Next generation transport network - Carrier Ethernet

Mobile Backhaul / Consumer Broadband / Enterprise Services

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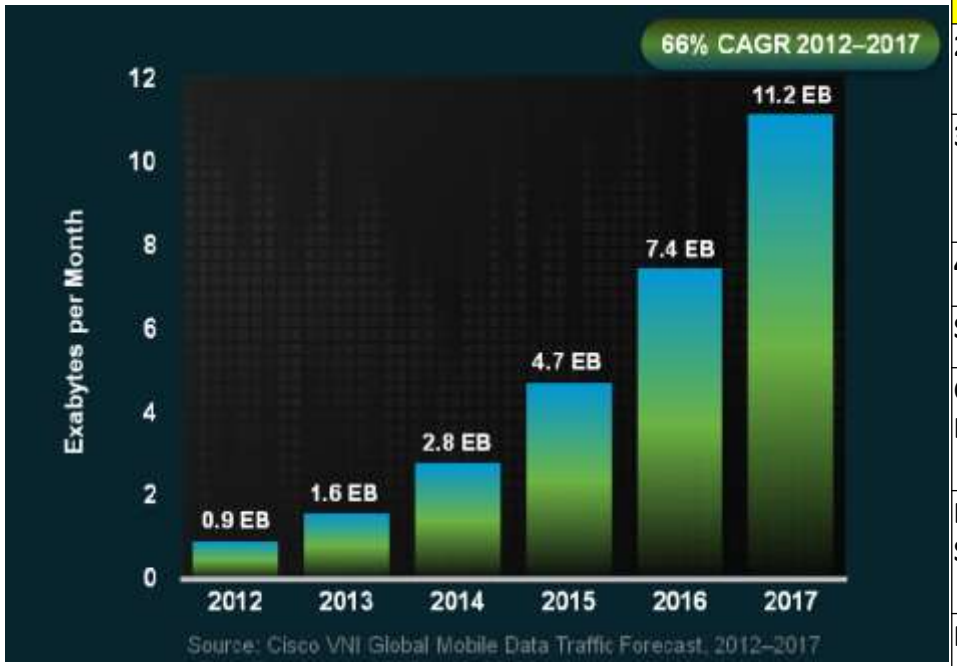
Agenda

- Evolution and Trends in Mobile Networks
- Mobile Backhaul with Unified MPLS
  - Unified MPLS introduction and architectures
  - 2G/3G, LTE Backhaul Services
  - Synchronization
  - Fast Convergence
- Consumer Broadband Services
- Enterprise Services
- Summary

Backhaul Network Challenges

- **Support of Multi-Technology over Transport Network. Mobile (2G, 3G, LTE), Enterprise, Consumer Services**
- **SDH based network is having lack of scalability for growing BW needs with low Capex. High Cost of backhaul Network**
- **Large Scale**
- **Fast Convergence**
- **Quality of Service**
- **Frequency Synchronization and Phase Synchronization**
- **Backhaul Network capacity is limiting the growth/expansion**

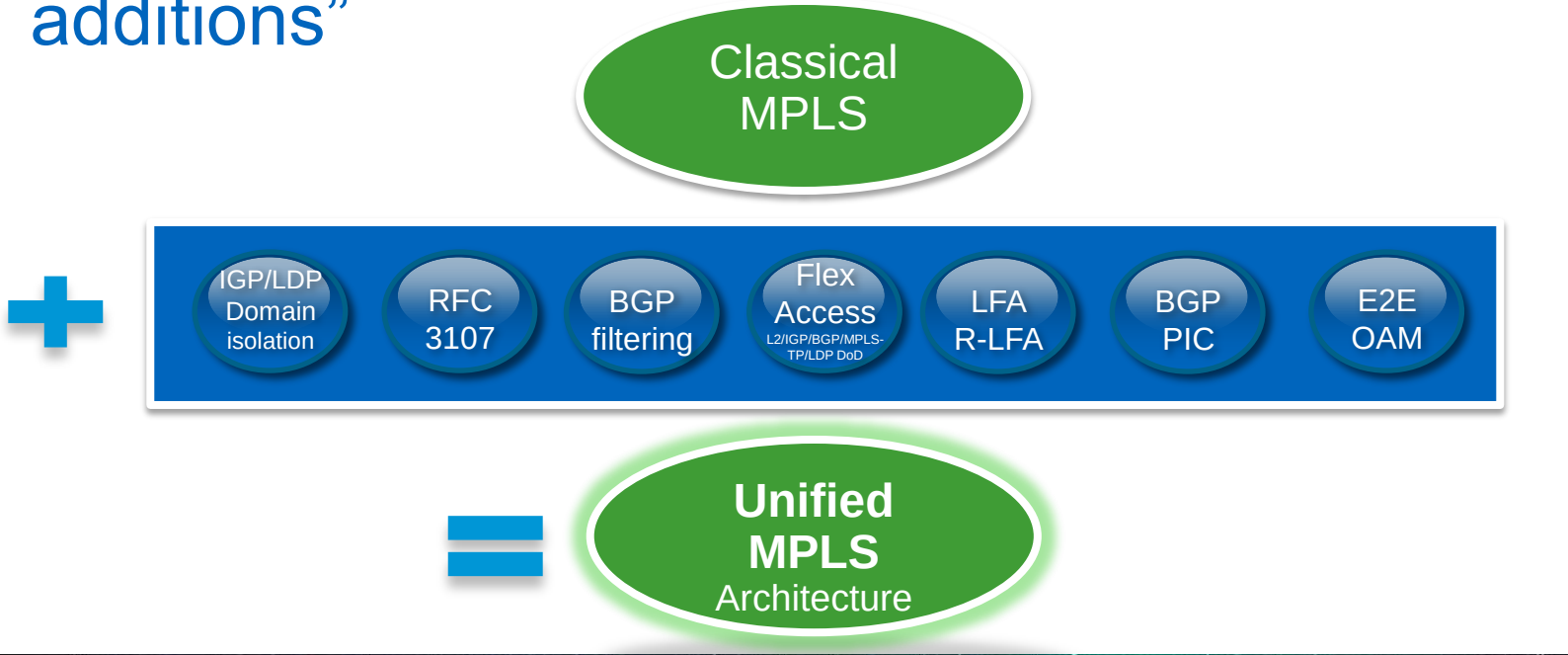
Metro Ethernet Backhaul Requirement



Service	Node Category	Bandwidth per Node
2G	BTS	Larger Cities 2-4 E1. Smaller Town: 1 – 2 E1
3G	NB	Voice: 1 E1 Data: 42MB in Large City 14-20MB in smaller Town
4G / LTE	eNB	100Mbps
SP Wifi	AP	4MB
Consumer Broadband	DSLAM / OLT	1G / 10G
Enterprise Service	WiMax	7MB Per Sector. No. of Sector: 3 to 4 Per Location
Microwave	Hybrid Backhaul	Vary from 25 or 50 or 400Mbps

