Future of slicing and ML

Cognitive High-Precision Slicing

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Topics Overview

- Baselining state of network slices
- Description of challenges with current framework
- Network 2030 applications and future network slices
- Extending machine learning to simplify management and orchestration aspects
- Questions proposal

Baselining Network Slicing in Fixed Networks

Circa 2016

- Concept & formalization
- Of 5G Slices of type URLLC, eMBB and mIOT.
- Focus on service specific SLA
- Orchestration and softwarization centric

New Capabilities for future/2030 applications

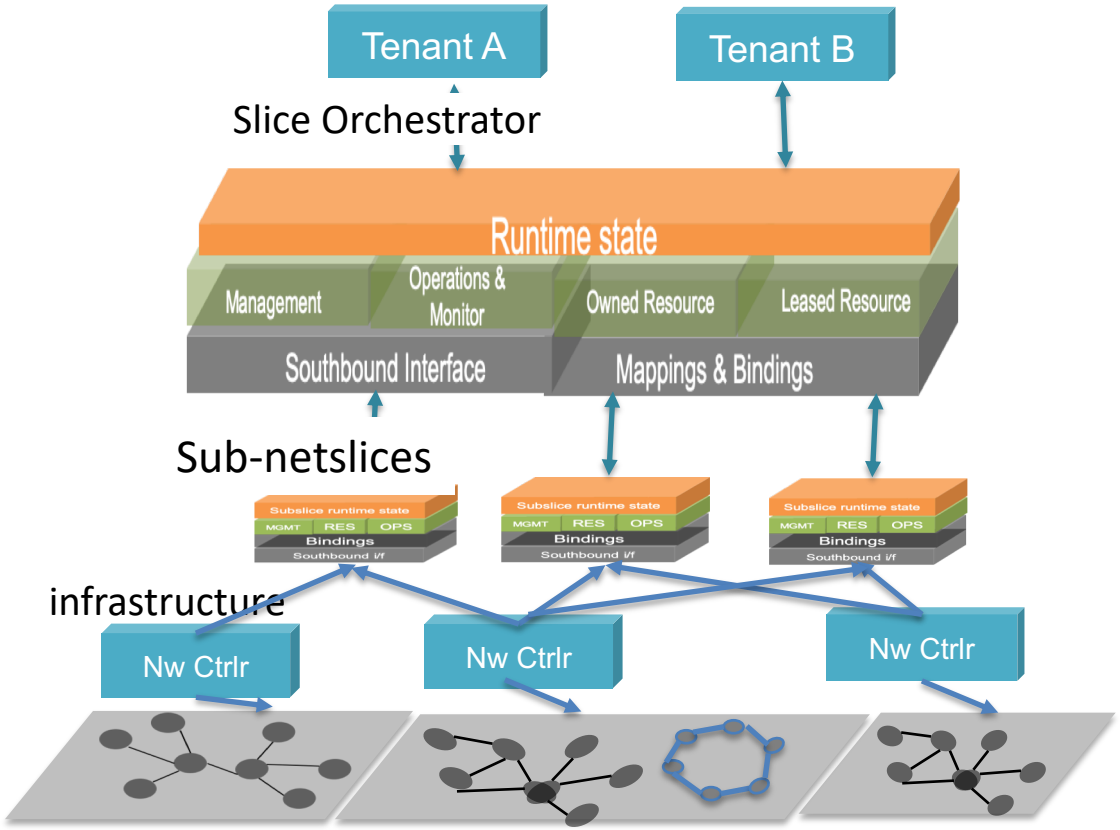
Simplification through Next gen management and Orchestration

2020-beyond

- High precision network slices for future demands
- Transition from transport to slice-centric user plane
- Federated network slice gateways
- Applying machine learning capabilities to orchestration and management

Challenge: Scale, Service objectives and Complexity

Use cases	Range	Frequency /Lifetime	Geography
Smart Drive Assistance	1-100	24hr/annual	Nationwide
Industry Automation	1K-100K	Minutes/weeks	Region
Smart/virtual office	100K-1000K	Minutes/Hours	Ltd. international
CDN/Edge Services	1-100	Seconds/day	City
Advanced Medical Services	10K-100K	Seconds/hours	Region
Network 2030 Scenarios	>100K	Variable – user-defined	local or regional



