SANOG

SDH vs. Carrier Ethernet

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Agenda

- Introduction – Backhaul for Mobile and Enterprise Services.
- SDH Transport Network
- Transport Network - Requirement
- Large Scale Packet Transport Network Design (UMMT)
- High Availability Design
- Summary

Circuit and Packet Switching

- **The first communication services were circuits – Voice Circuits for interconnecting TDM Voice Switches Provisioned Statically**
- **Thus, the first transport infrastructure built was circuit-switched, to support the above**
- **When packets became important, it used the existing transport network of circuit-switched infrastructure to carry packet traffic**
- **Things are changing. Packets are more important now. Packet bandwidth is significant and packets also enable a number of new services and revenue. Carrying packets over TDM/Circuit-switched is found not efficient. Higher Cost per bit..!**
- **Higher than 99% of the TDM circuits carry packets.**

Telecom Technology Trends

- **Voice TDM switches -> NGN Switches (Soft switch + Media Gateway).**
- **The IP RAN / Mobile Backhaul requirements for 3G, 4G/LTE, Enterprise, IPTV, Wimax, xDSL Broadband, GPON, Wifi backhaul are natively packets. Legacy 2G is TDM and will move to Packets in future.**
- **Technology supports carrying Circuits over Packets. Technologies like CESOP/SATOP, SyncE, PTP 1588V2 helps to carry TDM over packet network.**
- **SDH based network is having lack of scalability for growing BW needs with low Capex. Support of Multi-Technology over Transport Network is critical**

Mobile Backhaul Requirement

Service	Node Category	Bandwidth per Node
2G	BTS	Larger Cities 2-3 E1. Smaller Town: 1 – 2 E1
3G	NB	Voice: 1 E1 Data: 42MB in Large City 14-20MB in smaller Town
4G / LTE TDD & FDD	eNB	75 Mbps *
SP Wifi	AP	4MB
Enterprise Service	WiMax	7MB Per Sector. No. of Sector: 3 to 4 Per Location
Microwave	Hybrid Backhaul	Vary from 25 or 50 or 400Mbps

* Synchronization and Any-to-Any Services

Enterprise and Consumer Services

- MPLS Layer-2 VPN
  - Ethernet Line (E-line)
    - a) EPL – Ethernet Private Line
    - b) EVPL – Ethernet Virtual Private Line
  - Ethernet LAN (E-LAN)
    - a) Ethernet Private LAN
    - b) Ethernet Virtual Private Tree
- MPLS Layer-3 VPN
  - (a)Intranet (b)Extranet (c) MVPN
- IPv6 Services
  - a) 6PE (b) 6VPE Internet Leased Line
- Internet services
  - (a) Default Routing
  - (b) Full Routing Table

- Broadband
  - Wimax
  - Wifi
  - Ethernet
  - xDSL
  - GPON
- IPTV

Deployment Model

- Centralized Edge
- Distributed Edge
- Hybrid Model
- PW head end

SDH Transport Network

SONET/SDH Bandwidths

NET Optical Carrier level	SONET frame format	SDH level and frame format	Payload bandwidth (kbit/s)	Line rate (kbit/s)
OC-3	STS-3	STM-1	150,336	155,520
OC-12	STS-12	STM-4	601,344	622,080
OC-48	STS-48	STM-16	2,405,376	2,488,320
OC-192	STS-192	STM-64	9,621,504	9,953,280
OC-768	STS-768	STM-256	38,486,016	39,813,120

SONET/SDH Network

Main Function
Responsible for a fair chunk of cost. Limited utility going forward

SONET/SDH

Deep Channelization: down to DS0	⇒ remove
Framing: carry bits/cells/packets/frames	⇒ simplify
Overhead: OAM: liveness, management	⇒ split
Fast Restoration (1+1, ring-oriented)	⇒ move
Traffic Engineering (path and capacity mgmt)	⇒ move
Timing (clock/frequency synchronization)	⇒ remove/replace

Ethernet Over SDH

Encapsulation: Generic Framing Procedure or GFP
Higher capacity : Virtual concatenation (VCAT)
VC Signaling / Increase Capacity: Link Capacity Adjustment Scheme (LCAS)

SDH Transport Network

SDH Network Services :

- TDM (E1, E3/DS3, STM-4 / 16/ 64)
- Ethernet Over SDH

Issues with SDH

- High Cost per Bit. Does not scale
- Does not Meet Synchronization requirement for 4G Network
- Issues with Consumer services (Ex. IPTV)
- Does not Support Any-to-Any Services