Mobile Backhaul with Unified MPLS

"**Unified MPLS**…classical MPLS with a few additions"



Scalability

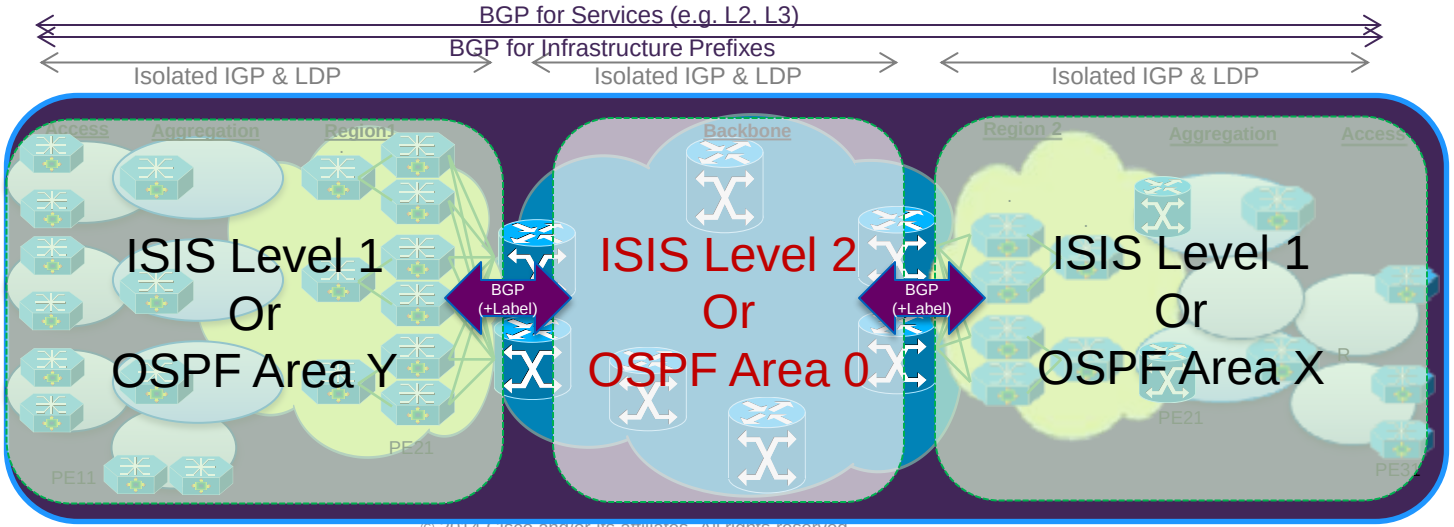
Security

Simplification

Multi-Service

Routing + MPLS Design
‘Divide & Conquer’ – Game Plan

- 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 (e.g. RFC3107)

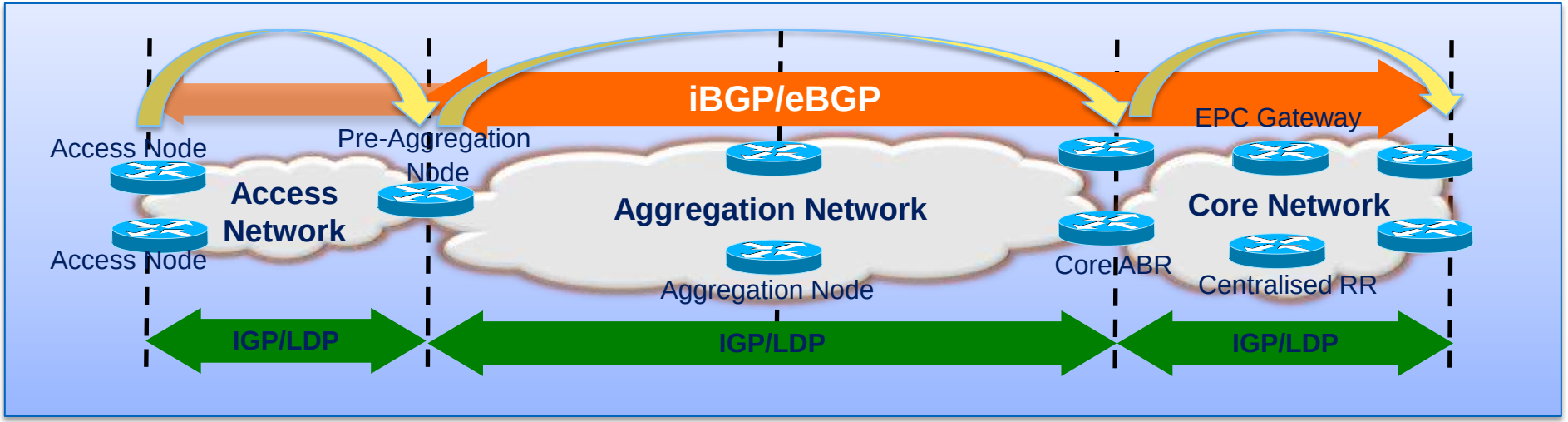


Unified MPLS Architecture (RFC 3107)