The architecture is inherently hierarchical and highly abstracted at the network slice orchestrator

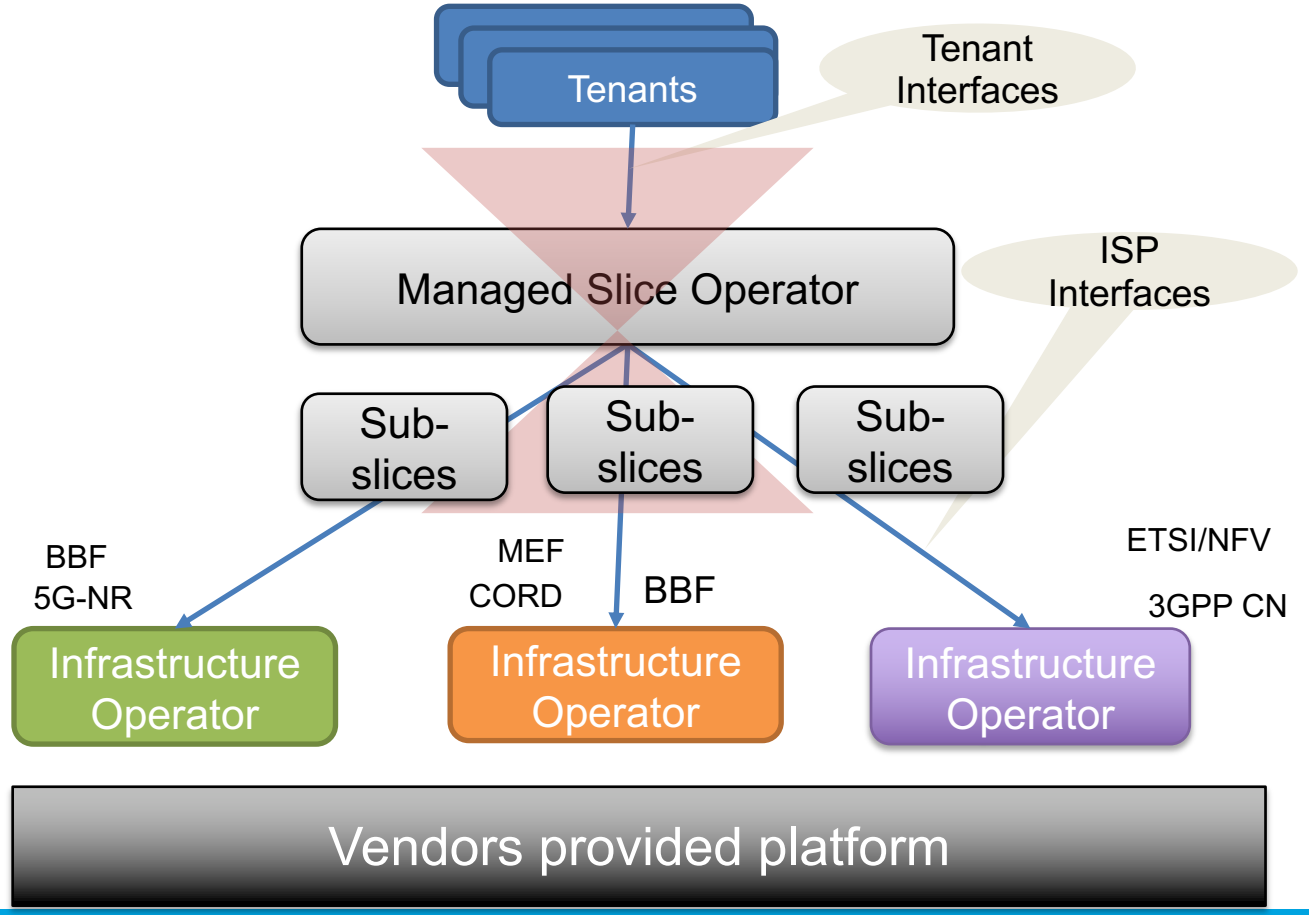
Can we utilize machine learning techniques to bring automation to manage complexity?