Transport Network - Requirement

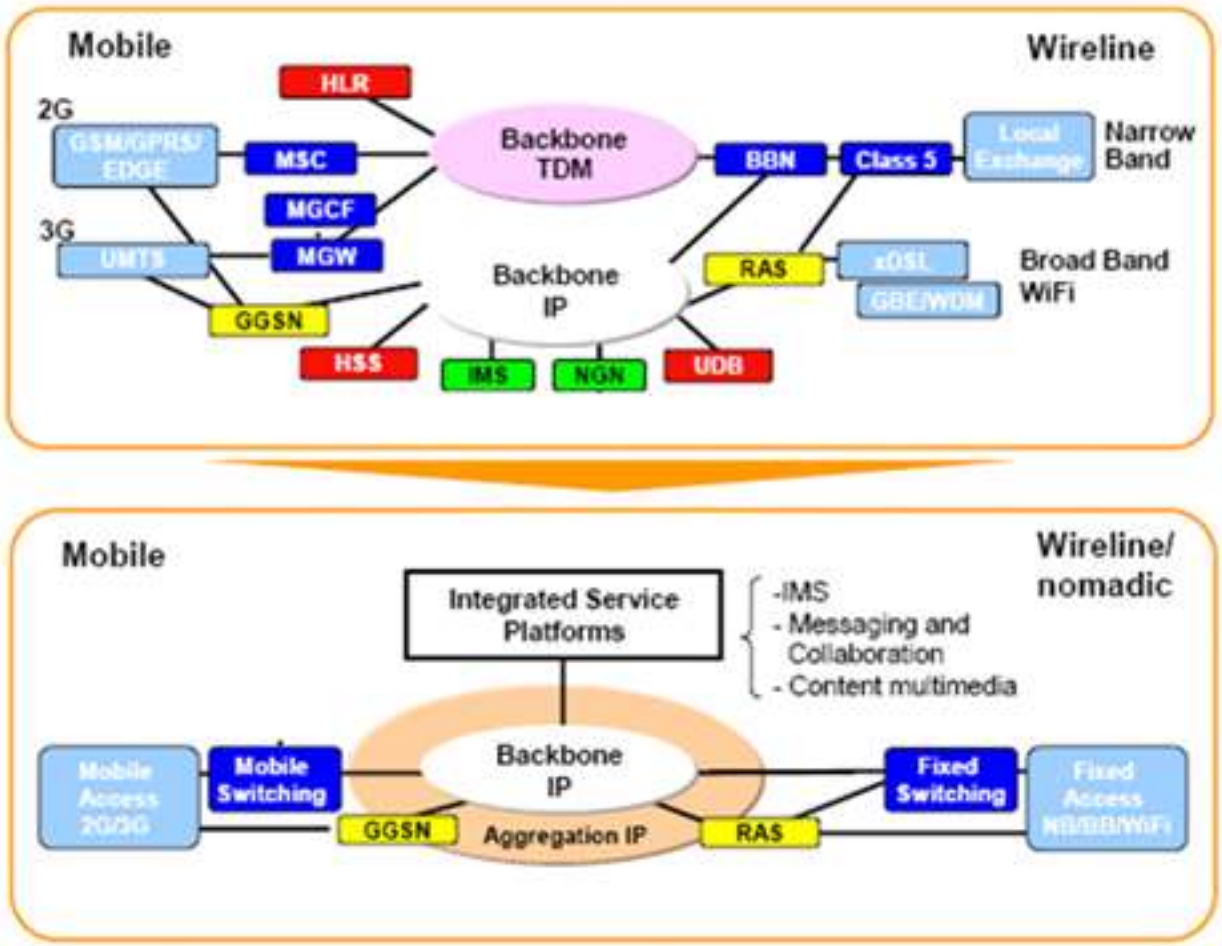
Mobile Backhaul Challenges

- **Support of Multi-Technology over Transport Network.**

Mobile (2G, 3G, LTE), Enterprise, Consumer Services

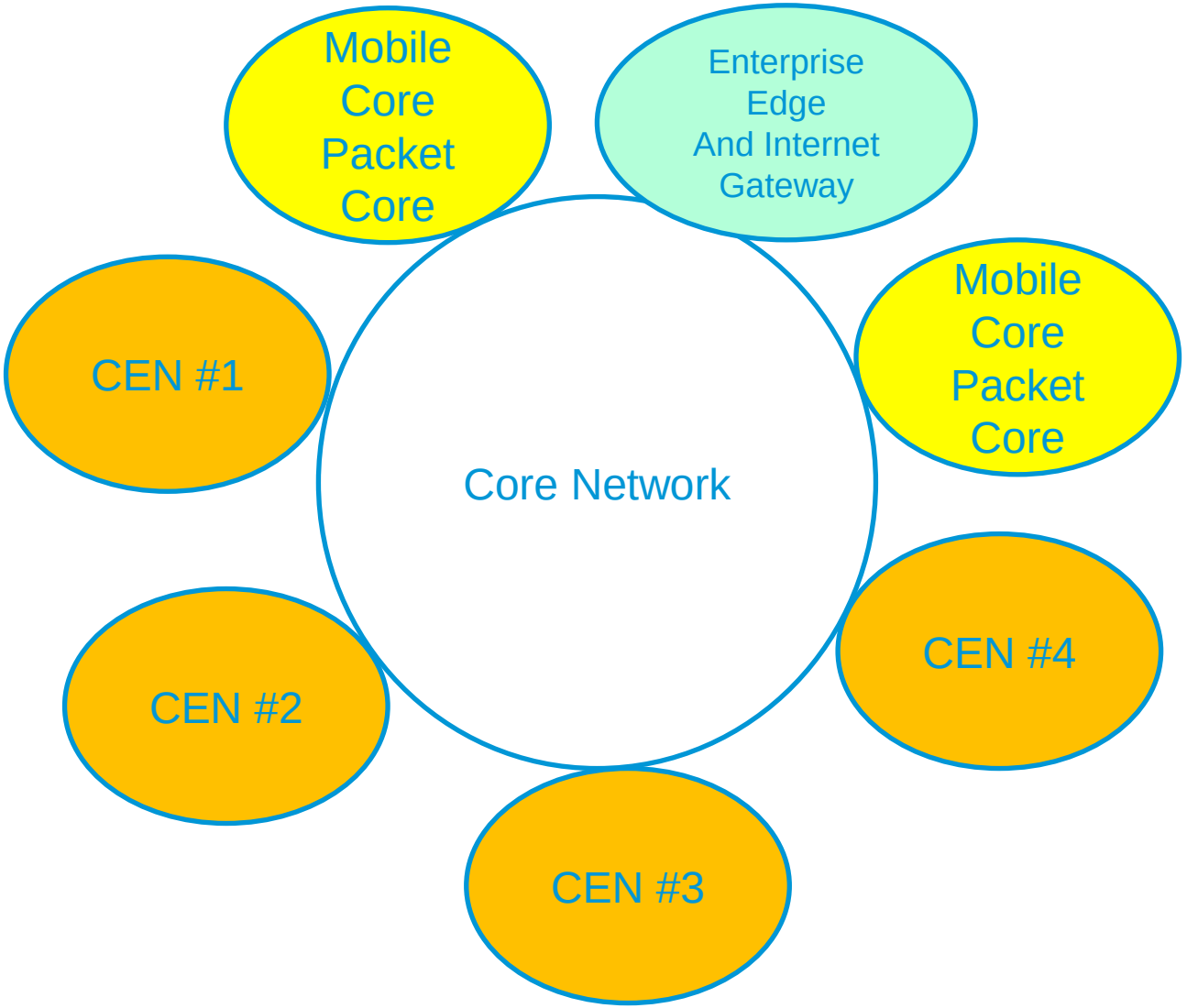
- **High Cost of backhaul Network**
- **Mobile bandwidth is growing exponentially – while revenues are decreasing.**
- **SDH based network is having lack of scalability for growing BW needs with low Capex.**
- **Availability of fiber Urban and rural areas and cost-effective backhaul solutions.**
- **Backhaul Network capacity is limiting the growth/expansion**

