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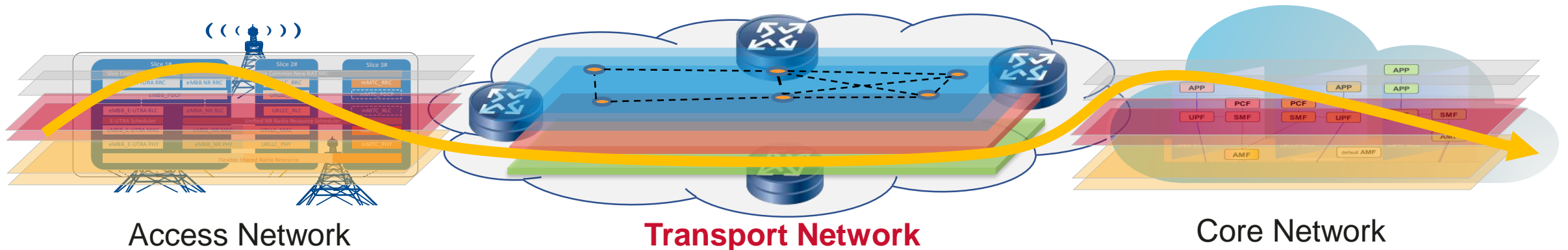
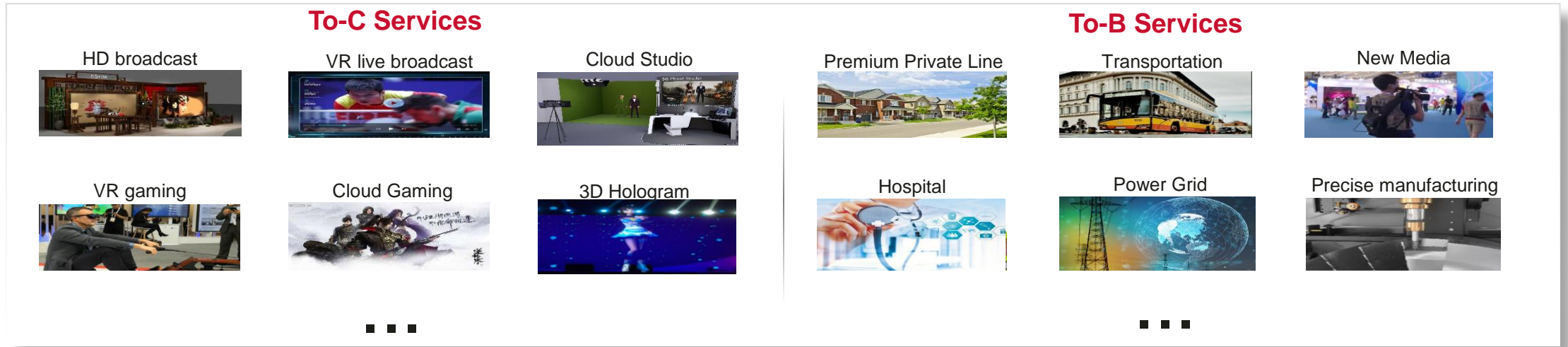
# **IPv6 Network Slicing: Technologies, Standards and Deployments**