IGP/LDP Label
BGP3107 Label
Service Label

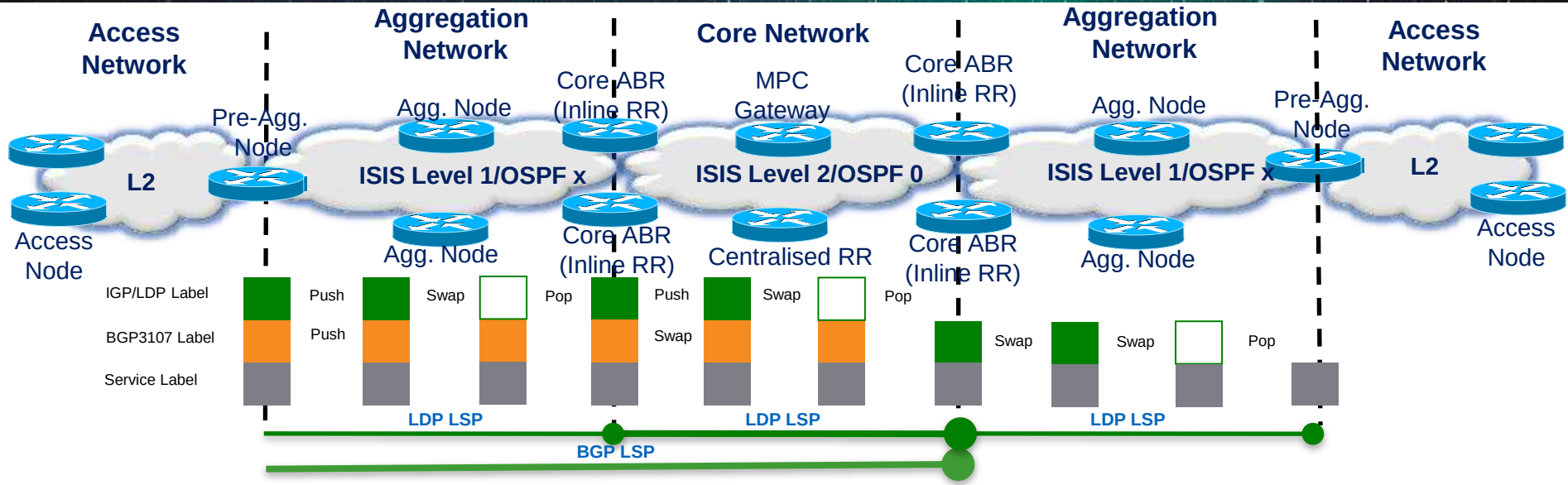
U-MPLS

Classical MPLS



Sample E2E Unified MPLS Architecture

Routing Isolation and Label Stack for LSP between Pre-Agg. Node Loopbacks

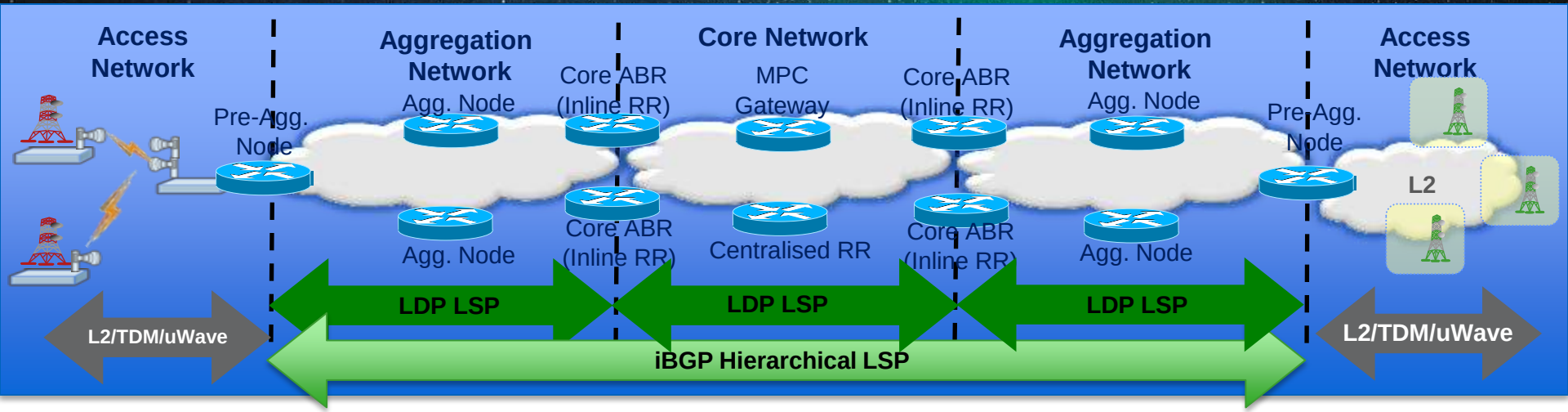


No IGP route is propagated from Aggregation to the Core. IGP area has routes for that area only plus routes to core ABRs. Only the core ABR's are propagated from L2 to L1

- LDP labels are used to traverse each domain and reach core ABRs
- BGP labels are used by Labeled BGP PEs & ABRs to reach Labeled BGP PEs in remote areas
- Service (e.g. PW) labels are used by Label BGP PEs

Unified MPLS Model 1

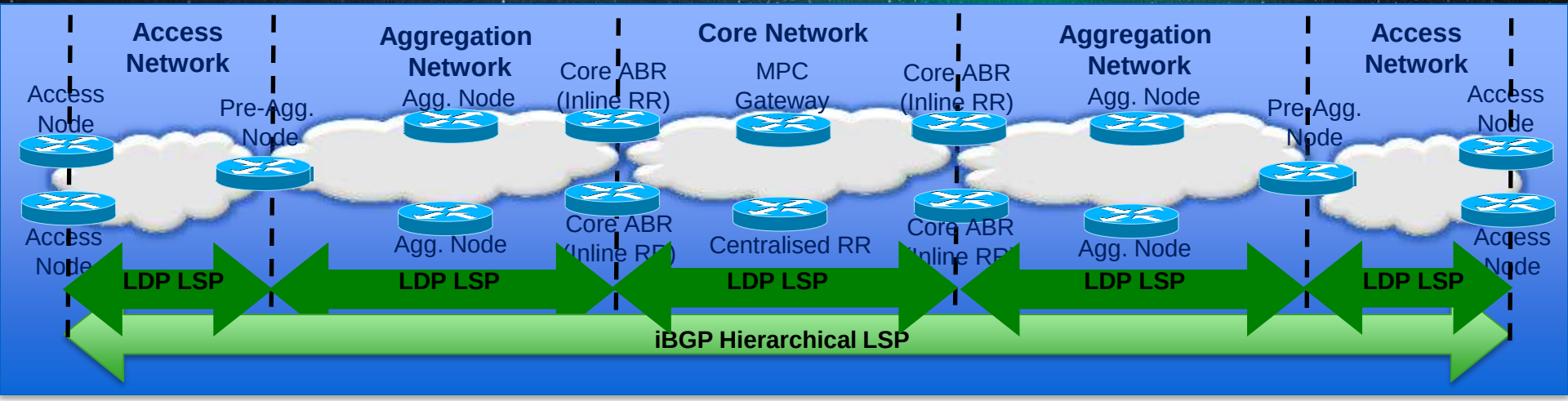
MPLS support in the Core, Aggregation with TDM, uWave or L2 in the access



