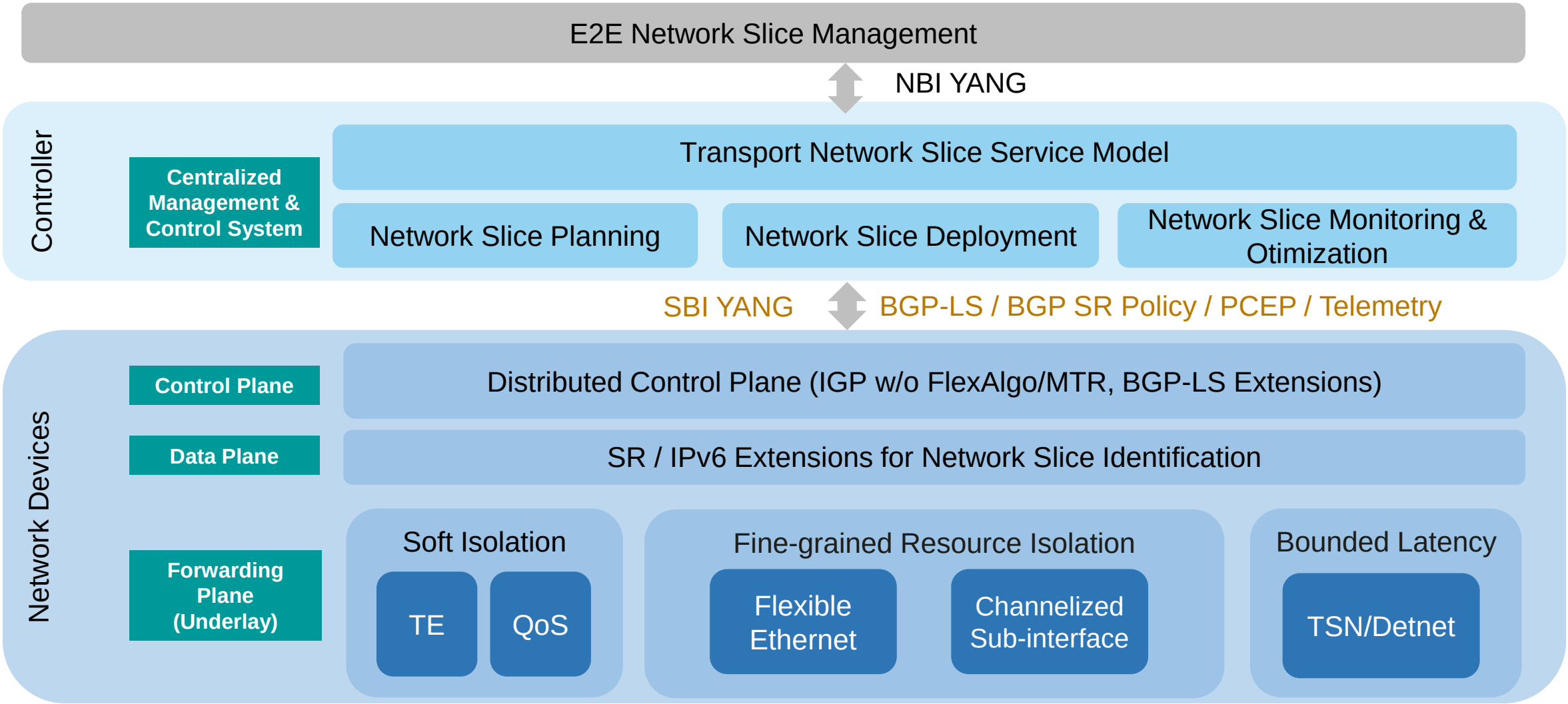
HUAWEI

5G E2E Network Slicing Architecture



HUAWEI

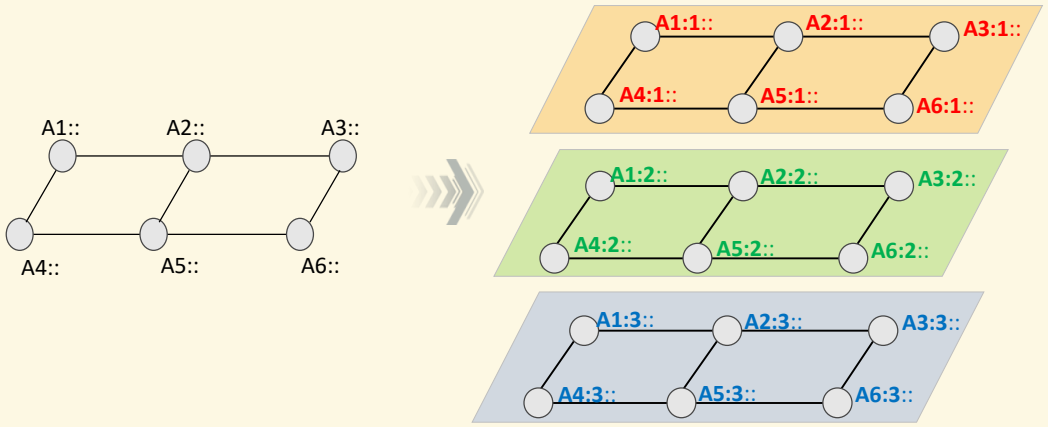
Network Slicing Architecture



Data Plane Encapsulation: Slice Identification in Packets

Per-Slice SR SIDs

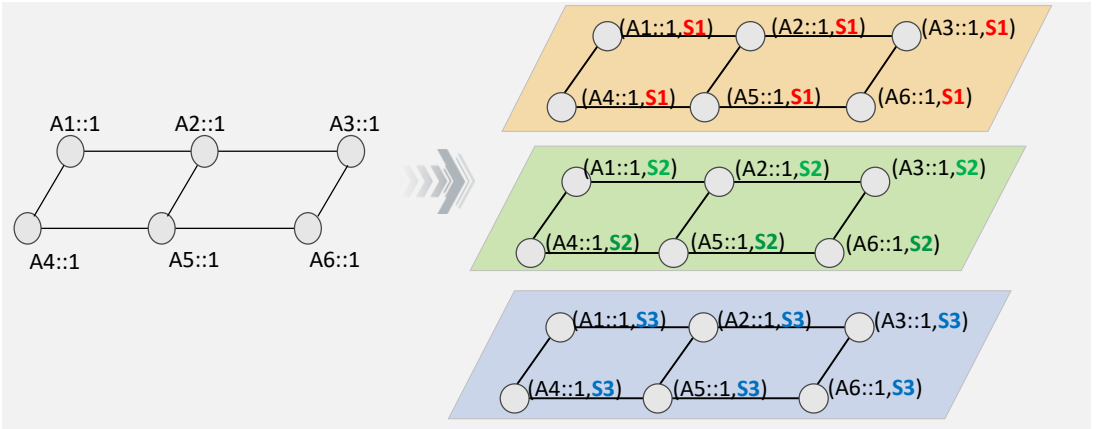
- **Reuse** existing segment routing data plane
  - SR-MPLS and SRv6
- Give additional semantics to SR SIDs
  - **Instructions** and **Resources**
- Allocate different resource-aware SIDs to slices



- **Pros**: Backward compatibility
- **Cons**: Scalability

Dedicated Slice-ID

- Introduce dedicated **Slice-ID** into data packet