Single Transport Network for Fixed and Mobile Services

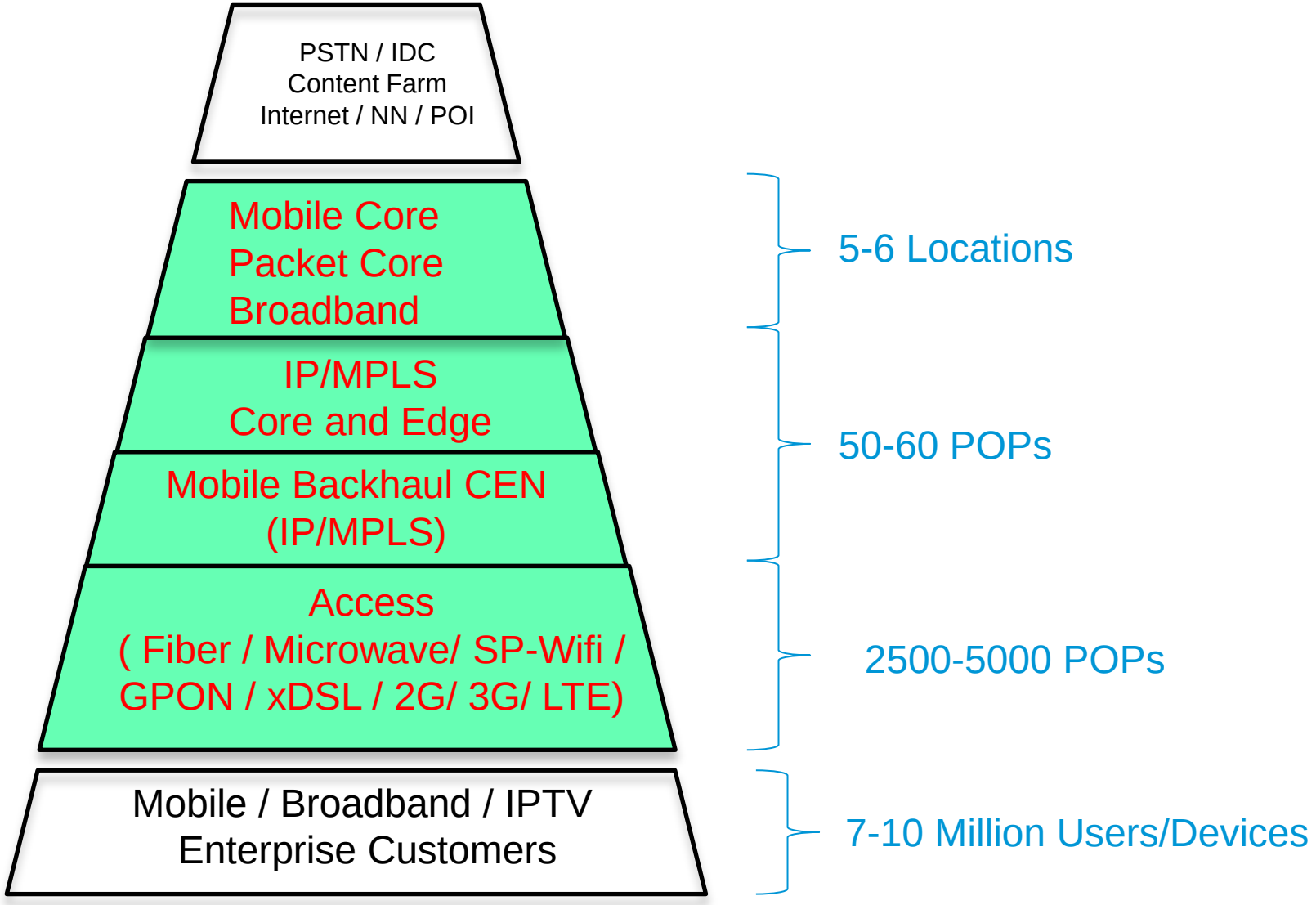


Source: Infonetics Research and Telecom Italia

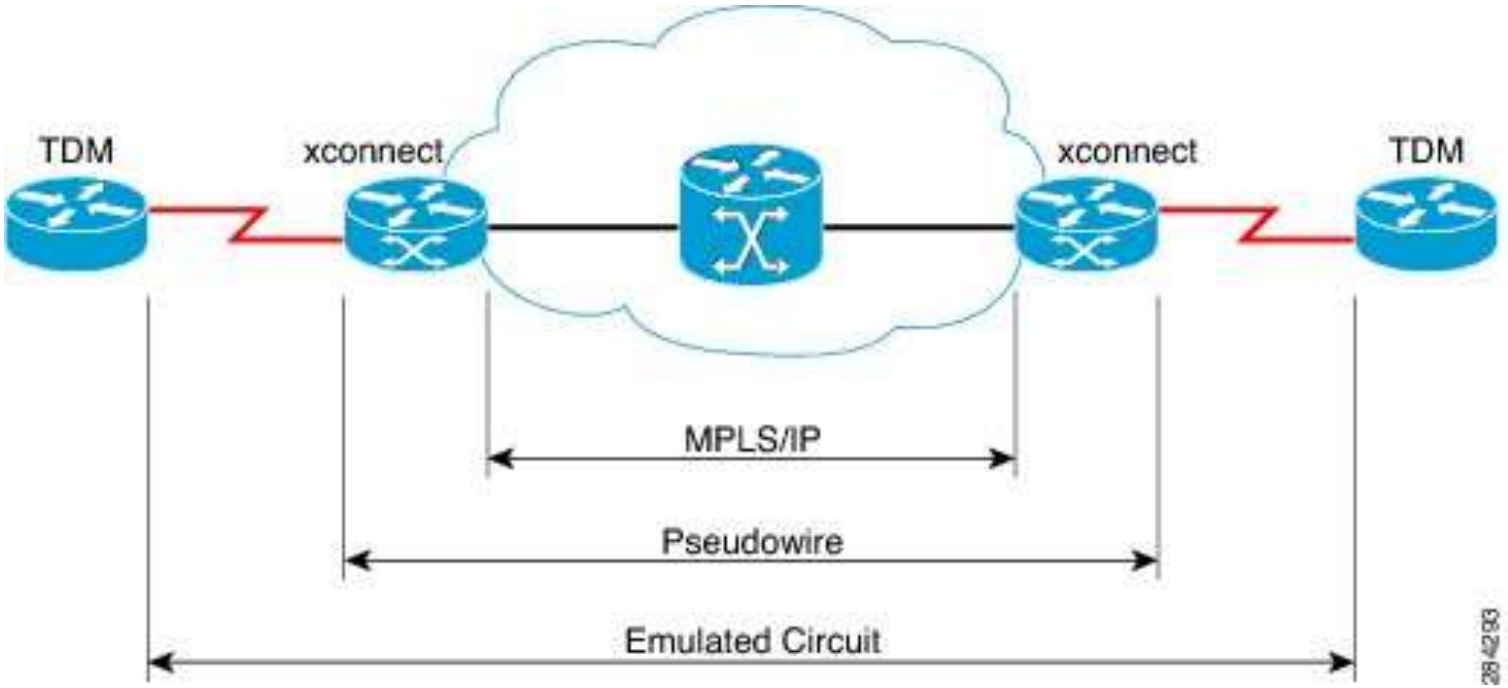
High Level Network Architecture



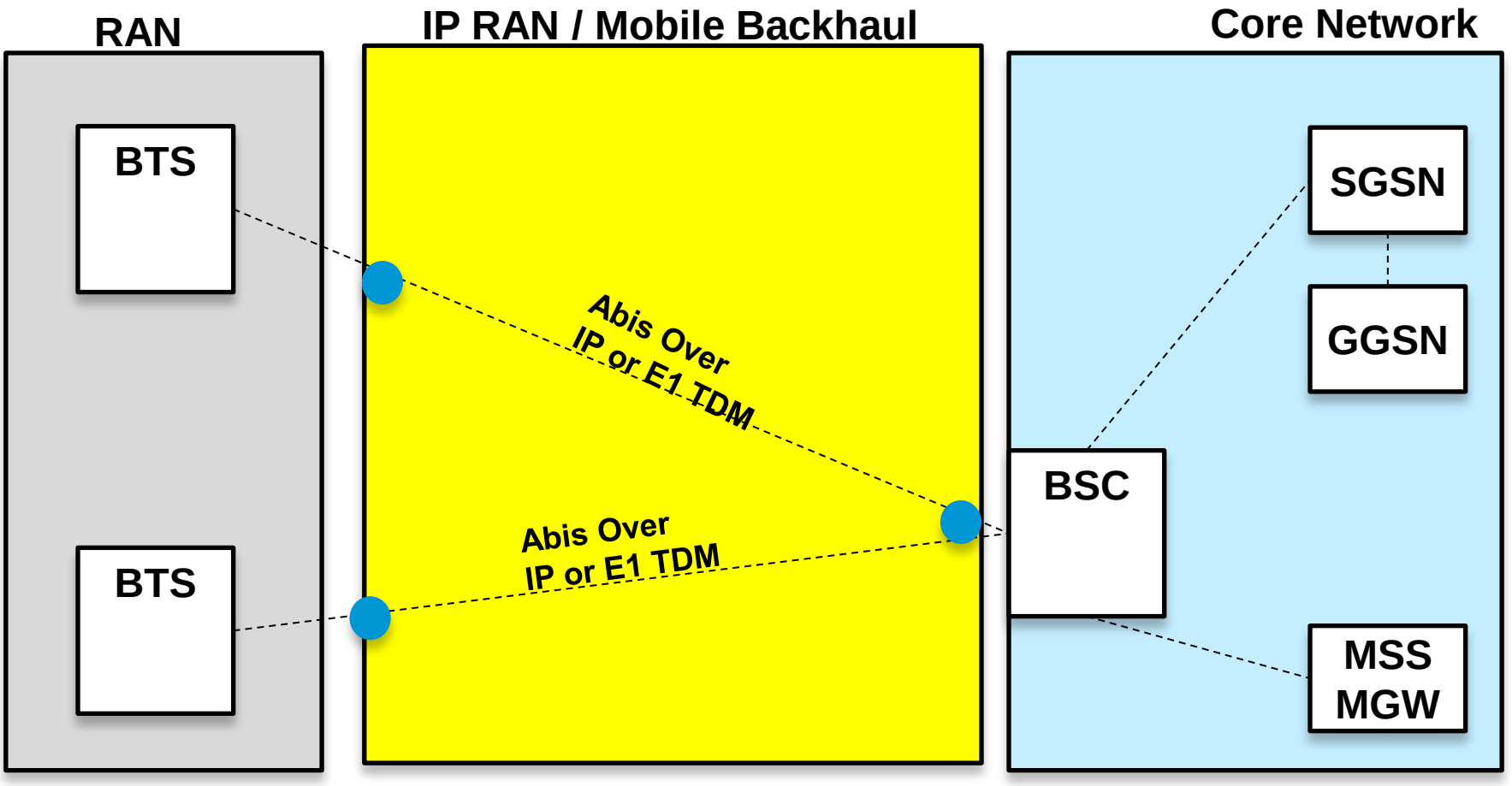
Consolidation and Transformation



SATOP and CESOP for TDM Services over packet Network

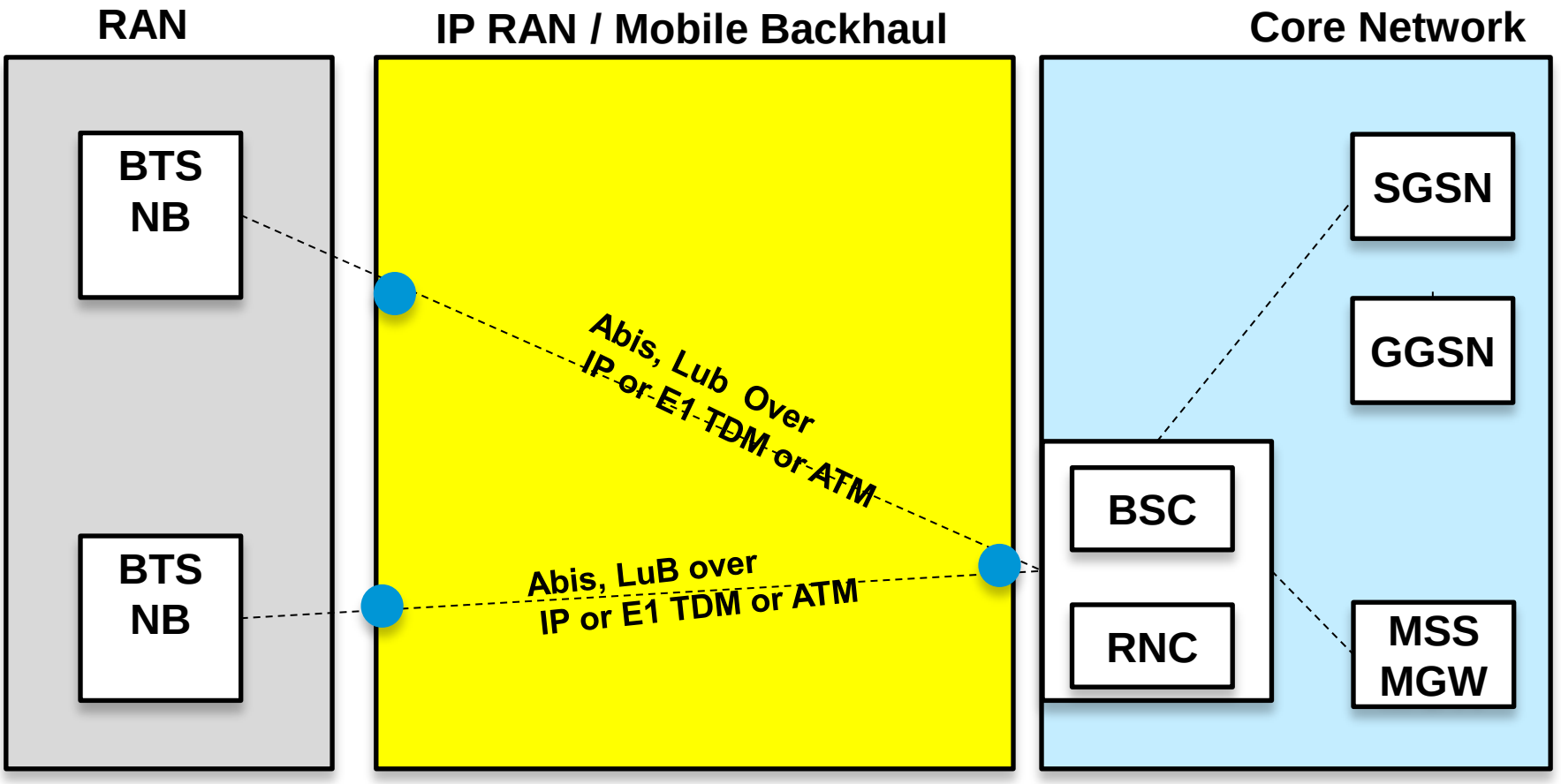


GSM Backhaul Architecture



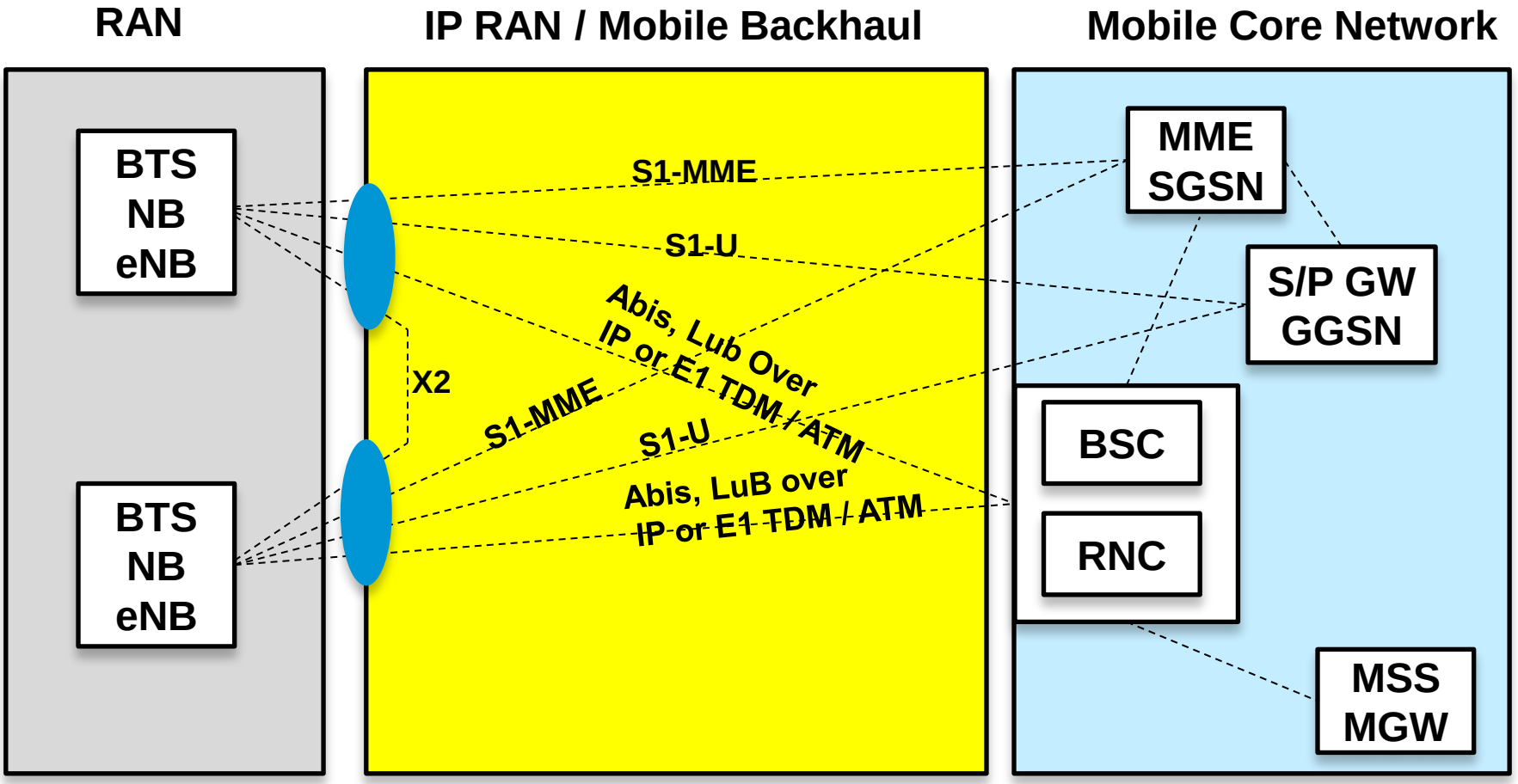
TDM over MPLS

GSM and UMTS Backhaul Architecture



TDM over MPLS