- The Mobile Core and Aggregation Networks enable Unified MPLS Transport
- The Core and Aggregation Networks are organized as independent IGP/LDP domains
- The network domains are interconnected with hierarchical LSPs based on RFC 3107, BGP IPv4+labels. Intra domain connectivity is based on LDP LSPs
- The Aggregation Node enable Mobile and Wire line Services. The Mobile RAN Access is based on TDM, Packet Microwave or pt-to-pt L2 connectivity

Unified MPLS Model 2

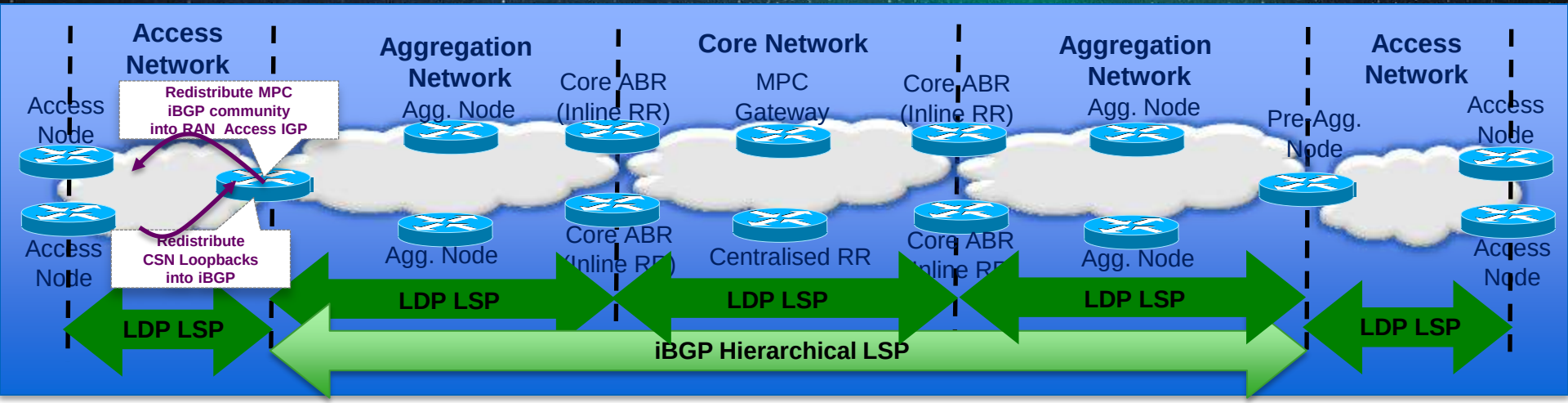
MPLS support in the Core, Aggregation and Access Network



- The Mobile Core, Aggregation, Access Network enable Unified MPLS Transport
- The Core, Aggregation, Access are organized as independent IGP/LDP domains
- The network domains are interconnected with hierarchical LSPs based on RFC 3107, BGP IPv4+labels. Intra domain connectivity is based on LDP LSPs
- The Access Network Nodes learn only the required labelled BGP FECs, with selective distribution of the MPC and potentially neighbouring RAN labelled BGP communities

Unified MPLS Model 3

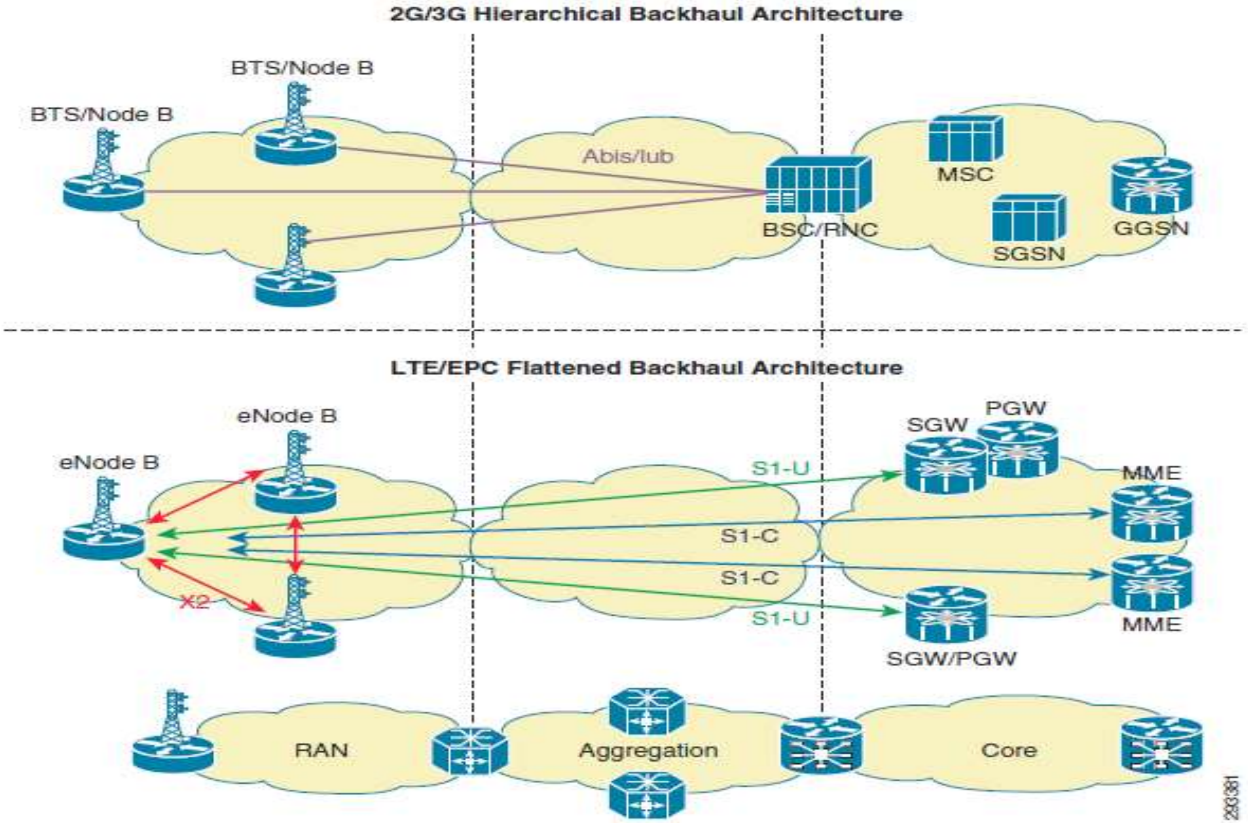
MPLS in the Core, Aggregation with IGP/LDP in the access



