Business Landscape

Mobile ARPU, Multiple Countries

Consumer ARPU is Declining or Flat

B2B or B2B2x Market Has Future Growth

Emergence of Low Latency Need for better QOE and to Enable New Applications
5G challenges for transport
5G Key Use Case Categories

**Enhanced Mobile Broadband** (inc. Fixed Access)
- Extra capacity delivered through new 5G frequency bands
- Not too concerned with connection density or latency.

**IoT/massive Machine Type Communications**
- Focused on low power wide area NB-IoT with high connection density and energy efficiency

**Ultra-Reliable Low Latency**
- For mission critical use cases (self driving, Public safety, ...)
- Desired 1ms access time only refers to radio interface and would be most useful in near field mission critical apps

Source: [Recommendation ITU-R M.2083](https://www.itu.int/rec/R-REC-M.2083/en)
Distributed workloads to the edge of the network driven by low latency applications, lower transport costs, QOE

Any-to-any connectivity between distributed UPFs and with centralized UPF&CP

Ability to run multiple logical networks as virtually independent

Simultaneous support of strict SLA & best effort traffic over same infra

Dynamic and flexible slicing creation/modification

Introduction of RAN splits and virtualization of RAN workloads

Low latency and high throughput access networks

Distributed workloads to different levels of the transport network

Unified Network Fabric, Network Programmability & Automation, Strict QoS, Convergence
5G Transport - RAN impacts Transport Design
5G ready transport architecture
Cisco’s overall 5G transport proposition

- **Use Cases**
  - SMB
  - Mobile Network Slice Manager
  - Consumer
  - Enterprise

- **Controllers / Automation / Telemetry / Analytics**
- **Telco/IT DC Domain**

- **BGP-VPN L2/L3 + Overlay VPNs**
- **Segment Routing**

- **Multi-service**
  - Flexible radio / mobile core / service placement
  - End2end packet infrastructure

- **Up to x10 radios (500k n/w devices)**
  - x4 – x100 bandwidth than 4G
  - Multi-Access Edge Compute
• MEC demands IP switching capabilities where ever there is DC
• Traffic demands are lambda level and above
• MEC creates discrete optical domains, reduces optical drive distances and simplifies optical infrastructure
• Open ROADM, pluggable DWDM optics driving new round of IP optical integration
Logical Network Evolution: Today’s Service Creation

E2E service provisioning is lengthy and complex:

- Multiple network domains under different management teams
- Manual operations
- Heterogeneous Underlay and Overlay networks
Logical Network Evolution: 5G Infrastructure

- Metro Network Domain
- Core Network Domain
- Metro Network Domain

### EPN 4.0
- L2/L3VPN Services
- Inter-Domain CP
- FRR or TE
- Intra-Domain CP
  - LDP
  - BGP
  - BGP-LU
  - RSVP
  - LDP
  - IGP

### EPN 5.0
- L2/L3VPN Services
- Inter-Domain CP
  - LDP
  - BGP
  - BGP-LU
  - IGP with SR

### Metro Fabric
- BGP
  - IGP with SR
5G Transport: Why Segment Routing

Network Resiliency
TI-LFA and automated 50ms protection

End to End path control
Shortest Path
Flex-algo
Multi-domain TE
SR-PCE + Distributed CP

Network Simplification
Eliminate LDP, RSVP and other protocols
Stateless core devices

Service Aware underlay
Traffic Steering
Automated Traffic Steering

Simplified Service Creation
Concurrent support for network and overlay VPNs

Scalability
Multidomain architecture
On-Demand Nexthop (ODN)
Stateless within core

OAM and performance management
Underlay and service monitoring
Real time adjustments based on PM

Standards Based
No vendor lock-in

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SR: Engineering the Underlay

• Flex-Algorithm
Builds domain level forwarding tables
IGP distributes multiple metrics / affinities
Multi-algorithms operational in network
SPF, Low Latency, constrained nodes / links (customer chooses)
TiLFA per algorithm

• SR Policies (or SR-TE)
Builds paths between nodes
Path computation based multiple constraints (b/w, latency, affinity)
Calculated by head-ends or an SR-PCE
Multi-domain / disjoint paths require SR-PCE

Example Green: Low latency, Red: IGP path
Segment Routing – Service Aware Traffic Steering

- Traffic Steering
  Mechanism on source router to steer traffic
  By default traffic uses IGP path
  Can steer traffic into a SR policy or specific Flex-algos
  Destination TS: destination only
  Flow based TS: destination + QoS criteria

- Automated Traffic Steering
  Hints on SR policy conveyed in overlay route updates
  Significantly reduces configuration
  Uses BGP color extended community (RFC 5512)
SR Path Computation Element (SR-PCE)