MPLS Layer-2 / Layer-3 VPN

GSM / UMTS/LTE Backhaul Architecture

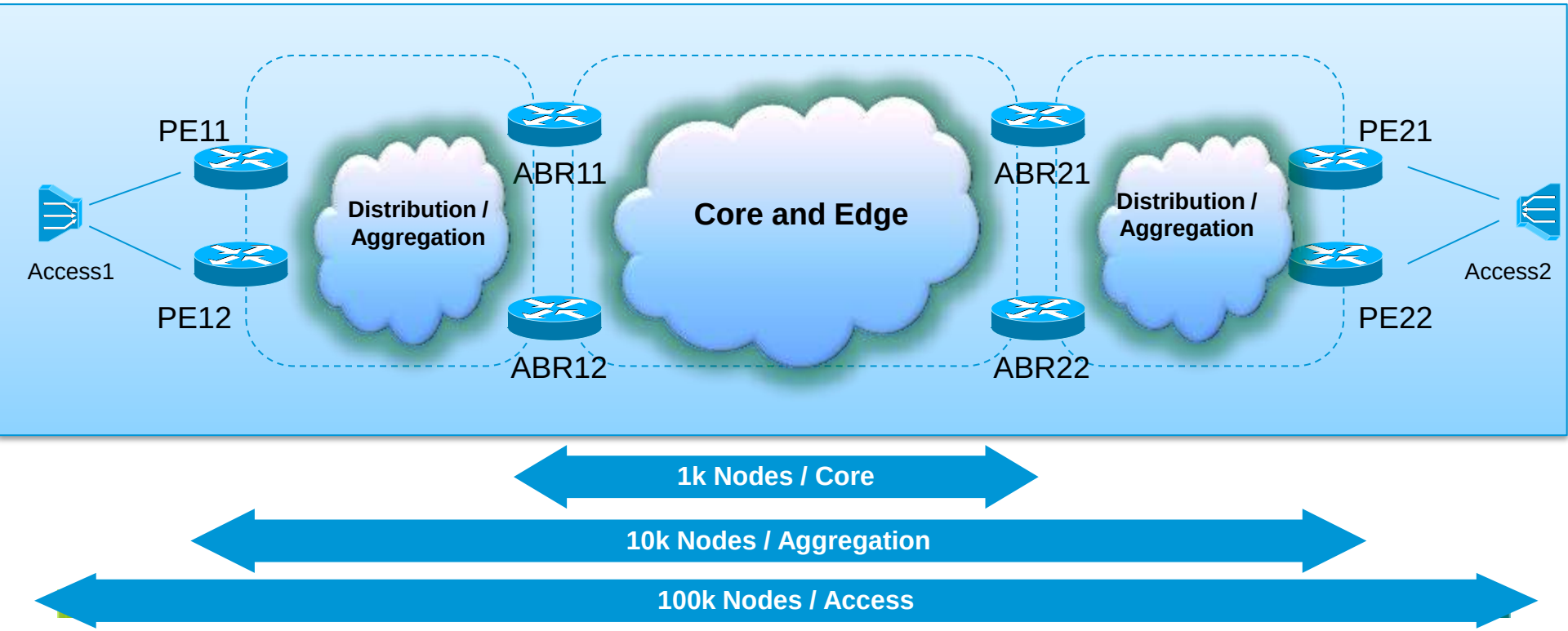


- TDM (SATOP/CESOP) over MPLS PW
- E-LAN, E-Line, E-Access, E-Tree Services
- Layer-3 VPN

Large Scale Packet Transport Network Design (UMMT)

Unified MPLS Design Goals & Reference Model

- Scale - Interconnect 100k Access nodes through an MPLS domain
- Resilience - Faster convergence as often as possible
- Service Provisioning Simplicity - Lower number of operational points without PW-stitching