- The Core and Aggregation are organized as distinct IGP/LDP domains
- Inter domain hierarchical LSPs based on RFC 3107, BGP IPv4+labels which are extended out to the Pre-aggregation
- Intra domain LSPs based on LDP
- The inter domain Core/Aggregation LSPs are extended in the Access Networks by distributing the RAN IGP into the inter domain iBGP and distribute the necessary labelled iBGP prefixes (MPC gateway) into RAN IGP (via BGP communities)

Unified MPLS Service Infrastructure

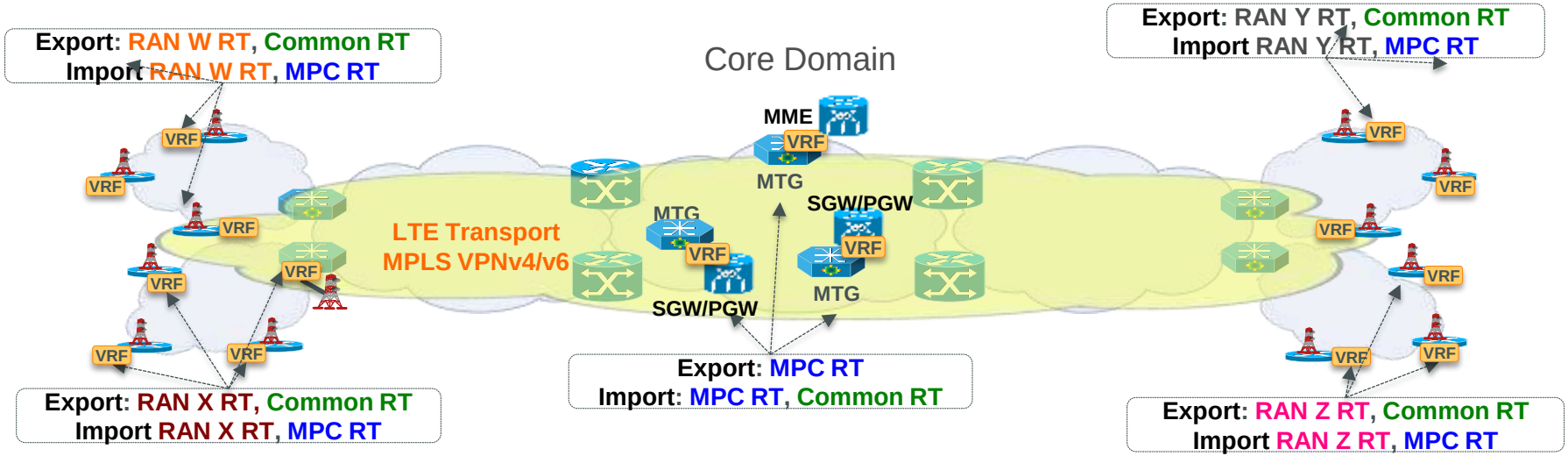
Mobile Backhaul – Services Requirement



LTE MPLS VPN Service

Scale Control for S1 and X2 communication

LTE

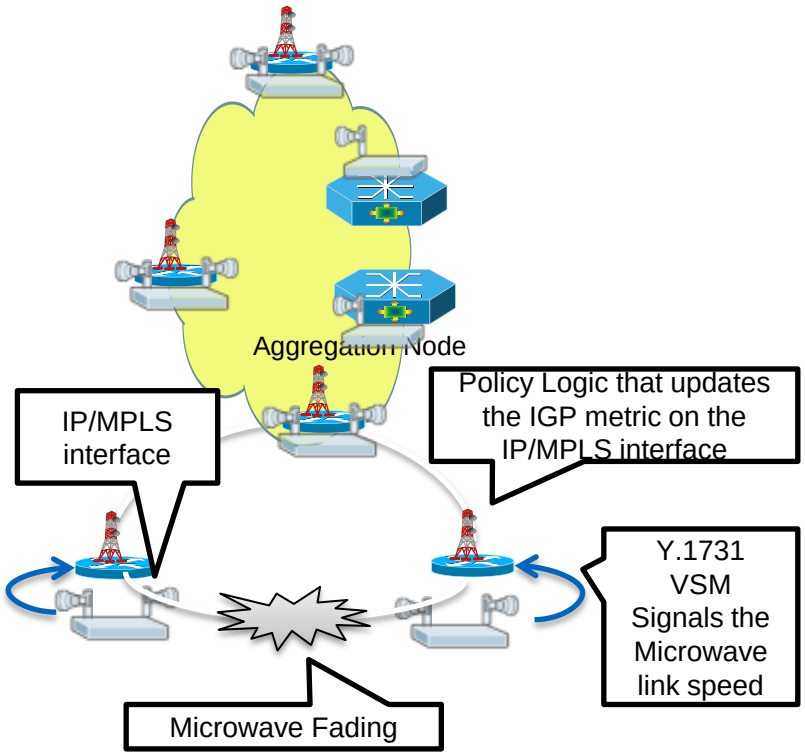


- Unified MPLS transport with a common MPLS VPN for LTE S1 from all CSGs and X2 per LTE region
- Mobile Transport GWs import all RAN & MPC Route Targets, and export prefixes with MPC Route Target
- CSGs (and Pre-Aggregation Node) in a RAN region import the MPC and neighboring RAN Route Targets:

Enables S1 control and user plane with any MPC locations in the core
Enables X2 across CSGs in the RAN region

Unified MPLS with Microwave Access

Integration with Microwave Adaptive Code Modulation (ACM)



- The IP/MPLS Access Network adapts intelligently to the Microwave Capacity drops
- Microwave Adaptive Code Modulation changes due to fading events are signaled through an Y.1731 VSM to the MPLS Access Node
- The MPLS Access Node adapts the IGP metric of the link to the new capacity, triggering optimized SPFs that account for the capacity drops
  - Degraded Link Cost = [n +1- n*CB/NB] * Original Link Cost
    - Where: CB = Current BW, NB = Nominal BW, n = nodes in the ring
- In addition the Access Node can change the Hierarchical QOS policy on the interface with the microwave system allowing EF traffic to survive despite of the capacity drop.