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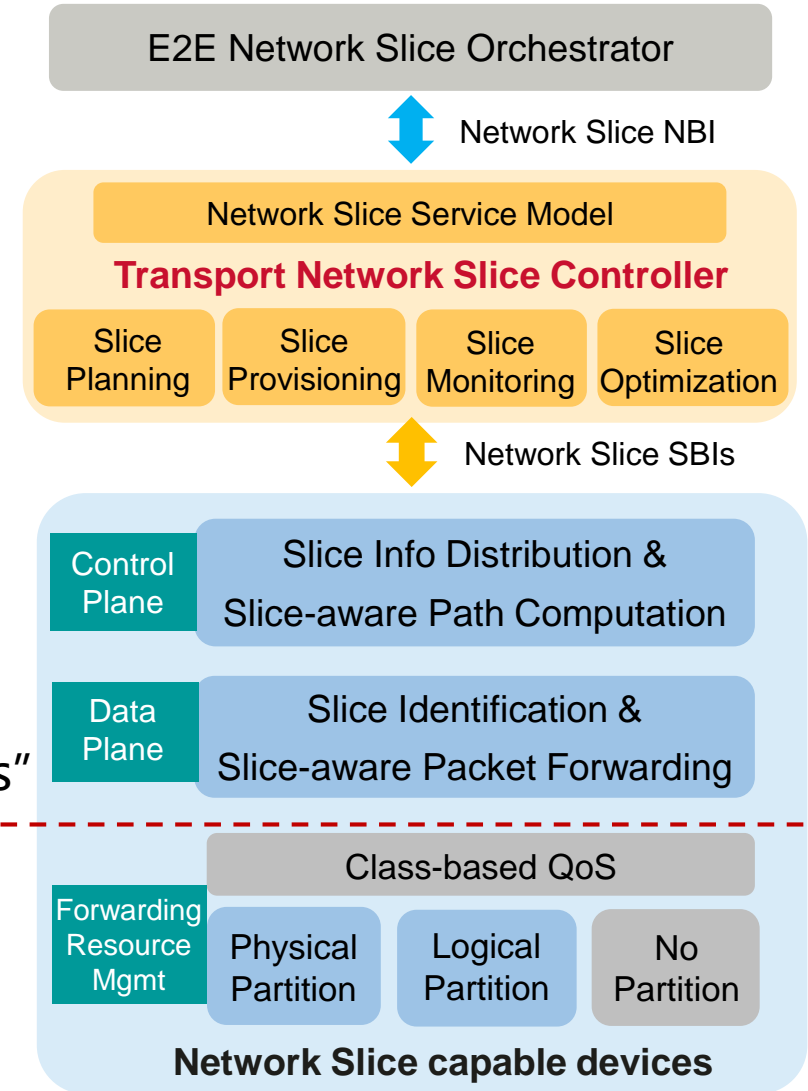
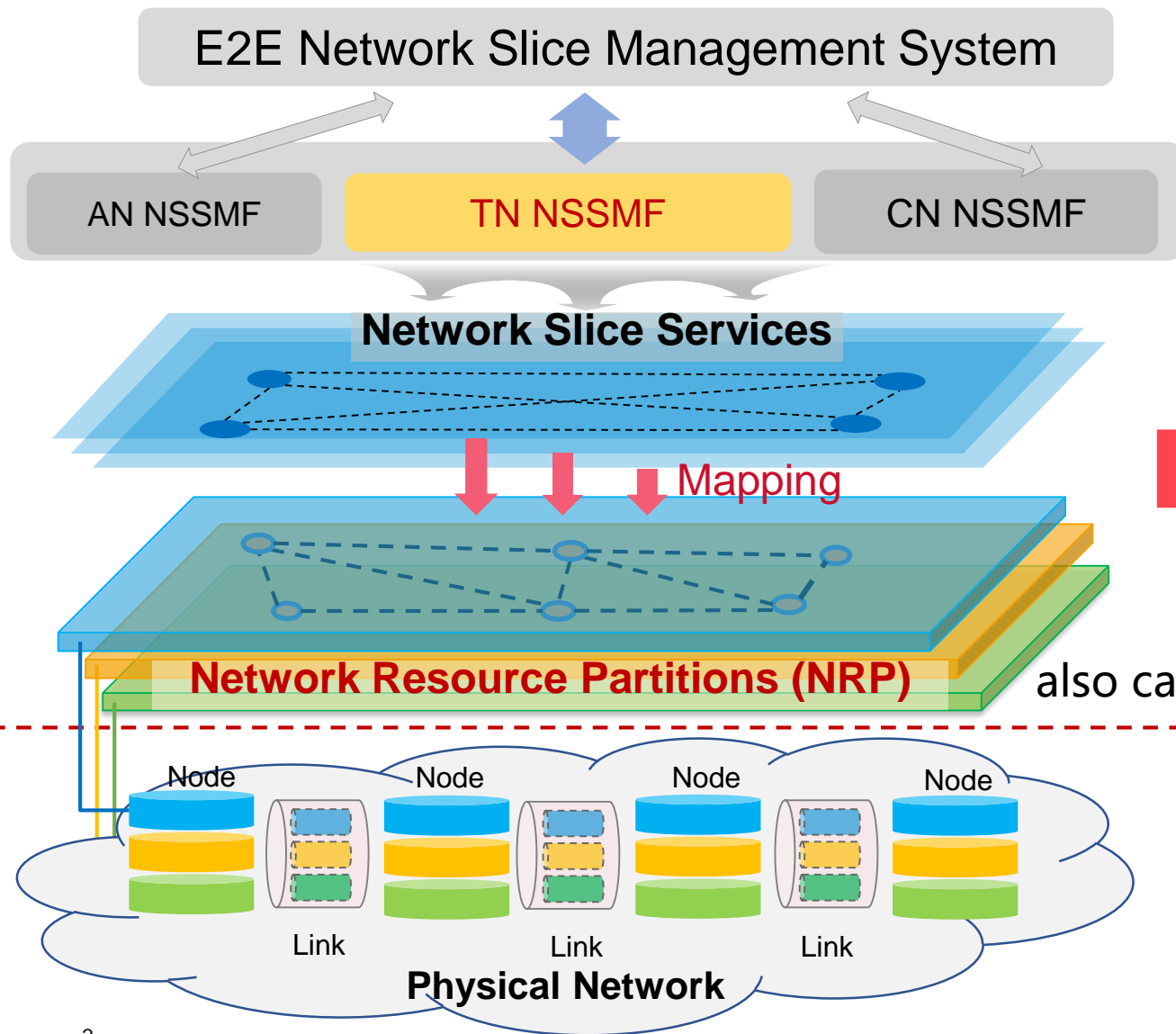
# Network Slicing Enables Services with Committed SLA



Network slicing needs to be **end-to-end** to meet the **SLA** of diverse services & customers

(Connectivity + SLO + SLE)