- Operational Simplicity - Operation of big MPLS networks is often considered difficult



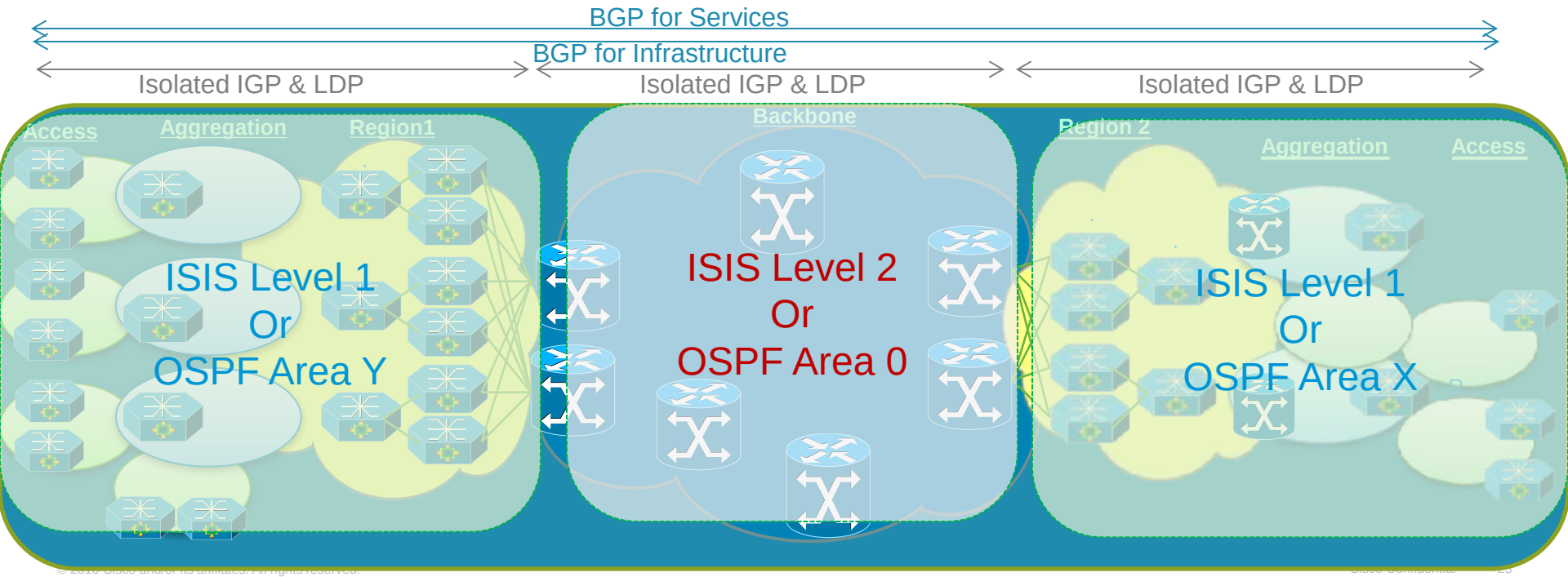
What is Unified MPLS?

Classical MPLS with few Additions

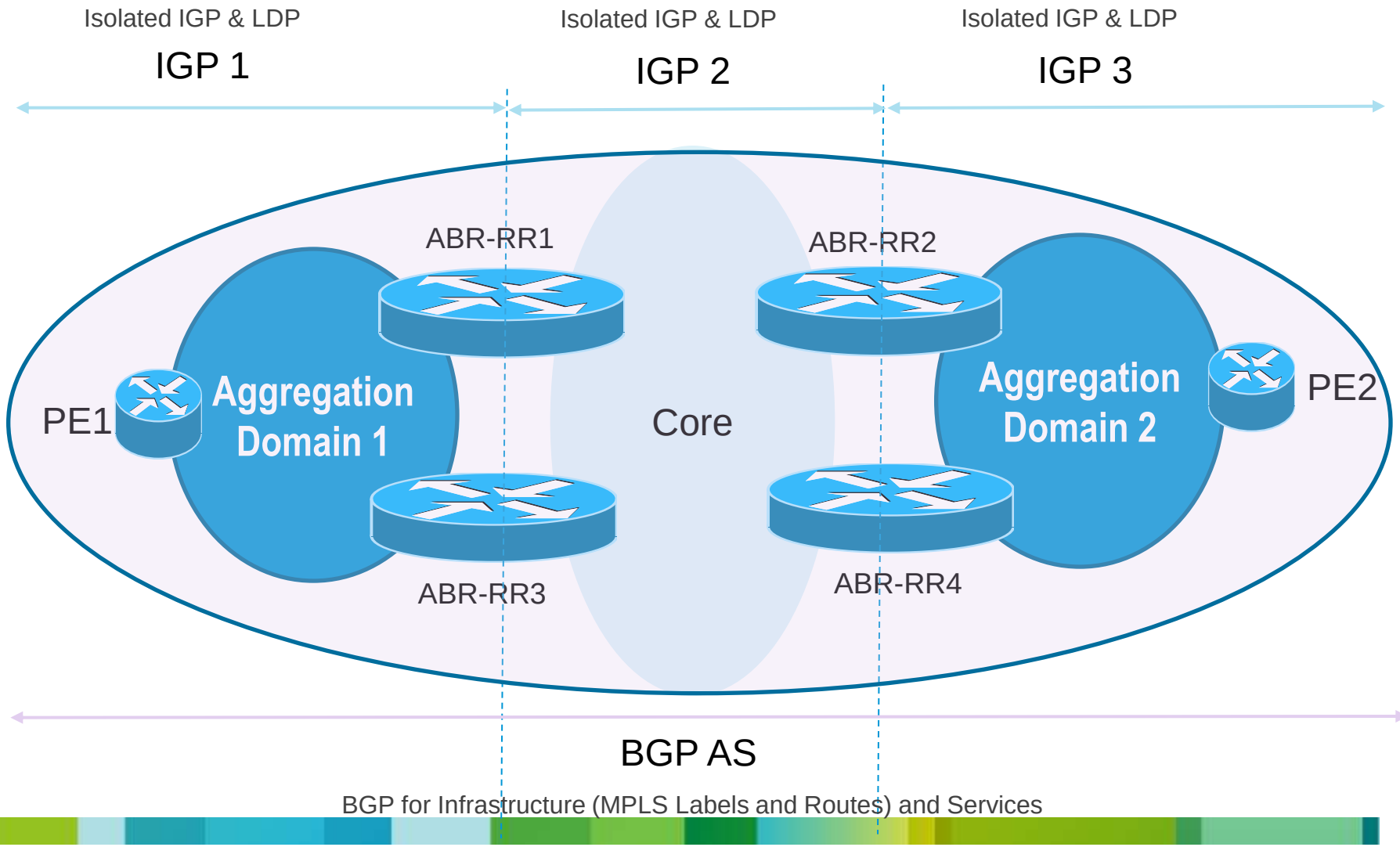
- Common MPLS technology from Core, Aggregation, Pre-agg and *potentially* in the access
- RFC 3107 label allocation to introduce hierarchy for scale
- Loop Free Alternates FRR for fast convergence with no configuration required (LFA FRR & Remote LFA FRR)
- BGP Prefix Independence Convergence to make the 3107 hierarchy converge quickly