Network Synchronization

Synchronization Needs for different applications

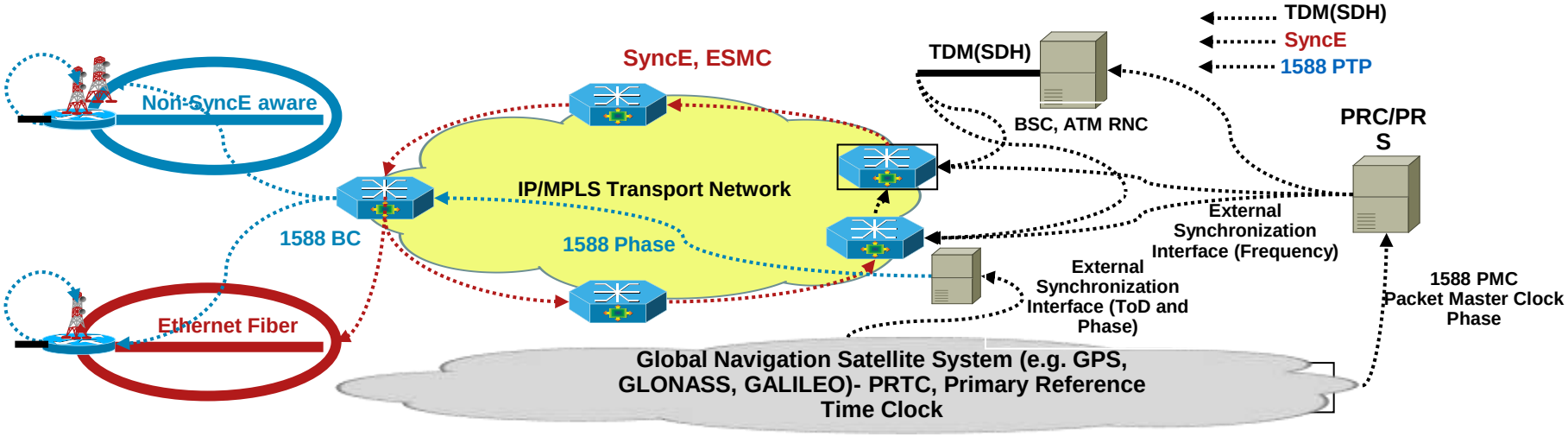
Technology	Frequency Read: better than…	Phase or Time Synchronization Read: less than…
GSM	Macro BS: ±50 ppb Pico BS: ±100 ppb	N/A
WCDMA (and LTE) FDD	WideArea BS: ±50 ppb Medium/LocalArea BS: ±100 ppb Home BS: ±250 ppb OBSAI: ±16 ppb	N/A
WCDMA TDD	WideArea BS: ±50 ppb LocalArea BS: ±100 ppb	± 2.5 µs between base stations
TD-SCDMA	WideArea BS: ±50 ppb LocalArea BS: ±100 ppb	± 3 µs between base stations
LTE TDD	WideArea BS: ±50 ppb LocalArea BS: ±100 ppb	± 3 µs between base stations May range from ±0.5µs to ±50µs
CDMA2K	Macro Cell BS: ±50 ppb Pico Cell BS and Femto Cell: ±100 ppb	ToD (UTC) sync *should* be less than 3 µs and *shall* be less than 10 µs
WiMAX Mobile	Up to ± 1 ppb Average target : ± 15 ppb	Usual values between ± 0.5µs and ± 5µs
LTE-Advanced Services	±5 ppb (CoMP)	CoMP, relaying function, carrier aggregation ± 0.5 µs [± 1 µs]
Multi-Media Bcast SFN Service	± 50ppb	± 1 µs
DVB SFN	Up to ± 1 ppb	General agreement : ± 1 µs
TDM transmission	G.823/G.824/G.8261	N/A
Network Monitoring	N/A	± 1 to 100 µs ToD synchronization for 10 µs to 1 ms measurement accuracy

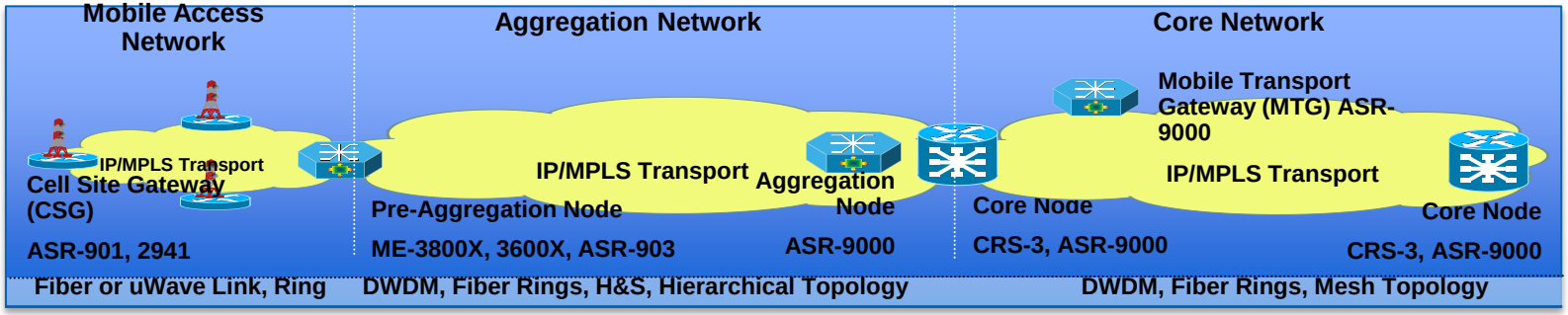
Synchronisation Requirements

Clocking Mechanisms Comparison

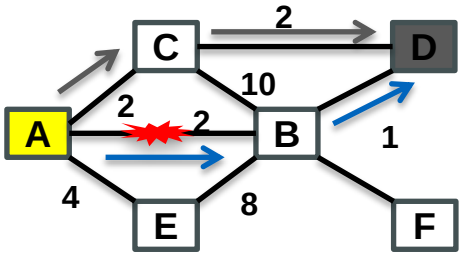
Clocking Mechanism	Advantages	Disadvantages
GPS	Reliable PRC Relatively cheap Frequency and phase	Antenna required US Govt owned
PRC/BITS	Reliable PRC Generally Available	No Phase Need to maintain TDM in all Ethernet deployment
1588-2008	Packet Based (Frequency and Phase)	Requires Master w/ PRC Performance influenced by network Undefined Profiles in SP environments
SyncE/ESMC	Physical layer (Frequency)	No Phase Every node in chain needs to support
NTPv4	Packet Based (Frequency and Phase)	Not as robust as 1588-2008 Open standard Some proprietary implementations