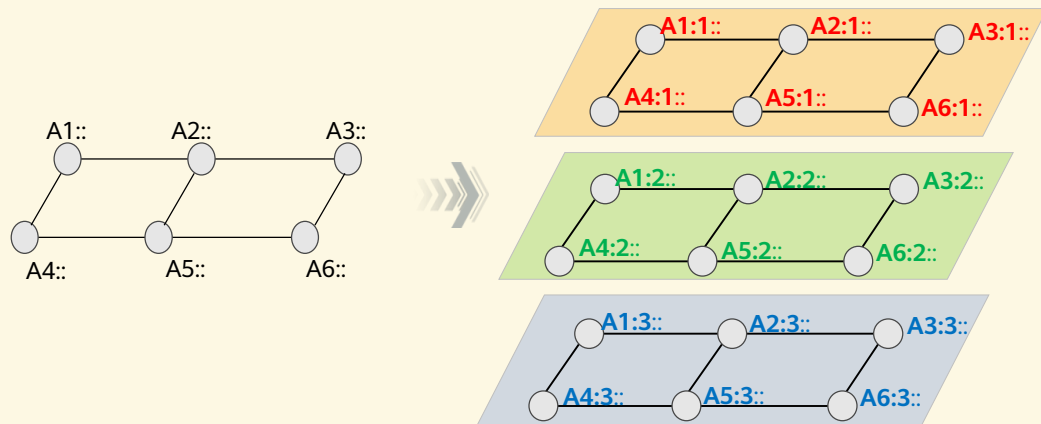
# Transport Network Slicing Architecture



# Data Plane Encapsulation: Slice Identification in Packets

## Per-Slice SR SIDs

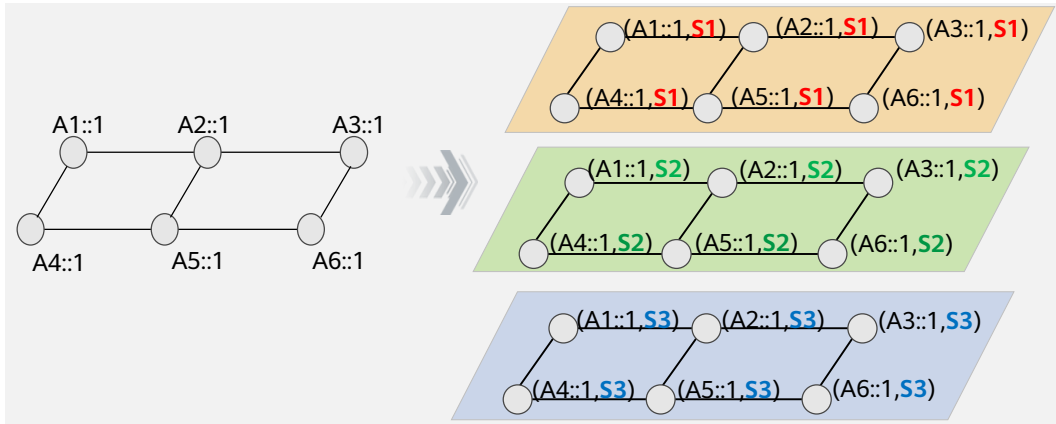
- **Reuse** existing segment routing data plane
  - SR-MPLS and SRv6
- Give additional semantics to SR SIDs
  - **Instructions** and **Resources**
- Allocate different resource-aware SIDs to slices



- **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

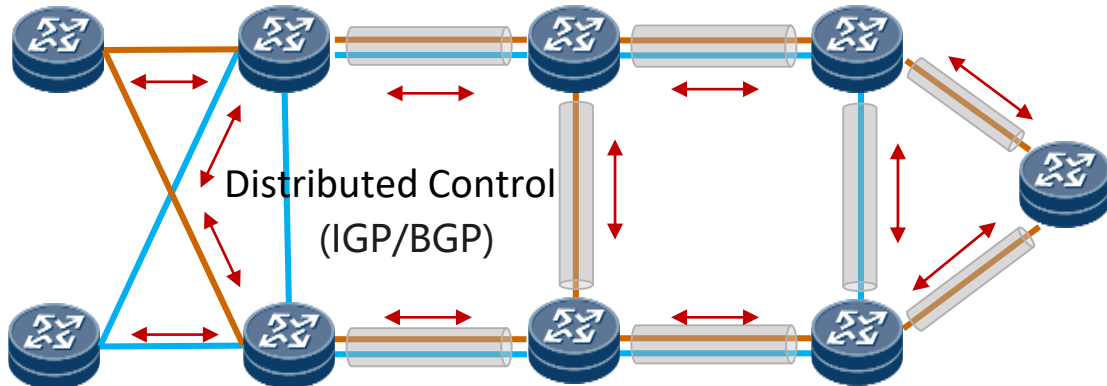
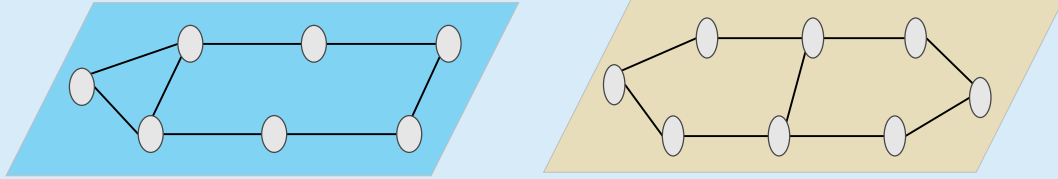
# Control Plane: Slice Information Distribution & Computation

Network Slice Controller

Centralized Control  
(BGP-LS/SR Policy/PCEP...)