Scalability through ‘Divide & Conquer’

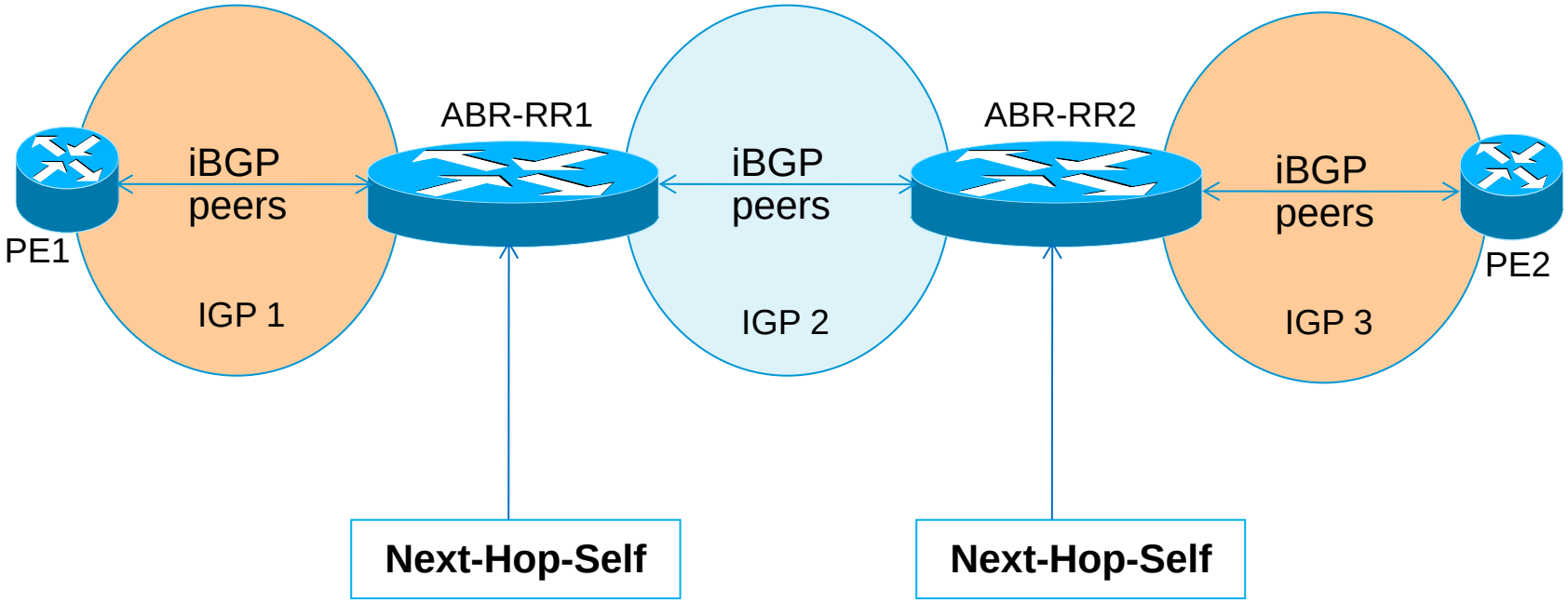
- Disconnect & Isolate IGP domains
  - No more end-to-end IGP view
- Leverage BGP for infrastructure (i.e. PE) routes
  - Also for infrastructure (i.e. PE) labels