Ref: https://5g-pagoda.aalto.fi/assets/demo/attachement/delivrables/D4.1_Scalability-driven_management_system_v1.0.pdf

Challenge: Dynamic Life-cycle management

1. Several assumptions about lower level network, the coordination among networks is missing
2. Orchestrated Traffic Engineering (TE) is already hard in single administration with overlapping bottlenecks
3. Centralized decisions on TE slows down and delays changes in underlying networks.

- Network Slice orchestration is Also excessively centralized
  Evaluate efficient distribution and delegation techniques for in management and control.



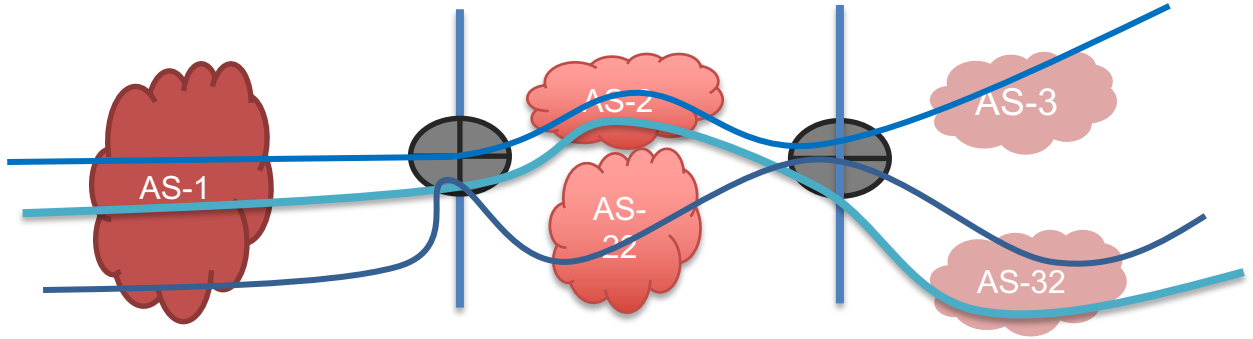
Challenge: Gaps in routing protocols for determination of resource-aware paths

Inter Domains protocols such as BGP distributes AS paths and communities.

BGP does not consider demand, capacity and performance – all are necessary for slicing

Built-in dynamic path steering in routing protocols are necessary for better resource-centric path control.

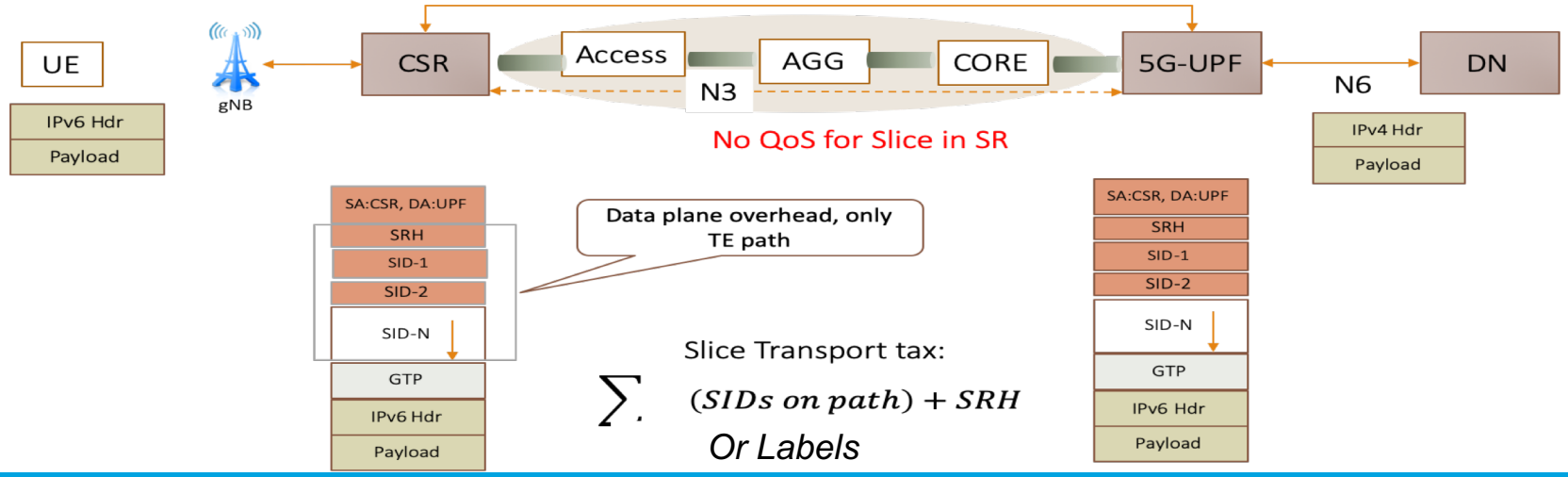
Type of enhancements necessary in control plane for distributed network slice support?