  - Clear semantics: Slice Resource ID
- Forward packet based on **SIDs and Slice-ID**
  - Make use of IPv6 extension headers
- Avoid the overhead of additional SR SIDs

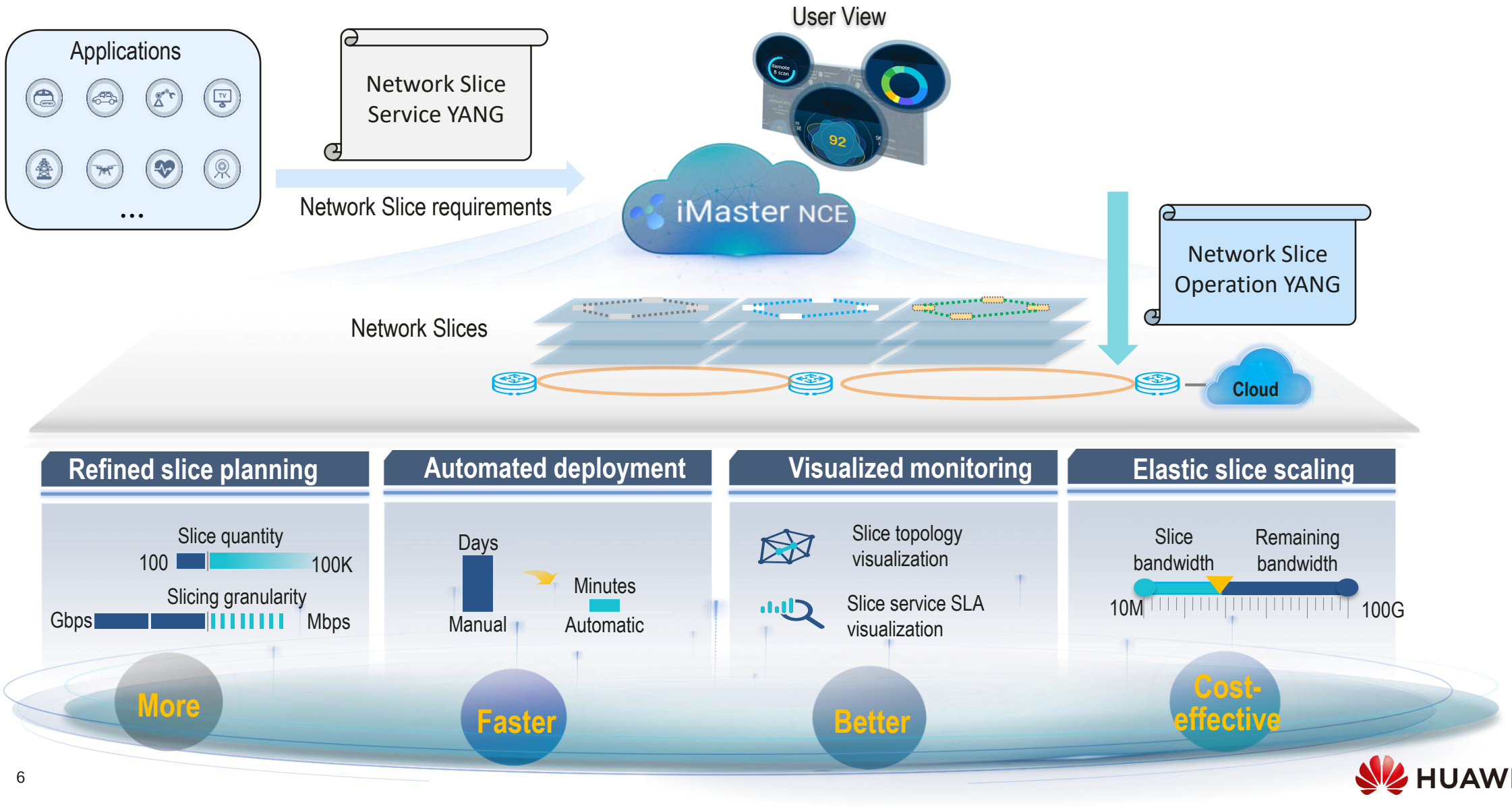


- **Pros**: Flexibility and scalability
- **Cons**: Device capability

- Both encapsulation mechanisms have been adopted in IETF

HUAWEI

Management Plane: Full-lifecycle Network Slice Automation



HUAWEI

Overview of Network Slicing Related SDOs

RAN & Mobile Core

- SA2: Network Slicing Architecture
- SA5: Network Slicing Management
- RAN2: The Radio technologies for network slicing
- RAN3: The RAN interfaces for network slicing