Unified MPLS High-level View

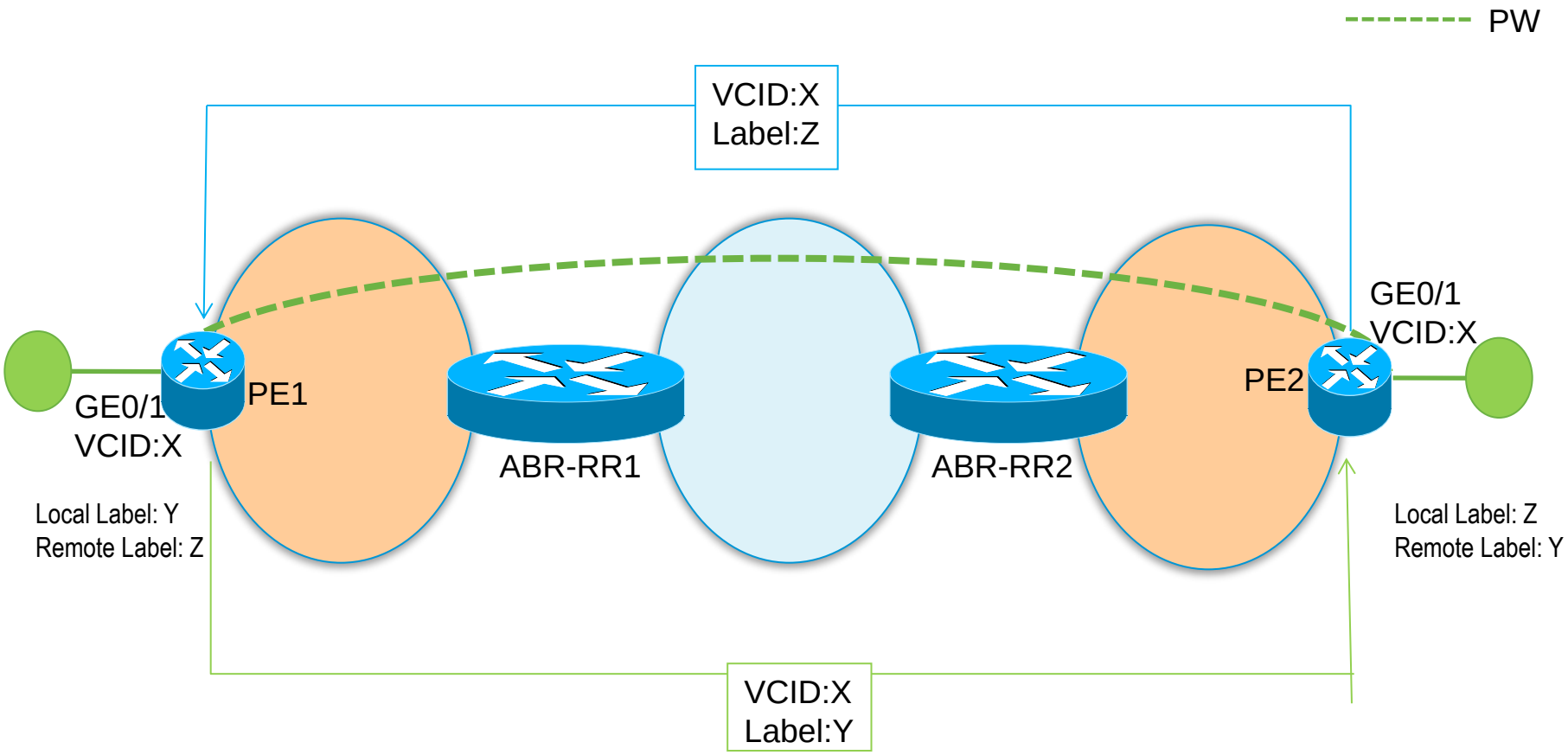


iBGP Peering between Access and Aggregation



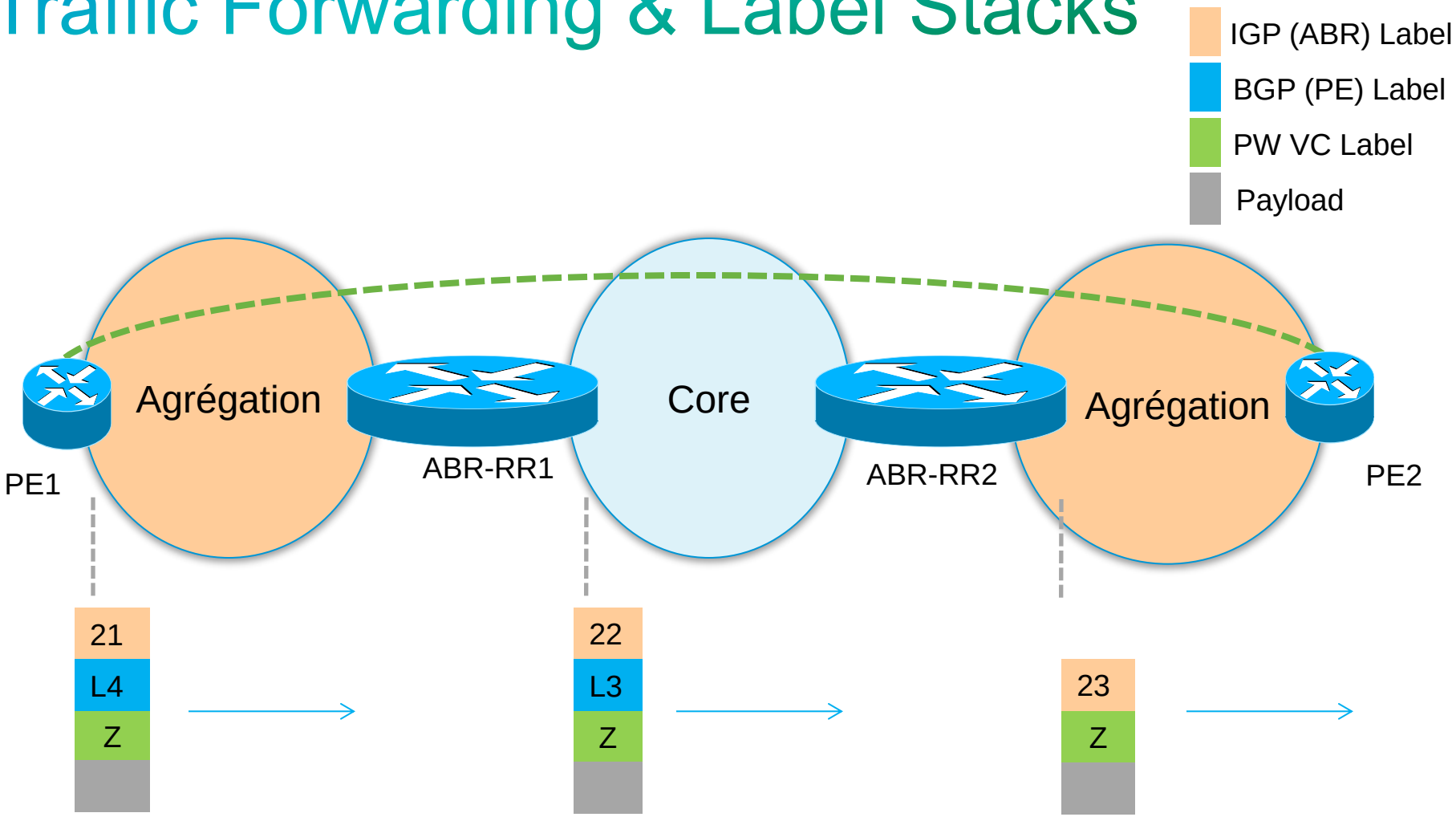
- ABRs are also Route Reflectors
- PEs in the same segment peer with ABR-RRs
- RRs are inserted in data path by setting next-hop-self

L2VPN Circuit Establishment



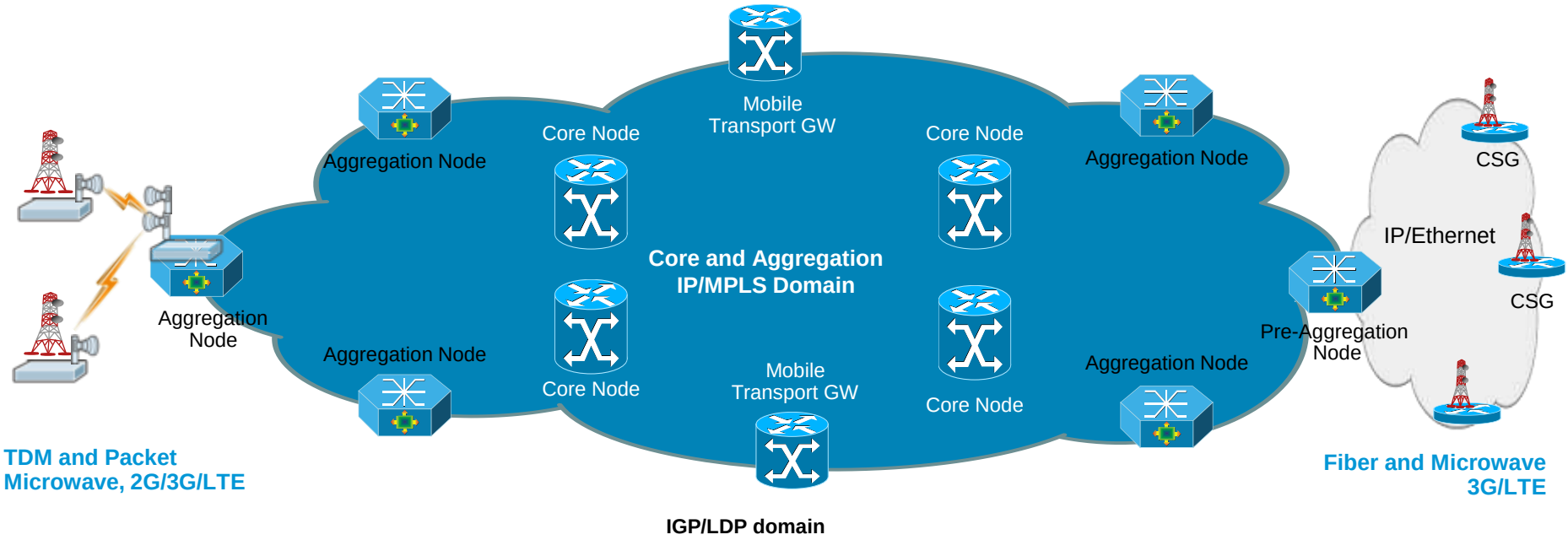
- PE1 and PE2 exchange PW Virtual Circuit labels as usual – i.e. LDP-based signaling

Traffic Forwarding & Label Stacks



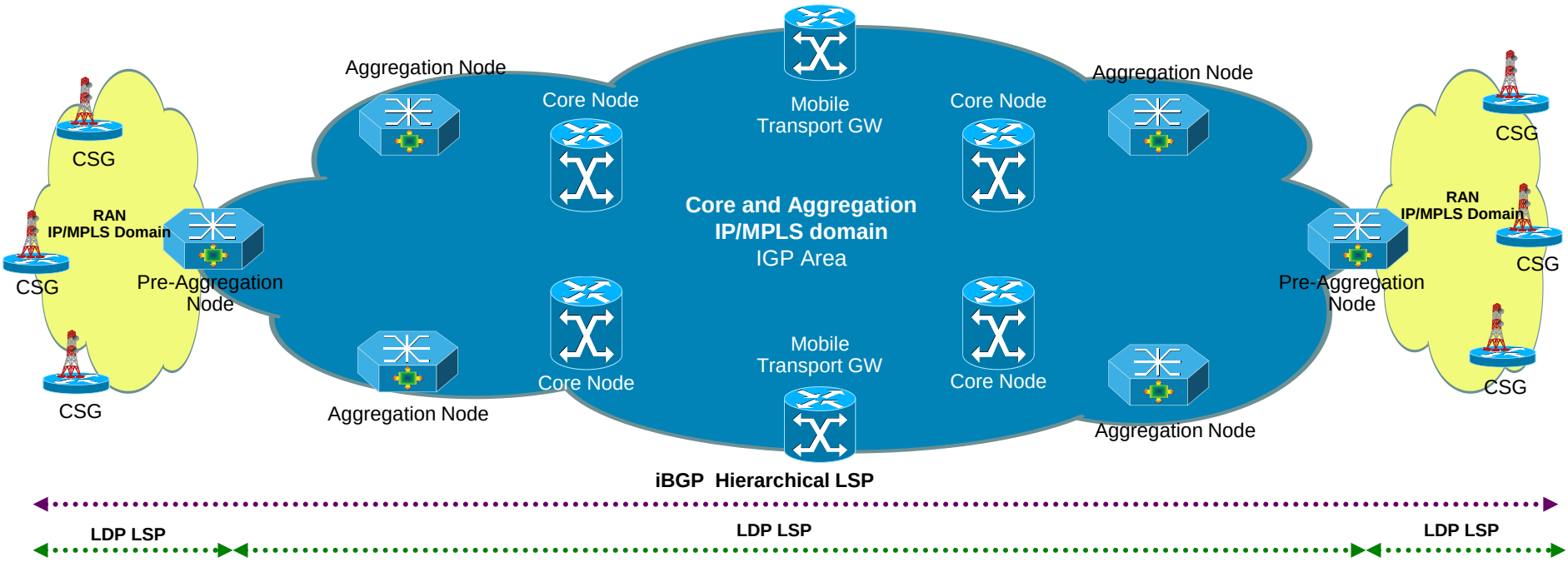
- LDP labels used to reach core ABRs
- BGP labels used to reach remote PEs
- Egress PE pops PW VC label