Logical view of network slices (Flex-Algo or Multi-Topology)



Collect

- **Slice Attribute & State Distribution**
  - IGP and BGP-LS
  - Affinity/Flex-Algo/Multi-Topology based slice topology and attribute customization

Compute

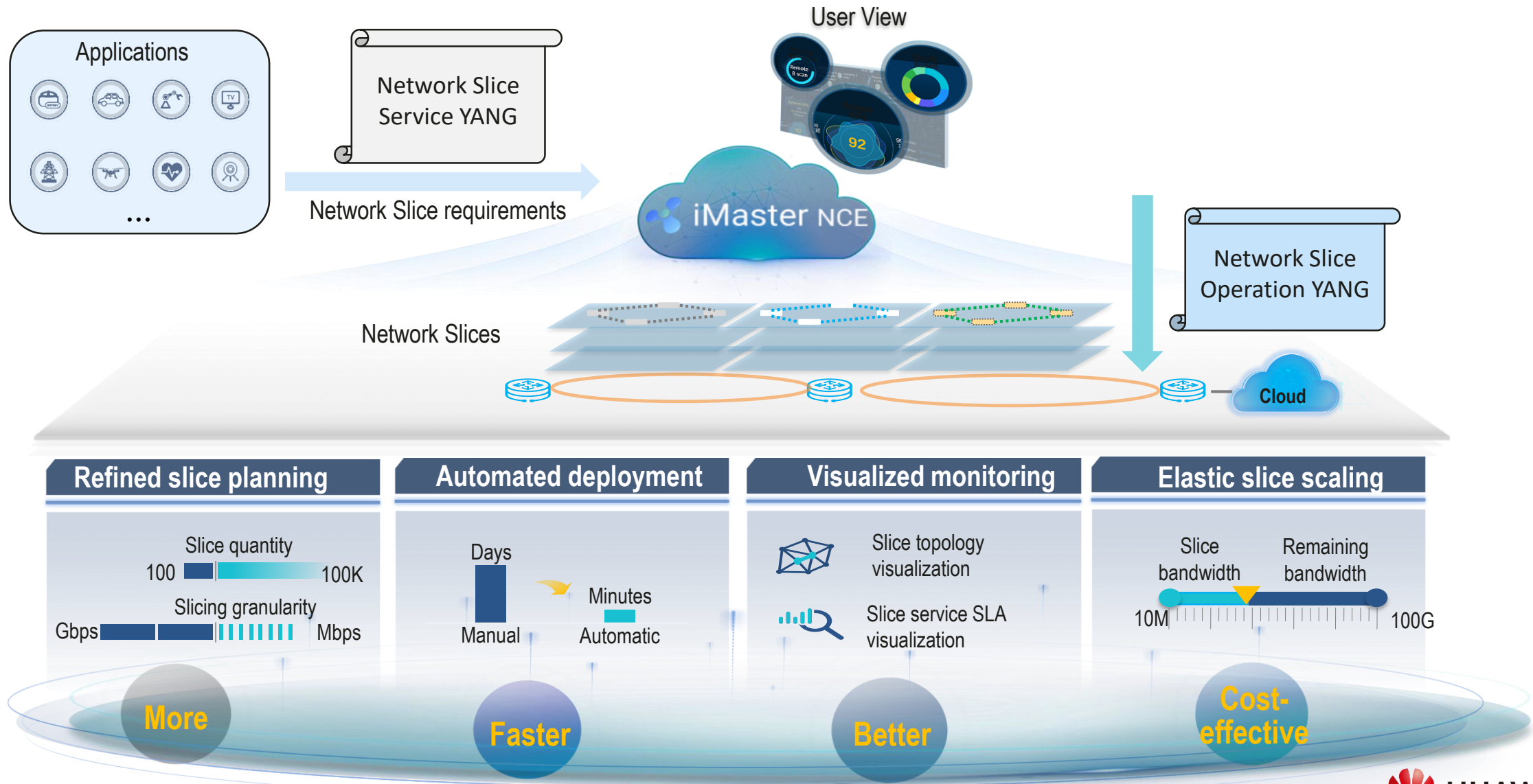
- **Slice-aware Path Computation**
  - Both distributed and centralized computation
  - Taking network slice attributes as constraints

Instantiate


- **Slice-specific Path Instantiation**
  - BGP or PCEP
  - Create TE/BE paths within network slice



# Management Plane: Full-lifecycle Network Slice Automation




# 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**

-  **IEEE** Time Sensitive Network (TSN)
  - P802.1 DF: TSN profile for service provider networks
-  **OIF** Flexible Ethernet
  - FlexE 1.0, 2.0, 2.1...
-  **ITU** 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