**SRTE Head-End**
Distributed Mode – SR-TE Head-End
Visibility is limited to its own IGP domain

**Solution**
Multi-Domain SRTE Visibility
Centralized SR-PCE for Multi-Domain Topology view
Integration with Applications
North-bound APIs for topology/deployment
Delivers across the unified SR Fabric the SLA requested by the service

**Benefits**
Simplicity and Automation
End-to-End network topology awareness
SLA-aware path computation across network domains
Disjoint paths
Multi-domain path computation and ODN

Native SR algorithms
SR-PCE runs on virtual or physical IOS-XR node

Topo DB
Compute
Collect
Deploy

REST API

Single / Multi-Domain Topology

APP

APP

APP

Topo DB

Collect

Compute

Deploy

SR-PCE runs on virtual or physical IOS-XR node

BGP

BGP-LS

IGP

PCEP

APP

APP

APP

Metro

Core

Metro

Data Center

Access

SR

1

SR

2

SR

3

SR

4

SR
Is Diffserv QoS “Good Enough” for 5G

• Yes, as a transport QoS strategy!
  Slice b/w / class protection through ingress conditioning and marking
  Class separation and protection with core scheduling
  Bandwidth reuse
  QoS aware capacity planning

• FOR LOW LATENCY SERVICES THE OVERALL DESIGN NEEDS CONSIDERATION
  Network delay = propagation delay + switching delay + scheduling delay + serialization delay

• Proximity of gateway functions to users
  Reduce propagation delay and OEO delays

• Proximity of applications to users
  Reduce propagation delay and OEO delays

• Serialization delay is a consideration for fronthaul applications (TSN)
Service Infrastructure

• Network based VPNs
  • 5G based VPNs

• Overlay / SDN-WAN based VPNs
  • Enterprise services
  • Inter-DC communications
Transport level 5G slicing
Example: 5G backhaul dataplane slice

3GPP control Plane
L3 VPN

Backhaul (N3)
E-LAN or L3 VPN

Central DC
3GPP control servers

Internet VPN
Enterprise VPNs

Far Edge DC
Edge DC
Regional DC

UPF

Access
Pre-Agg
Aggregation
Core
Slicing in the Underlay Based on SLA Requirements

- Small number of slice planes defined in underlay (across domains)
  5G mobility slices (eMBB, URLLC, mIoT, signalling, etc.)
  Major Service Type (Wholesale, MVNO, Enterprise, Content, etc.)
- Diffserv QoS enabled network
- Each Slice plane characterized by
  Optimization + constraint objective: latency, bandwidth, reliability,
- Based on a flex-algorithm (SPF included) or pt-2-pt SR policies
L2/L3 VPNs used for customer and service separation
- Potentially large numbers
- Traffic classified and controlled on ingress
- Automated Steering place VPN traffic into correct underlay slice plane
Timing and Synchronization
Timing and Synch – New Phase Requirements

- 5G (like modern LTE-A networks) requires phase synchronization
- New 5G TDD radios definitely require it:
  1. 3GPP: 3μs between base stations (for TDD, LTE-A radio co-ordination)
  2. Radio backhaul network: ±1.5μs from reference time
5G is also re-engineering the Fronthaul network towards Cloud RAN:
- CPRI to packet-based Fronthaul/Midhaul impacts timing
- Much tighter requirements for phase alignment budget
Timing and Synch – Solutions

**GNSS (GPS, Galileo) Receivers**
- Effective solution where site conditions allow (Sky view, $$)
- Susceptible to jamming (and increasingly spoofing)
- Time source for cell sites, PTP GM’s and monitoring equipment

**PTP/1588 and SyncE in Transport Network**
- Great solution: G.8275.1 with “on path support” for PTP
- Needs good network design in combination with SyncE
- End-to-end timing “budget” with accurate boundary clocks

**All of the Above**
- PTP/SyncE as a backup to GNSS receiver outages
- GNSS where it’s cost effective, PTP everywhere else

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- Include GNSS receivers inside routers where appropriate
- Routers as high performance T-BC boundary clocks with Class B/C G.8273.2 performance
- Flexibility in the design of the equipment allows them to be used in any situation

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Timing and Synch – PTP Profiles for Phase

• There are various profiles available for use
  • Most operators looking at G.8275.1 – the best timing solution
  • Supported across ASR900, ASR920, NCS500, NCS5500, ASR9K range
Summary
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- 5G brings new requirements and challenges to transport network
- Cost and simplicity is critical
- Outlined Cisco approach to 5G transport networking
- Streamlining network structure and packet optical integration
- Segment Routing for engineering and simplifying the underlay
- Concurrent support for BGP based VPNs and SD-WAN solutions
- Timing and synchronization is a vital component of the radio network
- Operators are investing in 5G-ready networks now!!
The End

Need more information??

Compass "Metro Fabric Design”  https://xrdocs.io/design/