## **Network Slicing Motivation: 5G and beyond**





# **5G E2E Network Slicing Architecture**



## **Network Slicing in Transport Networks**





# **Overview of Network Slicing Standards**



**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

#### Requirements



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

Architecture & Technical Specifications for Transport Network Slicing

## Architecture, Management, Control & L3 Data Plane

#### IETF Network Slice Framework

- Terminology, characteristic and general framework
- IETF network slice realization: VPN+ framework

#### IETF Network Slice Management

- NBI: IETF network slice service YANG model
- SBI: IETF network slice network/device YANG model

#### Data Plane extensions

- Segment Routing (SR) based data plane
- IPv6 data plane
- MPLS data plane
- **Control Plane extensions** 
  - IGP/BGP-LS
  - BGP SR Policy
  - PCEP
  - ...





# **IETF Standards on Network Slicing**





Huawei is leading the standards in IETF Network Slicing

## **Network Slicing Architecture**





# **Mechanisms for Resource Isolation in the Forwarding Plane**





# **Candidate Network Slicing Solutions**

## **Slice-Resource aware SR**



## Forwarding plane

• **Per-slice dedicated resources** are assigned using FlexE or channelized sub-interfaces

### **Control & Data Plane**

- Each slice interface has **independent SRv6 SID**, IP address and link affinity (color)
- Routing with SRv6 Policy/Flex-Algo based on link affinity constraints

## Scalability

- A limited number of slices can be supported
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## Hop-by-hop based Slice-ID



### Forwarding plane

VS

• **Per-slice dedicated resources** are assigned using FlexE or channelized sub-interfaces

### **Control & Data plane**

- Slices and routing are **decoupled**
- IP addresses and SRv6 SIDs are shared among multiple slices
- Routing with SRv6 Policy/Flex-Algo with slice constraints
- Use IPv6 HBH based Slice-ID to determine per-slice resources

### Scalability

• Target for thousands of slices



# **Algorithms for Slice Planning and Optimization**

### Inputs

- Service requirements: (BW, latency, protection...)
- Physical topology
- Current network utilization

**Network Slicing Engine** (NCE-IP)

#### Outputs

- Reservations for sub-interfaces
- Logical topology and routing policies in the physical network

## **Optimization intents**

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

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### **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 ٠ resource allocation problems



# **Multi-slice Planning and Defragmentation**

#### **Bandwidth Allocation Policies**



Life-cycle Management

### **Main requirements**

- **Planning:** maximize the number of accepted slices in the network
- Adjustment: quickly handle changes in the physical topology and traffic requirements
- **Defragmentation**: improve MLU and network utilization while limiting reconfigurations

#### **Granularity of FlexE / Chan. sub-interfaces**



### **Statistical multiplexing**

Convergence Ratio (CR) is used in IPRAN networks to avoid





# **Multi-slice Defragmentation**

### **Results on a 50k nodes IPRAN network**



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#### Illustration on a smaller network



Gains: 30%+ for MLU, 20% for Cost / BW reservations in a few seconds



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## **Network Slice Deployment Cases**

#### **30+ Network Slice deployments worldwide**

- Multiple vertical industries
- Fix-Mobile Convergence

• Premium Private Lines

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Multi-service networks

#### **Operator N: Network Slicing for Multiple Vertical Industries**













## **Future Evolutions of Network Slicing**

## Advanced Network Slice Deployment

- > Multi-domain network slicing (different administrations, different technologies, different granularities)
- > Hierarchical network slicing (provisioning, management and assurance of nested slices)

## Flexible Network Slice Mapping

- > E2E Slice-ID based mapping
- > Intent based mapping
- > APN (app-aware networking)-based mapping

## Data-driven Network Slice Automation

- > Optimization of capacity reservations based on parsimonious traffic measurements
- > Closed-loop control to guaranteed SLAs (dynamic slice expansion)