- 8 • Huawei is leading the network slicing standardization in IETF



# Network Slicing Deployment Status

## 80+ Network Slicing deployments worldwide

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

### Slicing for Vertical Industries

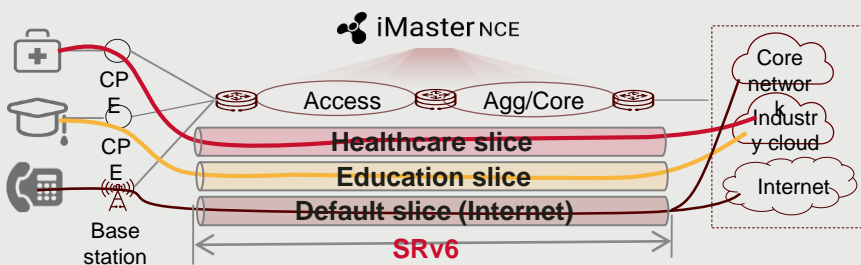
#### Healthcare



#### Education



#### Internet



### Slicing for Fix-Mobile Convergence

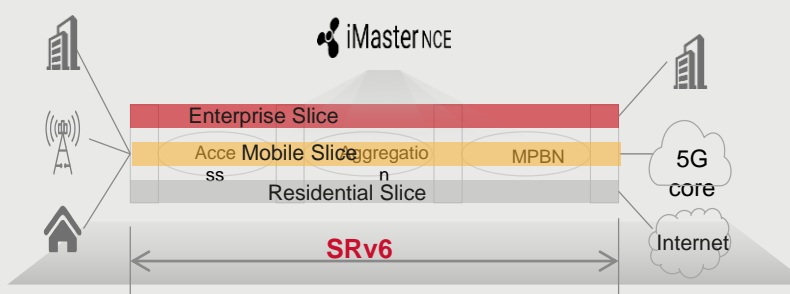
#### Mobile



#### Residential



#### Enterprise

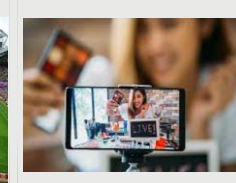