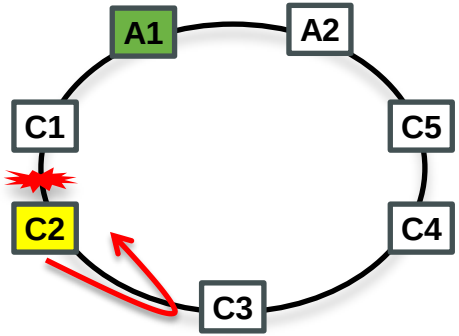
UMMT Synchronization Distribution



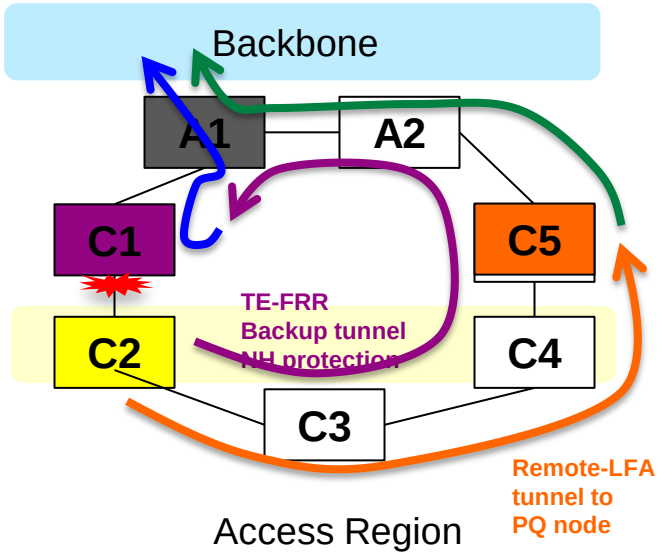


LFA FRR and Remote LFA FRR





RFC-5286 defines the baseline LFA-FRR



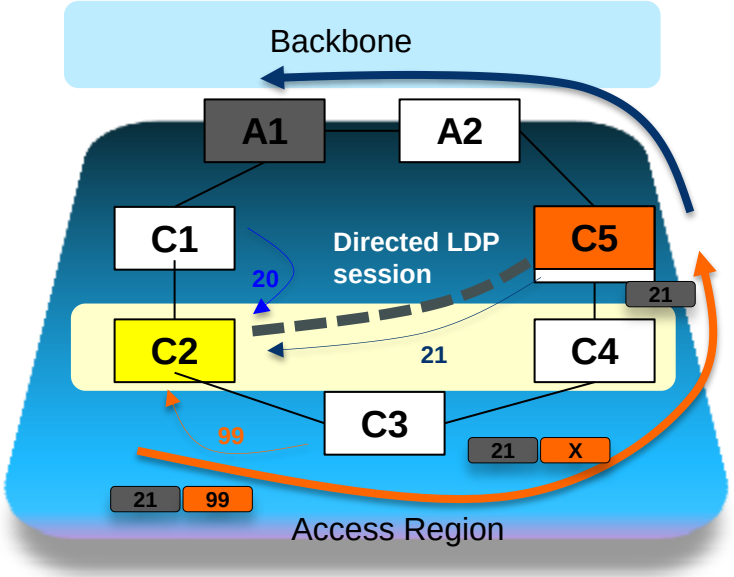
Access Region

http://tools.ietf.org/html/draft-shand-remote-lfa

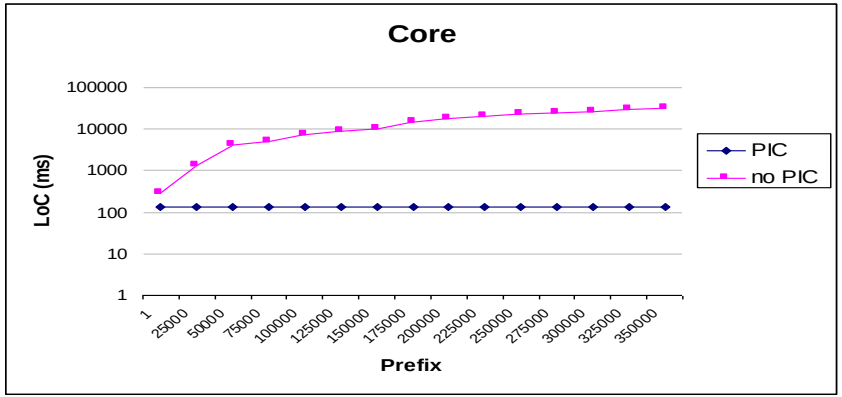
- Simple, Minimum Configuration
- No need for additional protocols overhead like (RSVP TE)
- Simpler for capacity planning then TE-FRR