Network & Service Management

- GS ZSM 003:

Zero-touch management and orchestration of end-to-end network slicing

Requirements

Architecture & Technical Specifications for Transport Network Slicing

Framework, Management, Control Plane & L3 Data Plane

- **IETF Network Slice Use Cases**
- **IETF Network Slice Framework**
  - Terminology and general framework
  - Network slice realization: VPN+ framework, …
- **IETF Network Slice Application in 5G E2E Slicing**
- **IETF Network Slice Management Interfaces and Models**
- **Data Plane encapsulation for Network Slicing**
  - Segment Routing, IPv6, MPLS
- **Control Plane for Network Slicing**
  - IGP, BGP, PCEP, etc.

Support

L2 & Underlay Data Plane

Time Sensitive Network (TSN)

- P802.1 DF: TSN profile for service provider networks

Flexible Ethernet

- FlexE 1.0, 2.0, 2.1…

SG-15 Metro Transport Network

- G.mtn: Interfaces for a metro transport network

Network Slicing Standards in IETF

Framework

- IETF Network Slice concept and general framework
- VPN+ Framework for network slice realization
- NRP Scalability Considerations
- Network Slicing using IP/MPLS
- IETF Network Slice Application In 5G E2E Network Slice
- Multi-domain and Hierarchical IETF Network Slices

Management Plane

- IETF Network Slice Service YANG
- NRP YANG for Network Slice Operation
- Network Slice Service Mapping

Data Plane

- SR based network slicing data plane
- IPv6 based network slicing data plane
- MPLS based network slicing data plane

Distributed Control Plane

- Multi-Topology based network slice info distribution
- Flex-Algo based network slice info distribution
- Scalable control plane for network slice info distribution

Centralized Control Plane

- BGP SR Policy for network slicing
- BGP Flowspec for slice traffic steering
- PCEP extensions for network slicing

Individual draft | In adoption call | WG draft

Huawei is leading the network slicing standardization in IETF

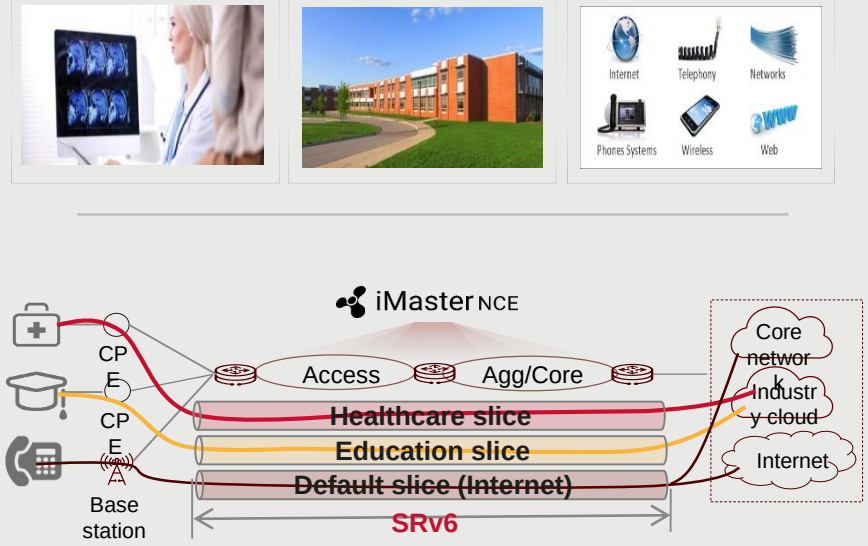
Network Slicing Deployment Status

80+ Network Slicing deployments worldwide

- Fix-Mobile Convergence
- Vertical Industrial Networks
- Premium Private Lines/Networks
- Multi-Service Networks
- Real-time Services
- …