### Slicing for Real-Time Services

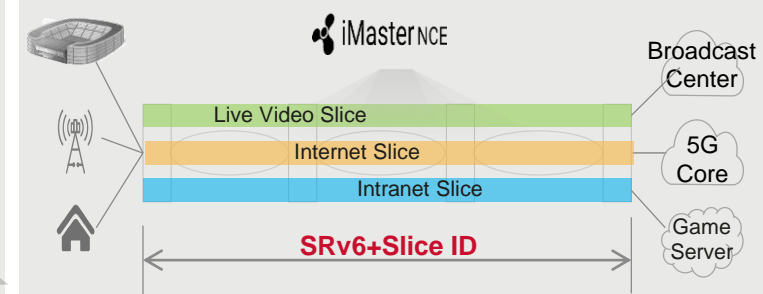
#### Live Video



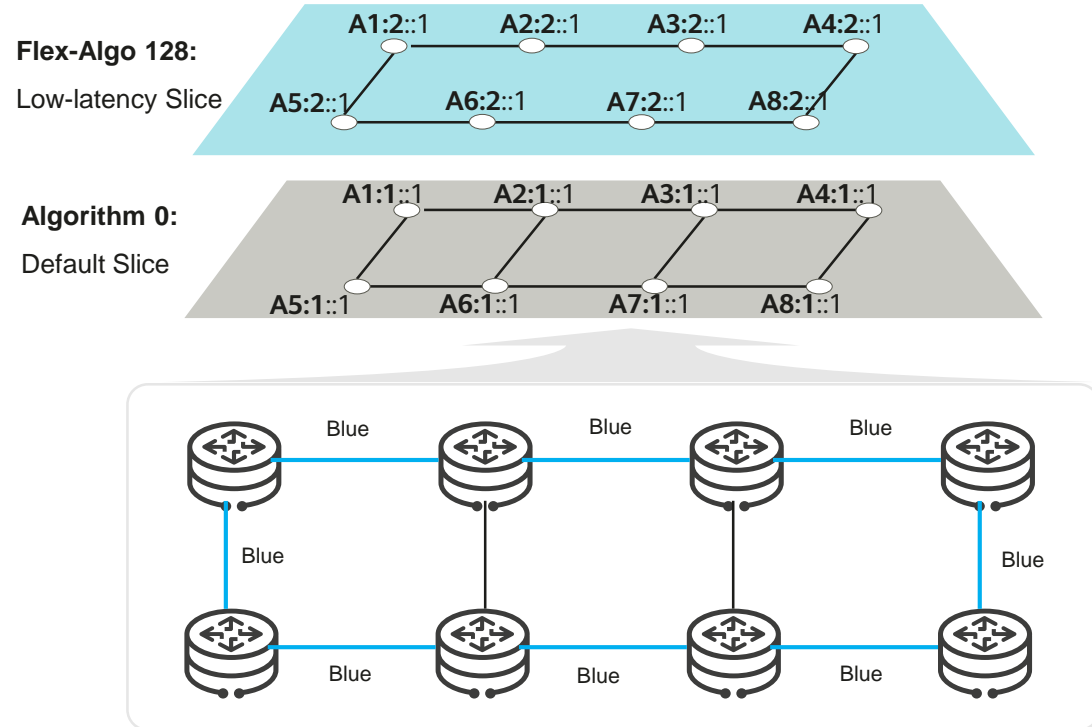
#### Internet



#### Intranet



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



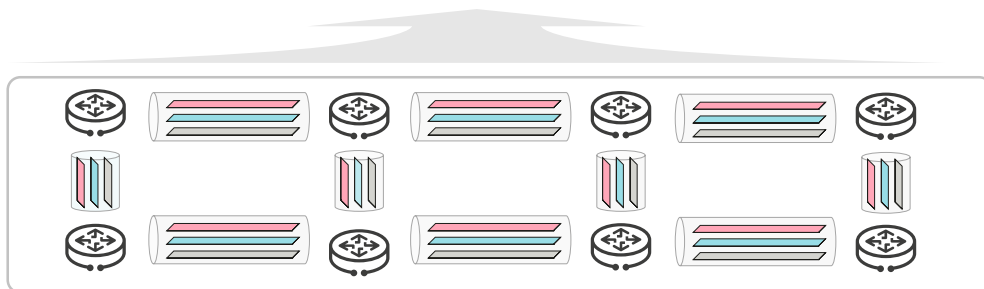
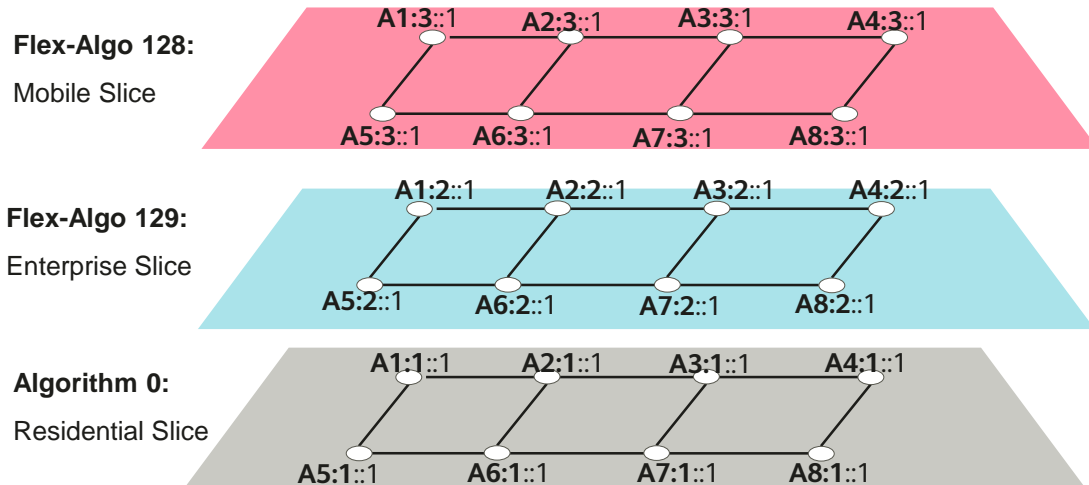
## Solution Overview:

- **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

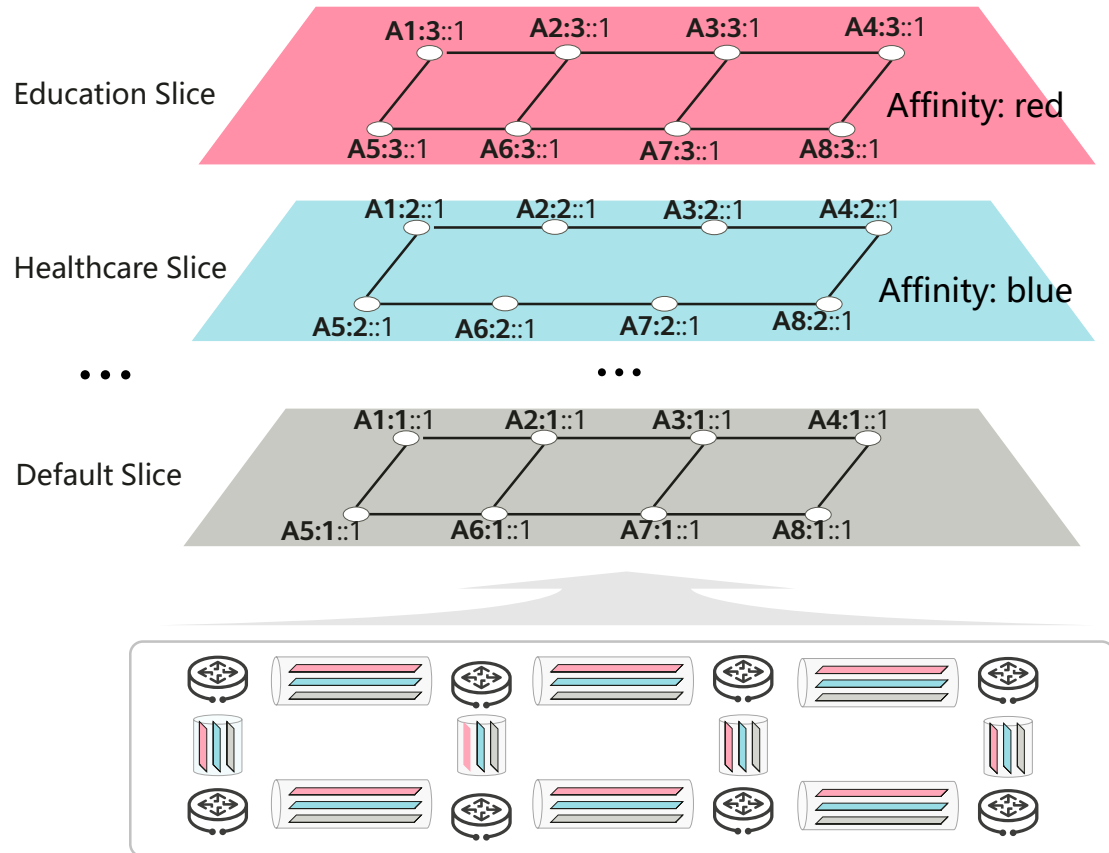
## Solution Overview:

- **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

# 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

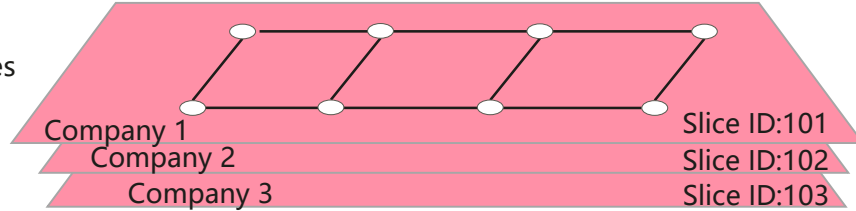
## Solution Properties:

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

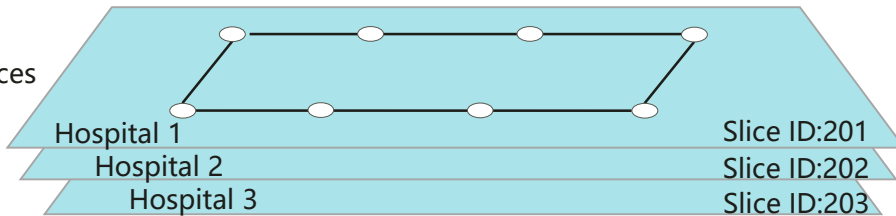
# Deployment Case 4: SRv6 + Slice ID + Resource Partition



Industry Slices



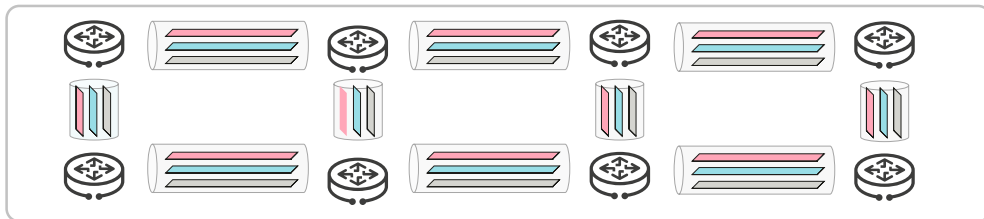
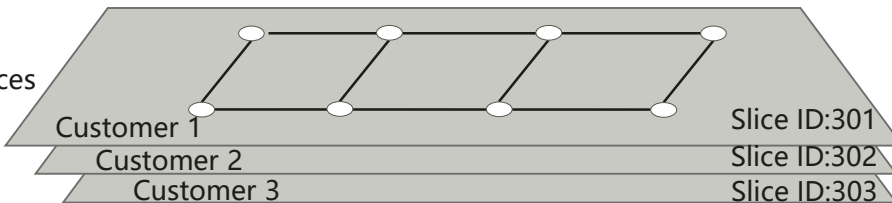
Healthcare Slices



...

...

Wholesale Slices



## 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

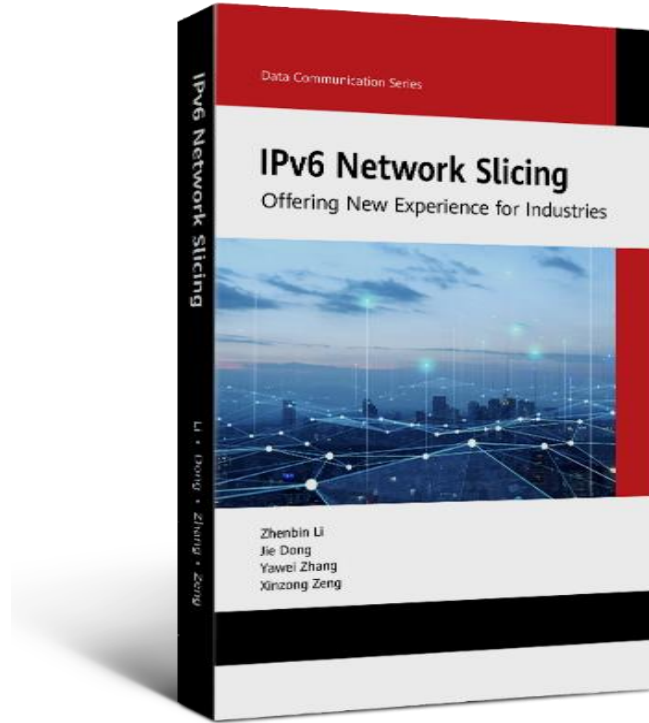


# Take Away

- **Network Slicing provides SLA commitment to 5G and many other applications**
  - › Not just connectivity, but also the SLOs and SLEs
- **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



**To be 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



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Thank You

# Network Slice Definitions

## 5G Network Slice

(TS 23.501 in 3GPP)

- **Network Slice:** A **logical network** that provides specific network capabilities and network characteristics.
- **Network Slice instance:** A set of **Network Function** instances and the required **resources** (e.g. compute, storage and networking resources) which form a deployed Network Slice.

