Network Slicing & related work in IETF

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SANOG 36
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Dhruv has been working in the networking domain for the last 16 years with Huawei Technologies. Over the years he has worked on MPLS VPNs, OSPF, NTP, ALTO, CSPF, etc for Huawei’s Routing Platform. He is currently working on research & standards for various emerging technologies as PCE, Segment Routing (SR), and Network Slicing. He is an active IETF contributor in the area of Path Computation and Traffic Engineering with 15 RFCs as the main editor and 12 as a contributor. He has filled 21 patents. He is also serving as the PCE WG co-chair at IETF. He is also part of the Routing Directorate and sergeant-at-arms for the IETF mailing list. He is a founding member and president of India Internet Engineering Society (IIESoc) & secretary for Industry Network Technology Council (INTC).
Let's talk about 5G

- 5G is the fifth generation of cellular networks, bringing new capabilities.
- 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.
Key 5G Use-cases

- Enhanced Mobile Broadband (eMBB)
  - High data rates across a wide coverage area.
- Ultra Reliable Low Latency Communications (URLLC)
  - Target latency of 1 ms and requirements for end-to-end security and 99.999% reliability.
- Massive Machine Type Communications (mMTC)
  - Large no. of devices that intermittently transmit small amounts of traffic.
Different Requirements!

- Deep coverage
  - To reach challenging locations

- Strong security
  - e.g. Health / government / financial trusted

- Ultra-low energy
  - 10+ years of battery life

- Ultra-low complexity
  - 10s of bits per second

- Ultra-high density
  - 1 million nodes per Km²

- Ultra-high reliability
  - <1 out of 100 million packets lost

- Ultra-low latency
  - As low as 1 millisecond

- Extreme capacity
  - 10 Tbps per Km²

- Extreme data rates
  - Multi-Gigabits per second

- Enhanced mobile broadband

- Mission-critical control

- Deep awareness
  - Discovery and optimization

- Extreme user mobility
  - Or no mobility at all

Source: https://www.qualcomm.com/media/documents/files/qualcomm-5g-vision-presentation.pdf
Network Slicing is the key enabler

- Different virtualized and independent logical networks on the same physical network infrastructure, in order to meet diversified service requirements.
- Each network slice is an isolated end-to-end network tailored to fulfil diverse requirements requested by a particular application.
- Network slicing enables the most economical model to provide service differentiation and meeting end user SLAs.
- Builds on SDN, NFV, service orchestration, telemetry and closed loop automation etc
Some “Networking” Background

- Started with simple service asking for connectivity - VPNs (L2 or L3)
- In traffic engineering
  - topology abstraction (summary)
  - virtualization (VN - virtual network) - edge to edge connectivity with certain qualities
    - Just connectivity
    - Enhanced connectivity (VPN with different per-site bandwidth)
    - Customer managed connectivity
    - Customer operated connectivity (multi-layer)
      - Carrier’s carrier
      - IP over Optical
- We have been doing this for a while...
Network Slicing - the concept

- Multiple **virtualized and independent** logical networks on the same **shared** physical infrastructure with each **slice tailored to fulfil diverse requirement**
- **Partitioning** of network resources
  - We know this - VPN, Overlays, RSVP-TE, SDN etc
- **Service guarantee** making sure no impact from other services
  - Throughput, latency, jitter...
- **Reserving resources** for service
  - Bandwidth, compute...
- **Isolation**: multiple slices over shared infrastructure
  - Performance, Traffic separation, Security, Privacy, Management
- **Control & Orchestration**
  - E2E and multi-domain
E2E Network Slice

The IETF Scoped Network

[Diagram showing the components of an E2E network slice, including Edge Slice (RAN), IETF Network Slice, and Core Slice, with symbols for tenants and cloud services.]
IETF Network Slice