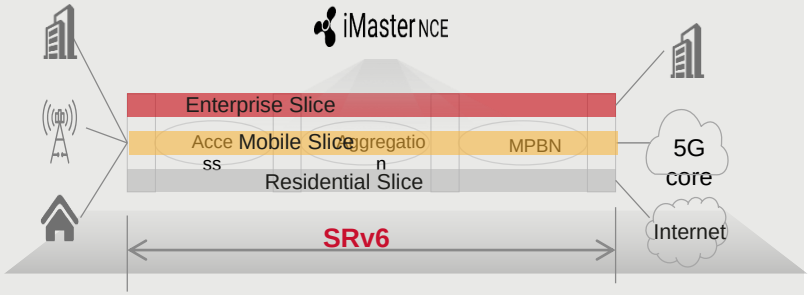
Slicing for Vertical Industries

Healthcare | Education | Internet



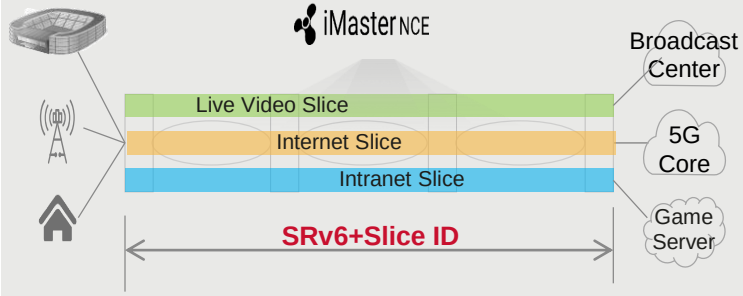
Slicing for Fix-Mobile Convergence

Mobile | Residential | Enterprise



Slicing for Real-Time Services

Live Video | Internet | Intranet



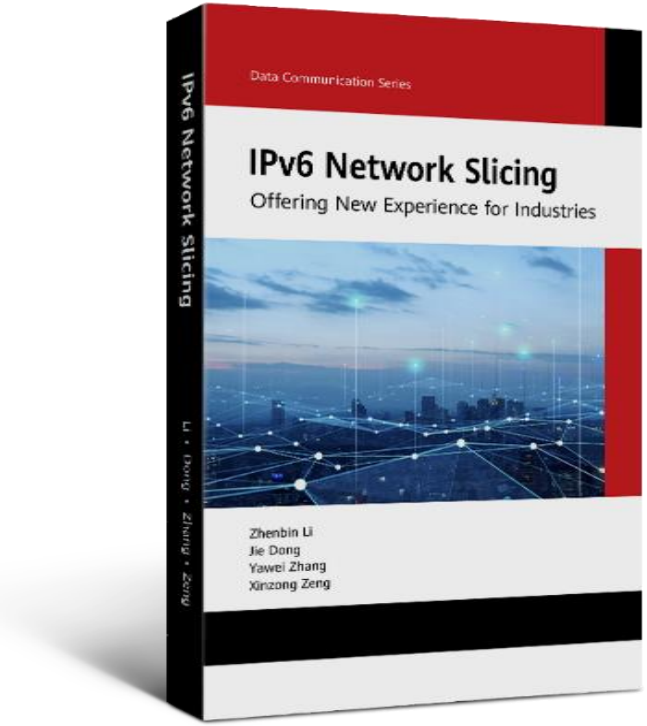
HUAWEI

Take Away

- **Network Slicing provides SLA commitment to 5G and many other applications**
  - Not just connectivity, but also the SLAs
- **Network Slicing requires integration of multi-layer network functionalities**
  - Resource partitioning
  - Data packet encapsulation
  - Centralized and distributed control
  - Automatic life-cycle management
- **IPv6 Network Slicing is easy to deploy and future-proof**
  - SRv6 Resource-SIDs based solutions for short-term, small number network slice deployment
  - Slice-ID based solution for long-term and large-scale network slice deployment

New Book on IPv6 Network Slicing

-- Offering New Experience for Industries



Published in 2023

Compiled by Professional Team

- Members of the IETF Internet Architecture Board (IAB)
- Huawei senior protocol experts
- Huawei senior research and standards experts

Comprehensive Experience Sharing

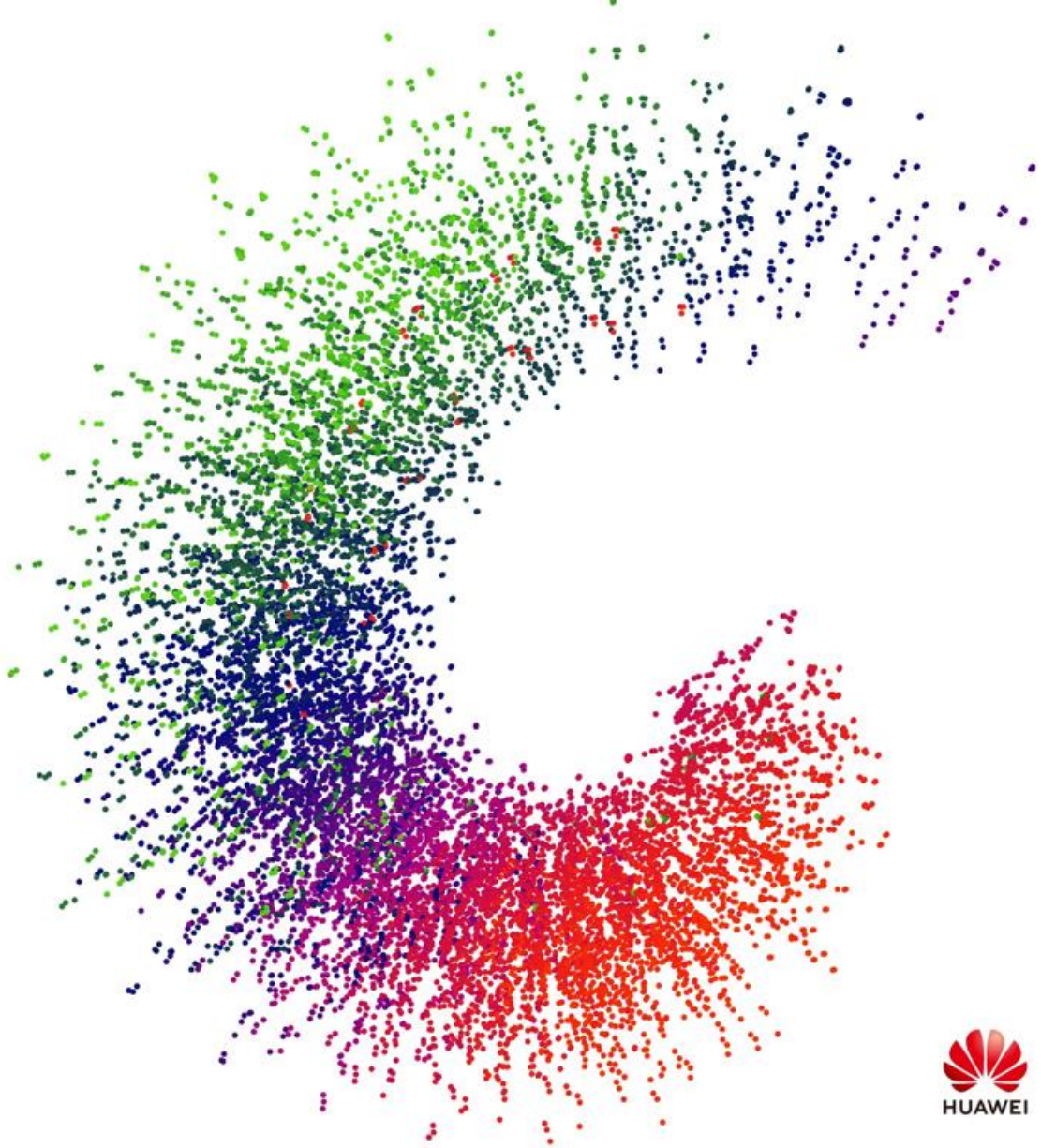
- Complete collection of IPv6 network slicing principles and technologies
- Authentic stories about the IPv6 network slicing standardization process