[https://datatracker.ietf.org/meeting/104/materials/slides-104-irtfopen-brandon-schlinker-anrp-2019-engineering-egress-with-edge-fabric-steering-oceans-of-content-to-the-world-01]

From Traffic Engineered Transport to High Precision User Plane

- Overlay transport (labels, source routing) only meet capacity and reliability
- **Requirement: Precision user plane for accurate resource allocations**
  - Guarantees of network resources: delay, throughput, resiliency, scale
  - Guarantees of compute resources: CPU and storage
  - Guarantees of service isolation may include FIB tables/addresses, memory



Network 2030 Applications impact

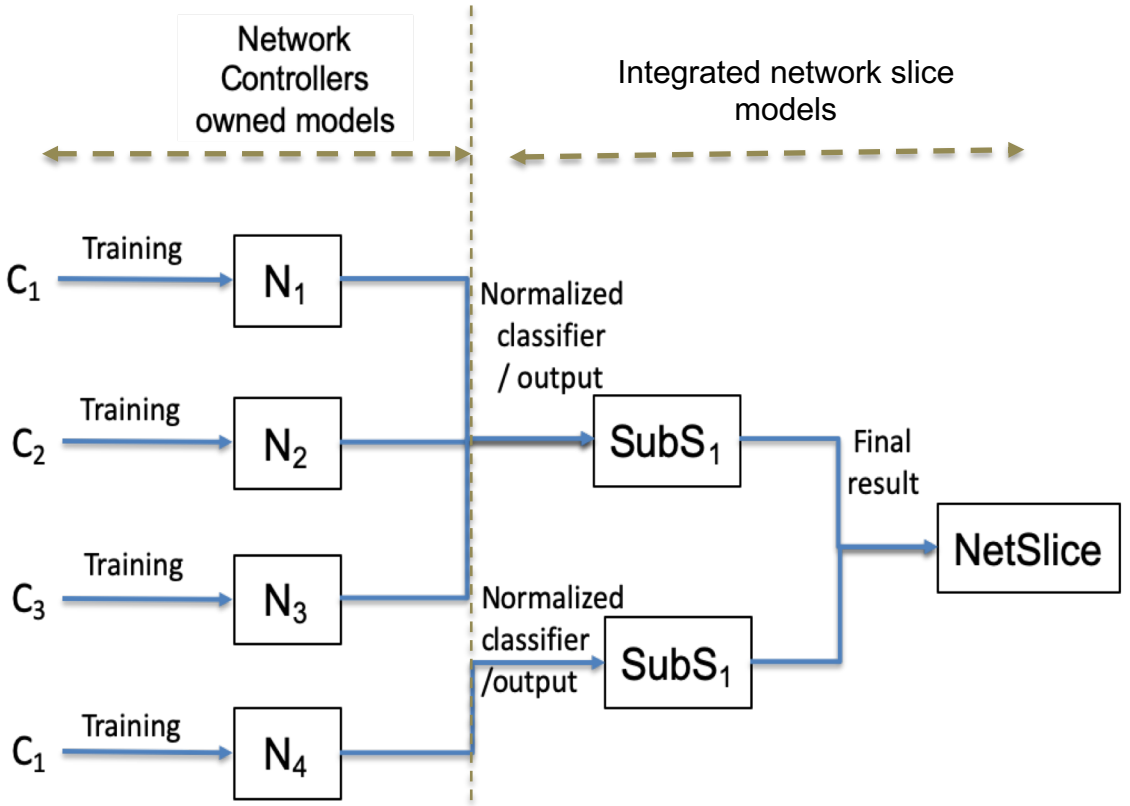
- Network slices are operator centric methodology
  - To customize general purpose infrastructures for special purpose services
  - Improve utilization of networks in doing so.
- Network 2030 recap
  - From AR/VR to Holographic media (higher bandwidth for volumetric data)
  - From low latency to high-precision (higher accuracy of resources)
  - From Internet to ManyNets (higher density of private & isolated networks)
  - New business models due to new services (coordinated, qualitative, holographic type comms)