## Transport Network Slice

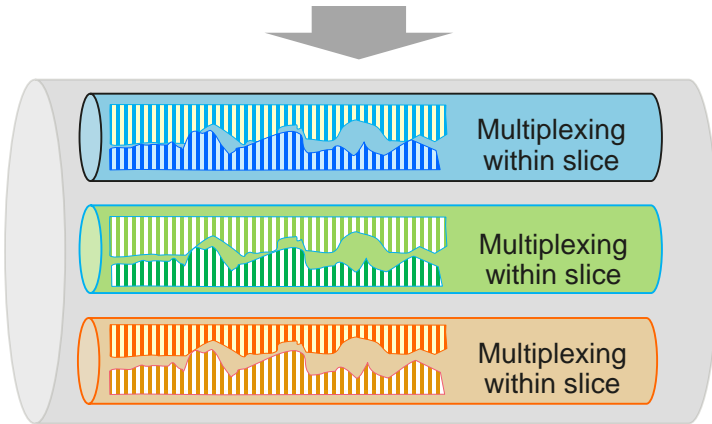
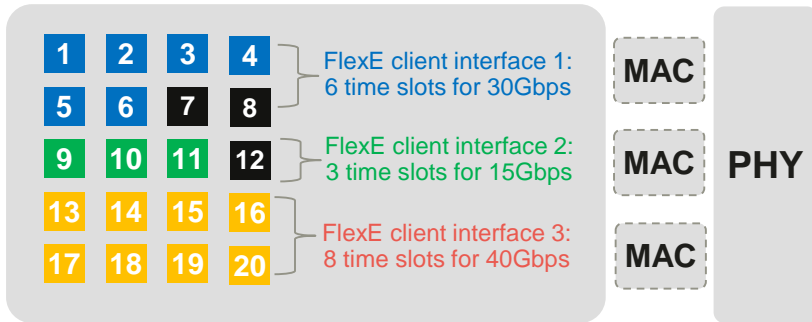
(draft-ietf-teas-ietf-network-slices in IETF)

- **IETF Network Slice** enables **connectivity** between a set of SDPs with specific Service Level Objectives (**SLOs**) and Service Level Expectations (**SLEs**) over a common underlay network.
  - SLOs: Bandwidth, latency, jitter, packet loss, availability, etc.
  - SLEs: Security, **isolation**, diversity, geographic restrictions, etc.

Transport network slice is an **essential component** in delivering network slice services

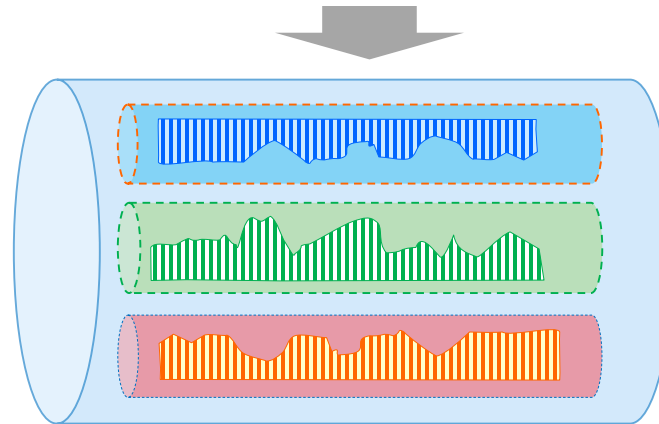
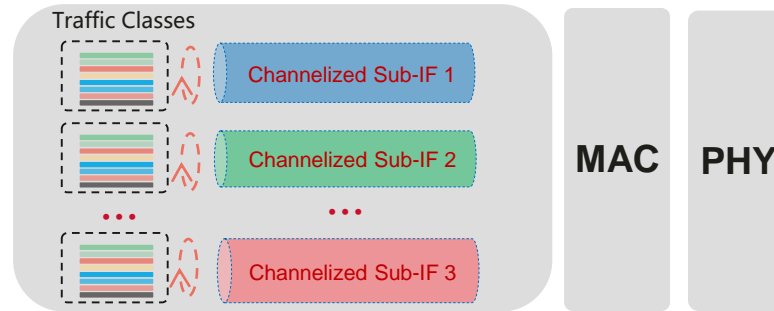
# Forwarding Plane: Partitioning of Network Resources

## Flexible Ethernet (FlexE)



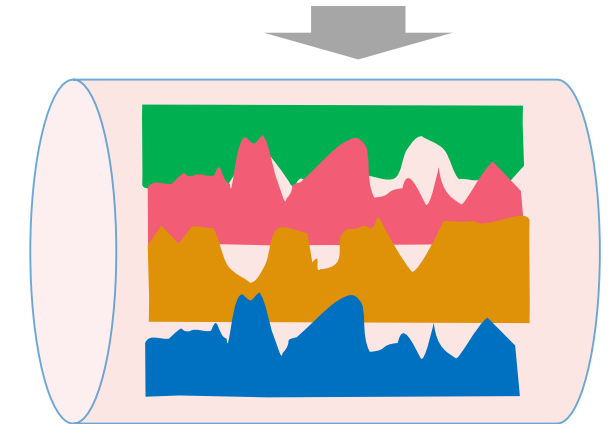
- ◆ Time slot-based resource partition
- ◆ Strict isolation between slices
- ◆ Statistical multiplexing within slice

## Logical sub-interfaces/channels



- ◆ Bandwidth resources partition
- ◆ Independent queue scheduling
- ◆ Fine granularity, high scalability

## Class-based QoS



- ◆ Coarse traffic classification
- ◆ Network resources competition
- ◆ No end-to-end service assurance