Flat LDP LSP across Core and Aggregation Networks



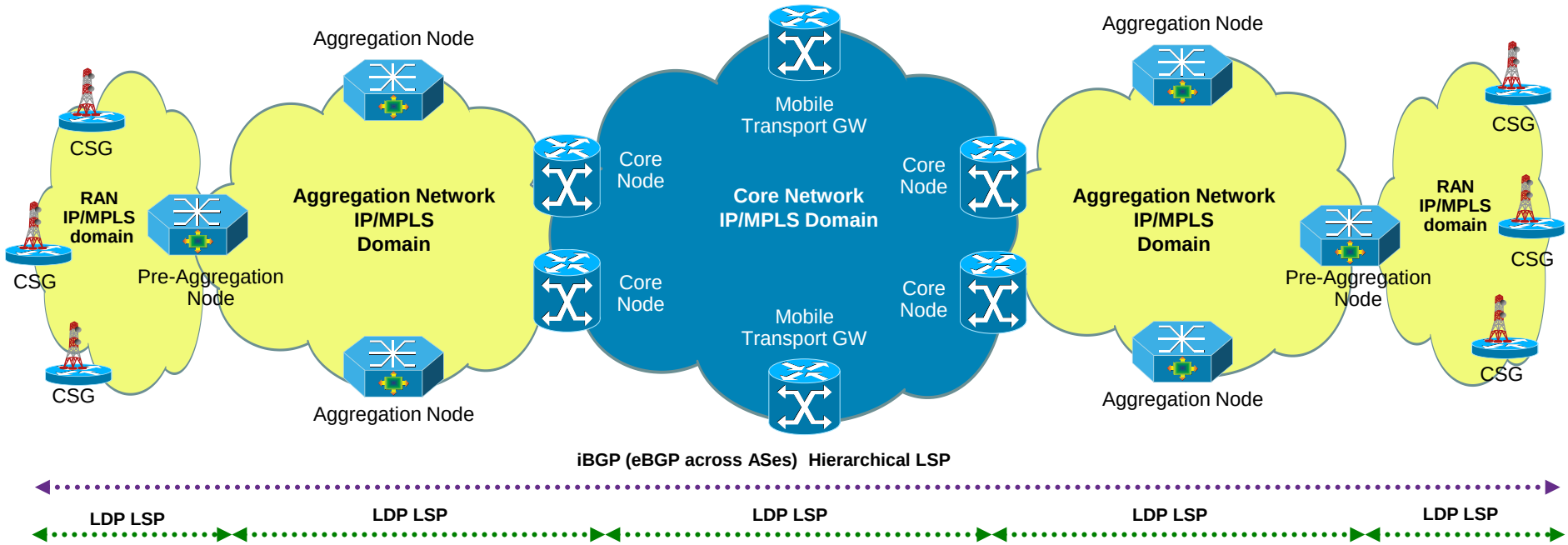
Upto 1000 Nodes

Hierarchical BGP LSP Across Core + Aggregation and Access Networks



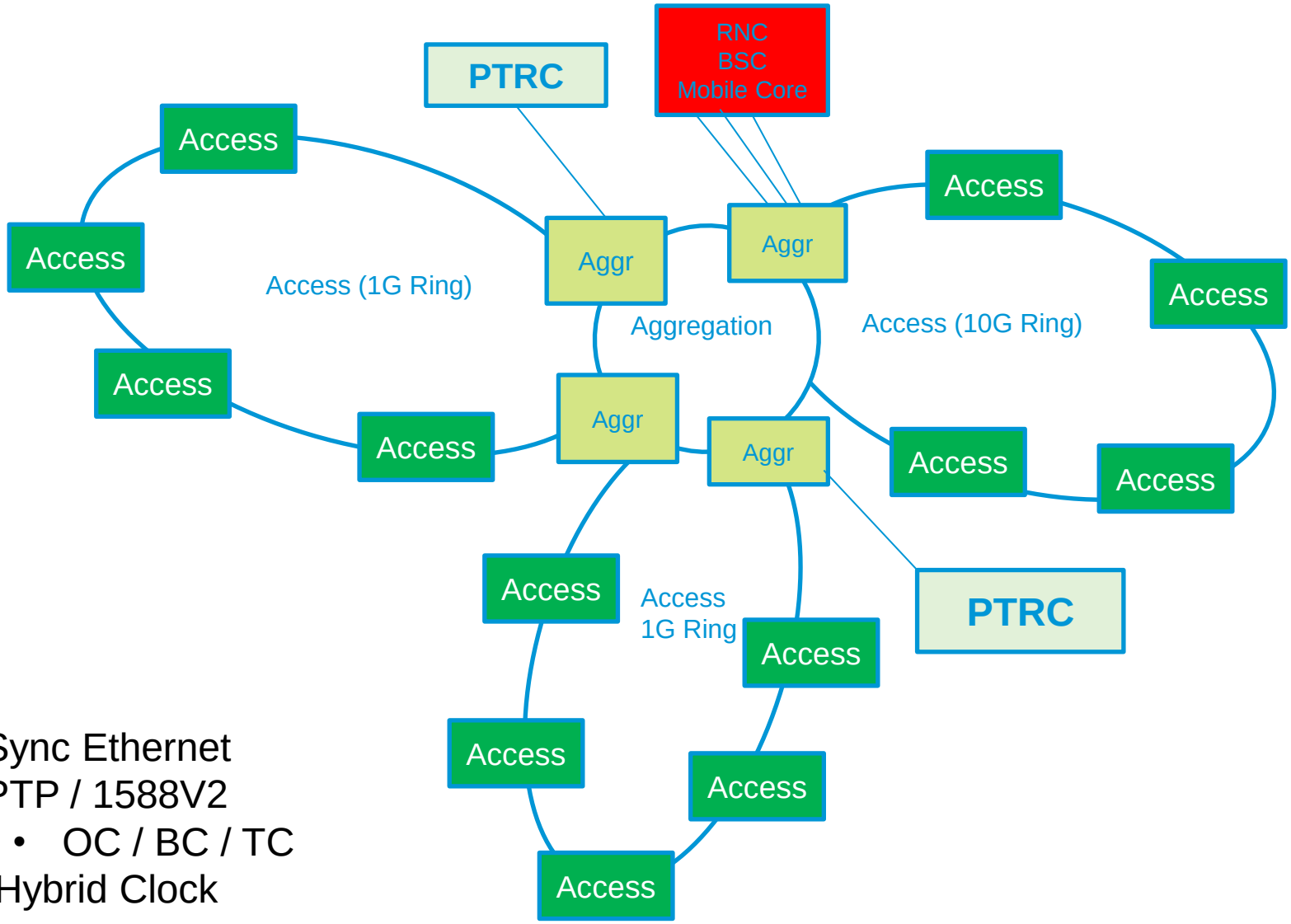
Access+Aggregation: 1000 Nodes
Upto 20K Access Nodes

Hierarchical BGP LSP Across Core, Aggregation and Access Networks



100K nodes and beyond

Clocking and Synchronization



- Sync Ethernet
- PTP / 1588V2
  - OC / BC / TC
- Hybrid Clock

High Availability

Fast Convergence

- Many Options
  - LDP convergence related Parameters
  - IGP Fast Convergence Parameters
  - Pro-active protection with OTN Framing
  - Failure Deduction - BFD and/or LOS
  - TE FRR
  - RLFA FRR
  - BGP PIC – Core / Edge

Summary

- Cost per Bit is lower with Ethernet Network
- Build one converged packet based transport Network that can carry TDM and Packet Services
- Multi-Technology backhaul - 2G, 3G, LTE , Enterprise and consumer Services (IPTV)
- High Capacity (1G / 10G / 40G / 100G)
- Large Scale (100K nodes and beyond)
- Fast Convergence
- Clocking and Synchronization over Packet Network
- Unified MPLS Design based on Standard based (RFC 3107)

Thank you.