Deployment Cases Disseminating

- Suggestions to IPv6 network slicing deployment

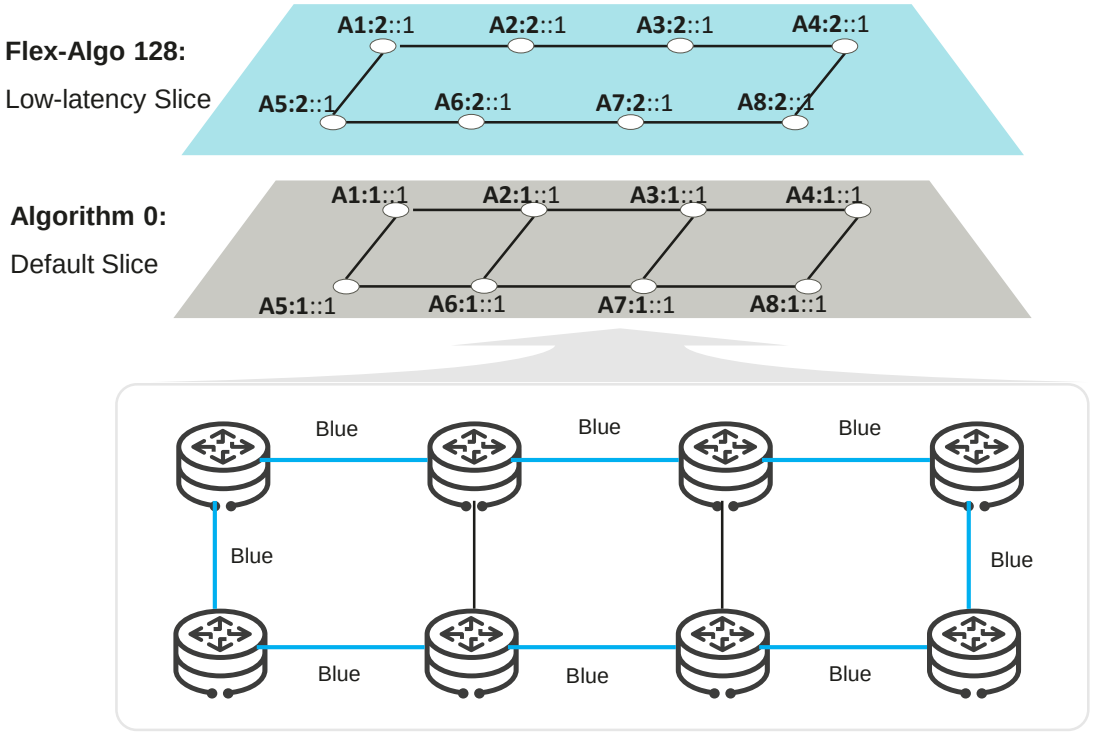
HUAWEI

Thanks



HUAWEI

Deployment Case 1: SRv6 Flex-Algo + Class-based QoS



Flex-Algo identifier 128

affinity include-any blue

metric-type delay

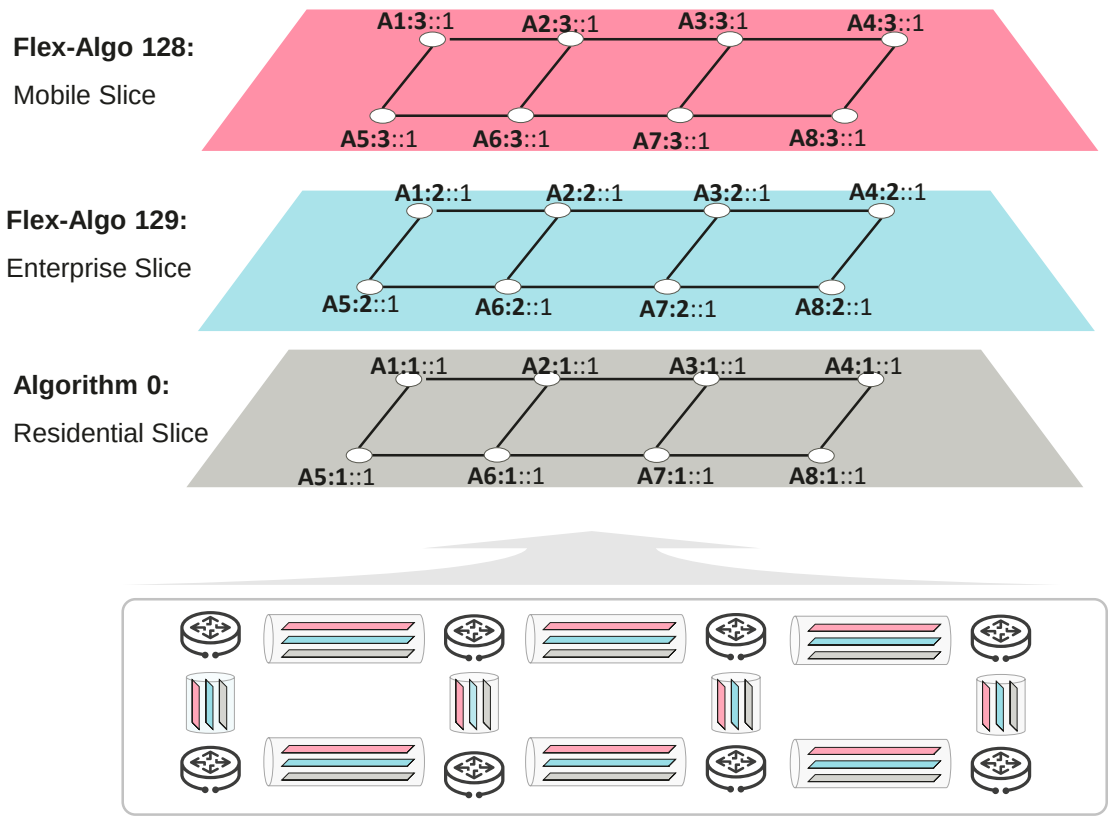
Solution Overview:

- **Resource management**: Class-based QoS
- **Control plane**: Flex-Algo
- **Data plane**: Per-Algo SR SIDs

Solution Properties:

- **Typical scenario:** Coarse service differentiation
- **Pros:** Easy to deploy
- **Cons:**
  - No SLA commitment
  - Limited number of slices

Deployment Case 2: SRv6 Flex-Algo + Resource Partition



Flex-Algo identifier 128

affinity include-any red

Flex-Algo identifier 129

affinity include-any blue

Solution Overview:

- **Resource partition**: FlexE/logical interface/channel
- **Control plane**: Flex-Algo
- **Data plane**: Per-slice Resource SIDs

Solution Properties:

- **Typical scenario:** Fixed-mobile service isolation
- **Pros:**
  - Committed SLA
  - Easy to deploy
- **Cons:** Limited number of slices

HUAWEI

Deployment Case 3: SRv6 Policy + Resource Partition

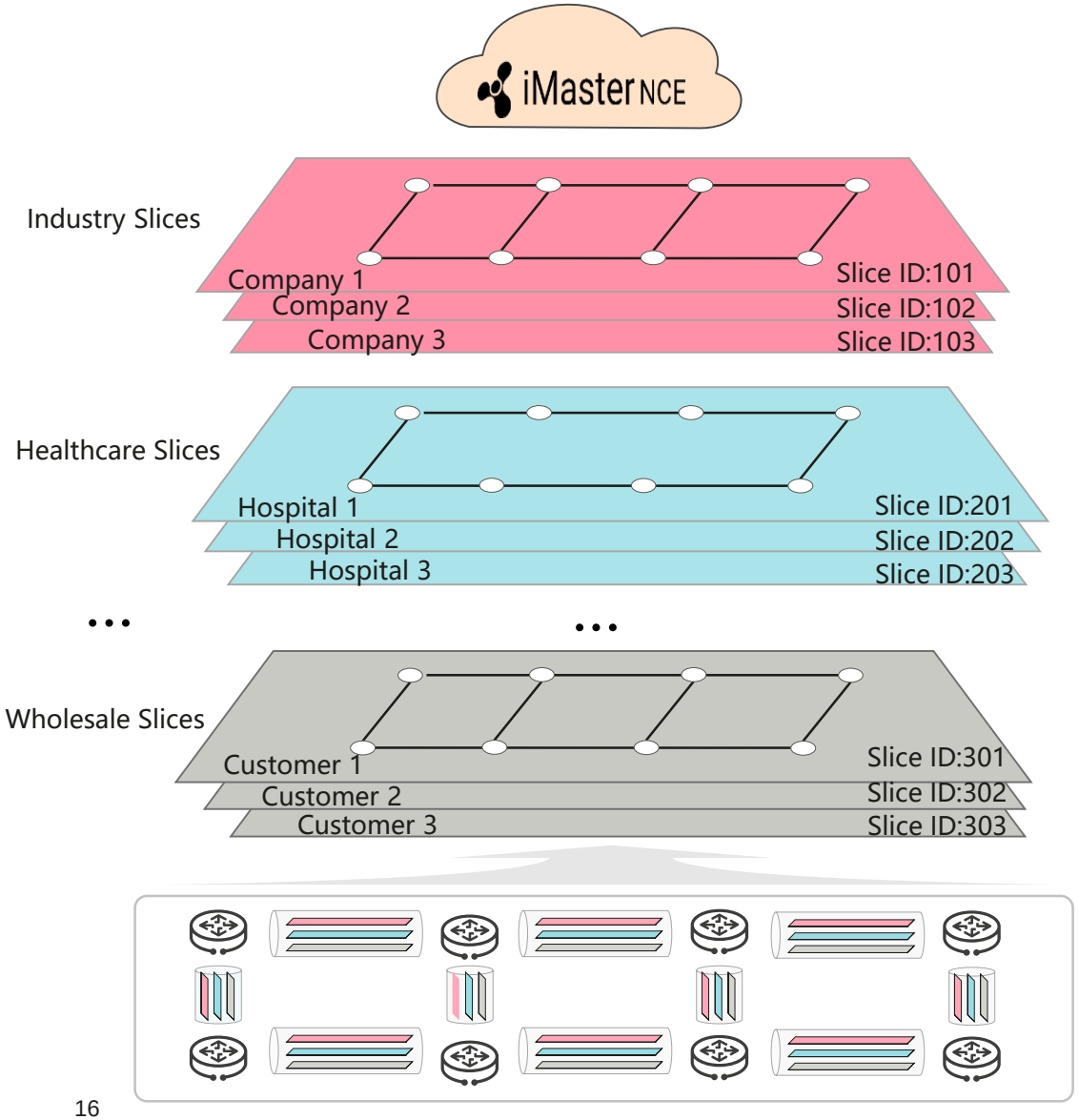
Solution Overview:

- **Resource partition**: FlexE/logical interface/channel
- **Control plane**: Affinity + SRv6 Policy
- **Data plane**: Per-Slice Resource SID

Solution Properties:

- **Typical scenario:** Multi-industrial networks
- **Pros:**
  - Committed SLA
  - SR Policy based traffic engineering
- **Cons:** Dependency on central controller

Deployment Case 4: SRv6 + Slice ID + Resource Partition



Solution Overview:

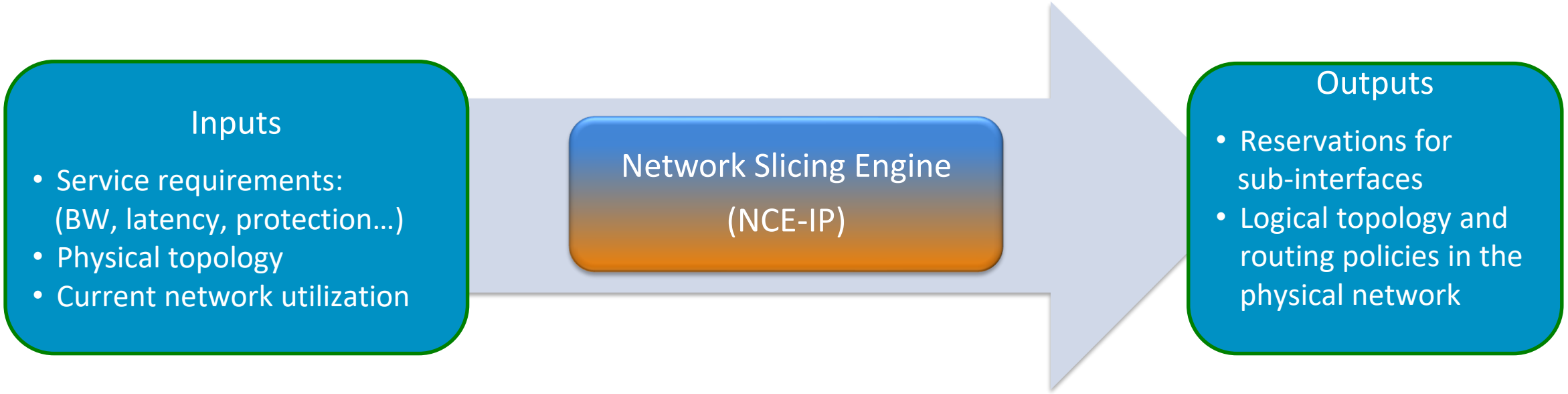
- **Resource partition**: FlexE/logical interface/channel
- **Control plane**:
  - SRv6 Policy/Flex-Algo
  - Scalability optimization with component sharing
- **Data plane**: IPv6 HBH-based Slice ID

Solution Properties:

- **Typical scenario:** Per-customer/application slicing
- **Pros:**
  - Committed SLA
  - Support large number of slices
- **Cons:** Device's capability of EH processing

HUAWEI

Algorithms for Slice Planning and Optimization



Optimization intents

- Maximize traffic acceptance
- Minimize the reserved capacity
- Load balance link utilization
- …

Optimization challenges

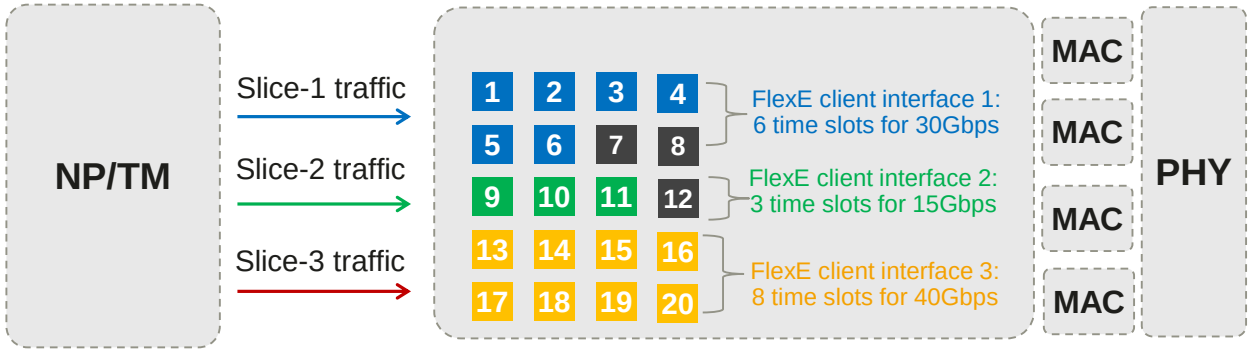
- Handle large-scale networks (50k nodes in IPRAN)
- Get near-optimal solutions in a few seconds

Optimization tools

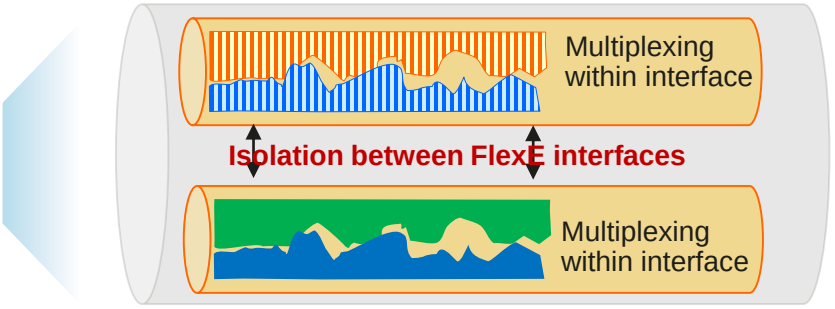
- Use advanced math-heuristics for combinatorial optimization
- Difficult path computation and resource allocation problems