Cognitive Network Slice Management & Control

- Greenfield Deployments - on-boarding a network slice from blueprints
  - can be a tedious a step when used with classical heuristic approach of trials and fine tuning configurations.
  - Instead utilize Machine Learning methods to train classical traffic-data and build best-fit models for a given type of service/slice.
- Post-Deployment – auto-tuning network slice performance
  - Utilize ML descriptive analytical methods (such as Adaptive Boosting) to increase precision in predicting traffic patterns in a slice
  - Each property/classifier (e.g src-dest, latency, NF, etc.) of a slice service is a weak learner.
  - Combine them together into a strong learner for a specific blue print.

Cognitive Network Slice Management & Control

- Runtime Lifecycle Management
  - Via distributed models (infra and service specific)
  - Of resources needed by a slice-service
  - Possibly build on top or complement Y.ML-IMT2020-Data-Handling work. In addition to API-g approach, normalize abstracted classifiers
  - Anonymization of data exported to orchestrator from network infrastructure



Strategic direction to be taken by ITU-T

- Define network slice user plane capabilities for services and applications described in Network 2030
- Distributed routing control for better scalability and gateways for multi-protocol stitching.
- Leverage ML framework Y.3172, as well as ITU-T Y.IMT2020-NSAA-reqts.
- Emphasis on hierarchical Machine learning approaches for cognitive network slices.
- Abstraction and anonymization of outcomes of data models at lower levels.

Questions for SGLA discussion

- Question 1: High-precision user plane mechanisms in network slices for services with stringent guarantees of future applications defined in 2030.
- Question 2: Distributed control plane approaches for dynamic network changes
- Question 3: Utilize Machine learning framework for resource optimization with-in and across domains.
- Question 4:Cognitive slice management control and operation.

Questions for SGLA discussion – 1

- Question 1: High-precision user plane mechanisms in network slices for services with stringent guarantees of future applications defined in 2030.
  - Determination of lean data planes beyond low latency URLLC and eMBB. Considerations for precise time-based and constant throughput media (holographic type) in transport networks should be studied.
  - For example how to associate different constraints at device level on scheduling for accurate time-based delivery slices
  - How to provide consistent throughput, latency and low jitter for future holographic media as defined in network 2030

Questions for SGLA discussion – 2

- Question 2: Distributed control plane approaches for dynamic network changes
  - Formalization and role of network slice gateway functions for interoperation and interconnection. Provide dynamic stitching of data planes with different protocols across multiple subnets and domains.
  - Distributed control plane support for dynamic response to resource centric network changes.

Questions for SGLA discussion – 3

- Question 3: Utilizing Machine learning framework for overall resource optimization with-in and across networks (Orchestration domain).
  - Study mechanisms that best optimize resource usage at a very high scale fulfilling different objectives. Where objectives are multi-functional: such as on-boarding, runtime adaptive slice environment.
  - Integration of outcomes from ML models in different subnets and ASs.
  - Improve upon result of a resource allocations by using boosting algorithms. Study how boosting from different domains and different slices together provide best use of resources known to a slice operator.

Questions for SGLA discussion – 3

Question 4:Cognitive slice management control and operation

- Identify what-if scenarios due to changes in environment. E.g.
  - Effect of onboarding a network slice on other slices.
  - Predict best network domain transit path and its ability to meet SLA.
  - Use test data on trained models to forecast scale of service impact. E.g. what happens at large scale when a link goes down, or during scheduled maintenance.
- Identify right algorithms and distributed ML models for analytical techniques for runtime monitoring of network slices.