- An IETF Network Slice is a logical network topology connecting a number of endpoints with a set of shared or dedicated network resources, that are used to satisfy specific Service Level Objectives (SLOs)
  - Use of ‘IETF’ to limit the scope
  - There was a long debate on the name, it was called Transport Network Slice before!
- IETF Network Slicing has multiple use cases
  - 5G (enhanced mobile broadband (eMBB), ultra reliable low latency (URLLC), massive machine type (mMTC))
  - NFV & DCI
  - Sharing of Network infrastructure among multiple operators
  - Network wholesale service
- IETF Network Slicing is technology-agnostic and independent of underlying infrastructure connectivity
- Enable a diverse set of applications that have different requirements to coexist on the same network infrastructure.
- Slice refers to a set of characteristics & behaviours that separates one type of user-traffic from another!
Service Characteristics

- ‘quantifiable’ is key
- **SLI - Service Level Indicator** is a quantifiable measure of network performance (throughput, latency)
- **SLO - Service Level Objective** is a target value/range for the measurement of SLI
  - slice = set of SLOs
  - not ‘how, but ‘what’ (remember intent)
  - direct or indirect measurable objectives
- **SLA - Service Level Agreement** is the contract between consumer & provider
- A debate on how to characterize isolation - SLO or NOT!
  - negative impact of other slices
  - traffic separation / interference avoidance / service assurance
  - pragmatic isolation
Endpoints & Connectivity Types

- An IETF Network Slice is a well-defined composite of:
  - a set of **endpoints**
    - Conceptual point of connection of customer network, network function, device, application
  - the **connectivity requirements** between subsets of these endpoints
    - P2P / P2MP / MP2MP
    - Hub & Spoke
    - Full Mesh
  - associated service requirements
    - SLOs
Proposed Framework

- **Lifecycle** management (creation, modification, monitoring, deletion...) of IETF network slice.
- NSC takes request from higher system via NBI, request is then realized (or translated) to the underlying infrastructure and a mapping maintained.
Proposed NBI

- A **technology-agnostic** NBI for creation/deletion/modification/monitoring of slice.
- **Endpoints**
- **Connectivity** between network slice endpoints
  - Slice Members
  - Allow grouping of connections with same SLO
  - Connection type
- **Service requirements** (**SLO**)
  - Well known and custom templates
- **Status & Monitoring**
- *Need to also maintain a* **mapping** *between consumer view (NBI) and the network slice realization (provider view)*
Building Blocks

- **Frameworks**
  - ACTN, Enhanced VPN

- **YANG Models**
  - Slice NBI model
  - Service - L3SM, L2SM etc
  - TE - Topology, tunnel, VN, TE-Mapping, etc
  - ...

- **Techniques**
  - SDN
  - L3VPN, L2VPN, EVPN
  - MPLS-TE, Detnet
  - SR / SRv6
  - Telemetry, OAM

- **Protocols**
  - BGP, BGP-LS, PCEP, IGP, RSVP-TE, Netconf, Restconf...
ACTN - Abstraction & Control of the TE networks

- ACTN facilitates **virtual network operations** by
  - abstracting underlying **heterogeneous** network domains
  - Coordinating between **multi-domain, multi-layer** network in a recursive hierarchical fashion
  - Providing a **customer view** of the network
  - **Mapping** customer request into network provisioning request

- ACTN (RFC 8453) maps well with Network Slice framework
Enhanced VPN (VPN+)

- Builds on VPN service with **guaranteed network resources & predictable performance**
- A **tighter coordination & integration** between underlay & overlay
  - VPN - Overlay
  - Virtual Transport Network (VTN) - underlay customized network topology
  - Enhanced VPN is the integration of the two!
- Centralized Control & management - builds on ACTN & service model
- Customized virtual networks - overlay & underlay
- Enhanced dataplane - TSN, FlexE
- Pragmatic Isolation
Some of the Realization Techniques...

- **Using SR for Enhanced VPN**
  - Resource Awareness to SR segments
  - Embedding Slice-ID in SRv6 SID
  - IGP extension - use MT / Flex-Algo
  - BGP SR Policy/BGP-LS extension
  - IPv6 Extension Header (HBH)

- **Packet Network Slicing using SR**
  - New slice based identifier - Administrative Instance Identifier (AII)

- **Realizing slice in IP/MPLS**
Lot of work ongoing in this area! Join TEAS WG mailing list...
Thank You!

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