Mechanisms for Resource Isolation in the Forwarding Plane

Flexible-Ethernet interface

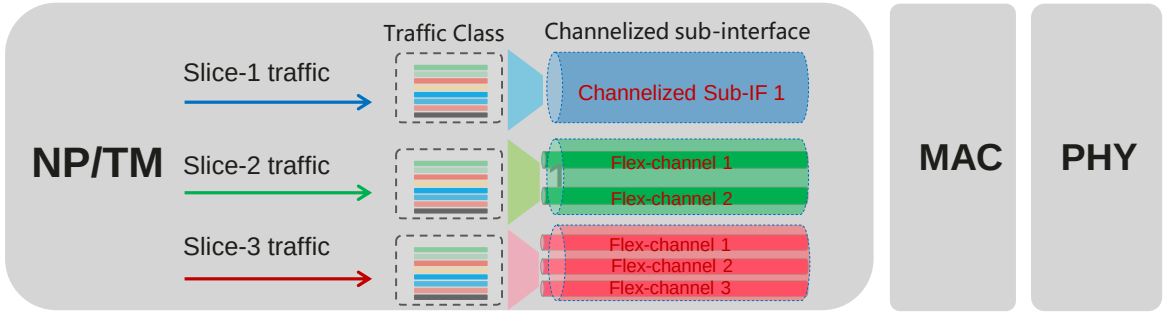


Time slot-based resource partition

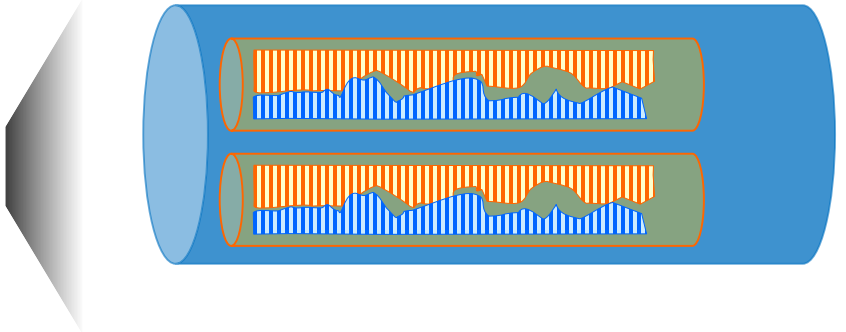


- Dedicated time slot
- Large bandwidth (>1Gbps)

Channelized sub-interface / Flex-channel



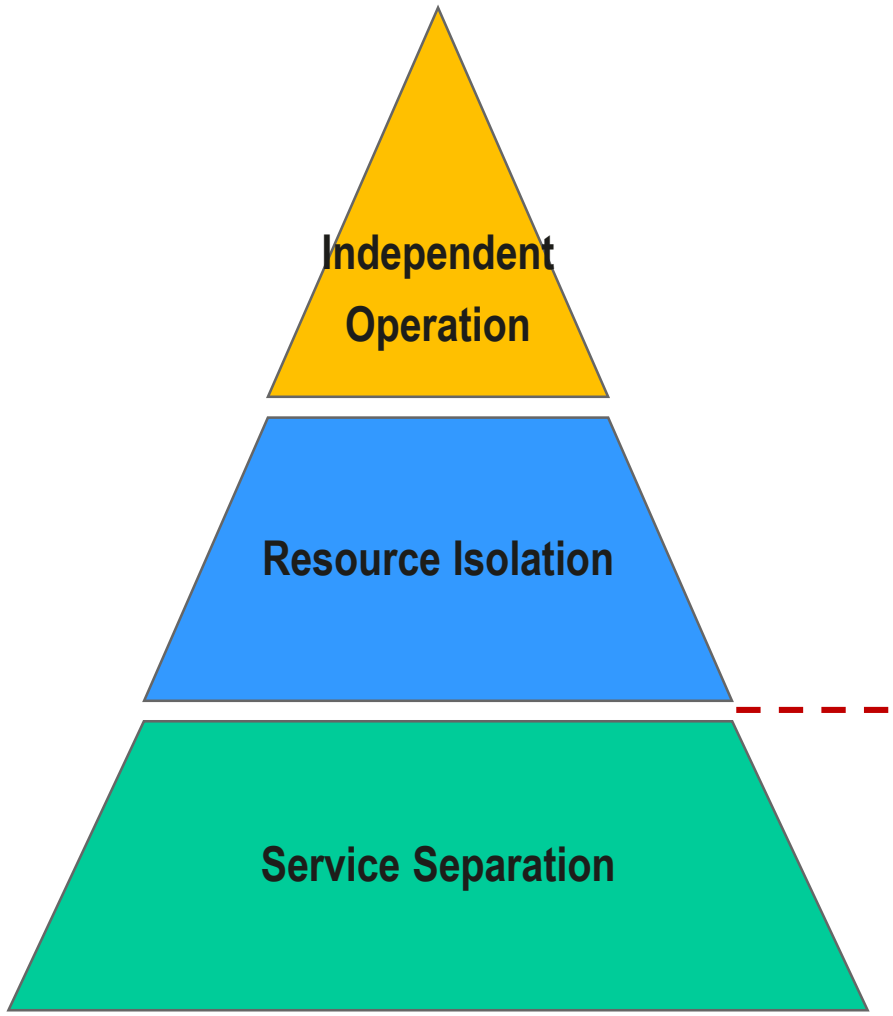
Dedicated queueing and scheduling resources



- Dedicated bandwidth
- Fine granularity (~1Mbps)

HUAWEI

Network Slicing in Transport Networks



Level 3 – Independent Operation

- **Independent management** plane for on-demand provisioning of network slices
- For wholesale or self-operated vertical services

Level 2 – Resource Isolation

- Dedicated resources **ensure no interference** between slices (with FlexE, chan. sub-interfaces)
- For **5G critical services** with demanding SLA requirements

Addressed by Enhanced VPNs

Level 1 – Service Separation

- Isolation in service access & connectivity
- **Possible interference** between services
- For traditional enterprise services

Addressed by Existing VPNs