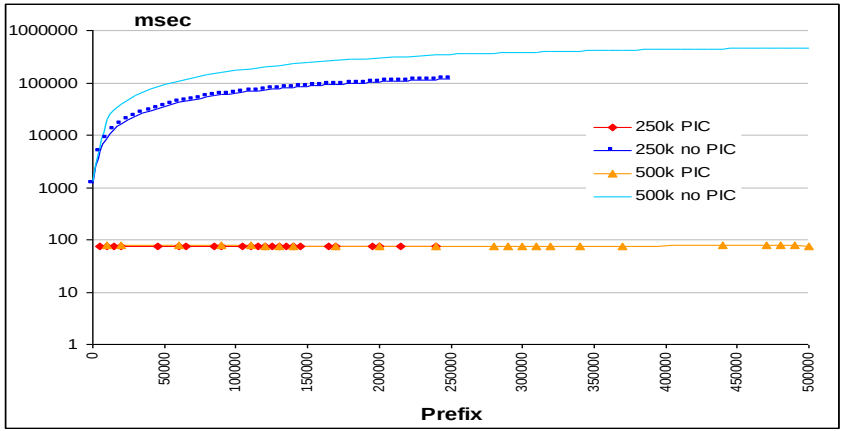
Remote LFA FRR - Protection

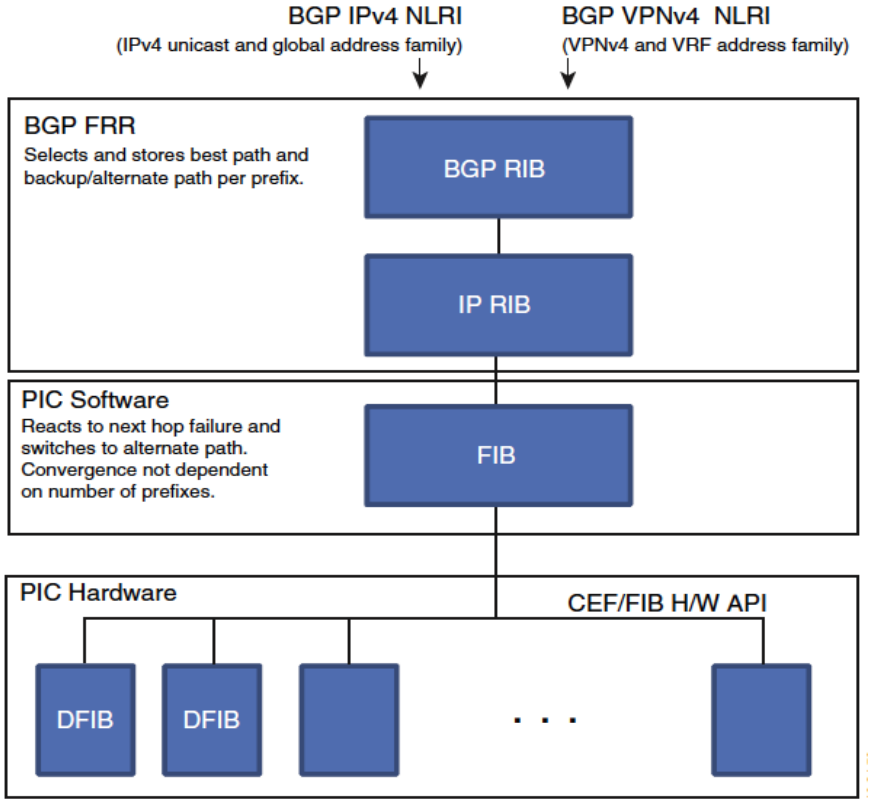
- C2's LIB
  - C1's label for FEC A1 = 20
  - C3's label for FEC C5 = 99
  - C5's label for FEC A1 = 21
- On failure, C2 sends A1-destined traffic onto an LSP destined to C5
  - Swap per-prefix label 20 with 21 that is expected by C5 for that prefix, and push label 99
- When C5 receives the traffic, the top label 21 is the one that it expects for that prefix and hence it forwards it onto the destination using the shortest-path avoiding the link C1-C2.



What Is PIC or BGP FRR?



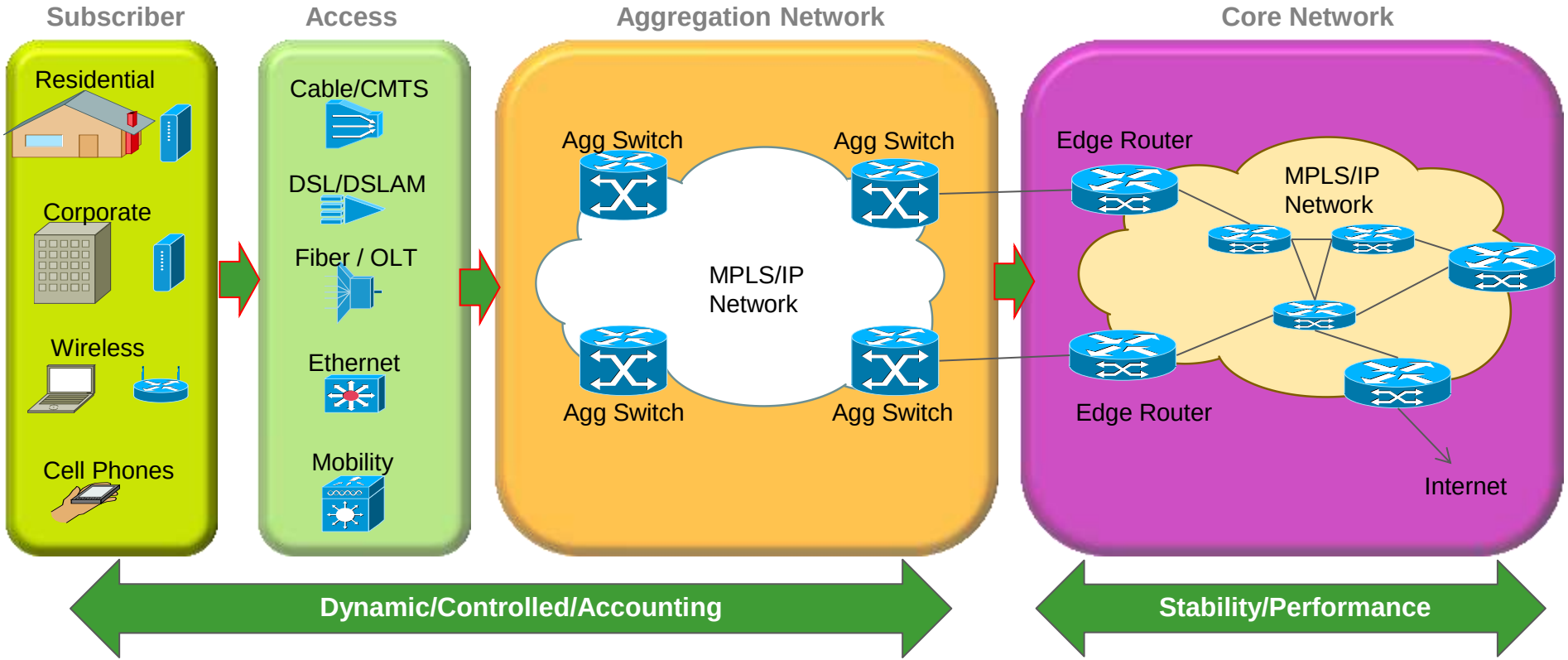




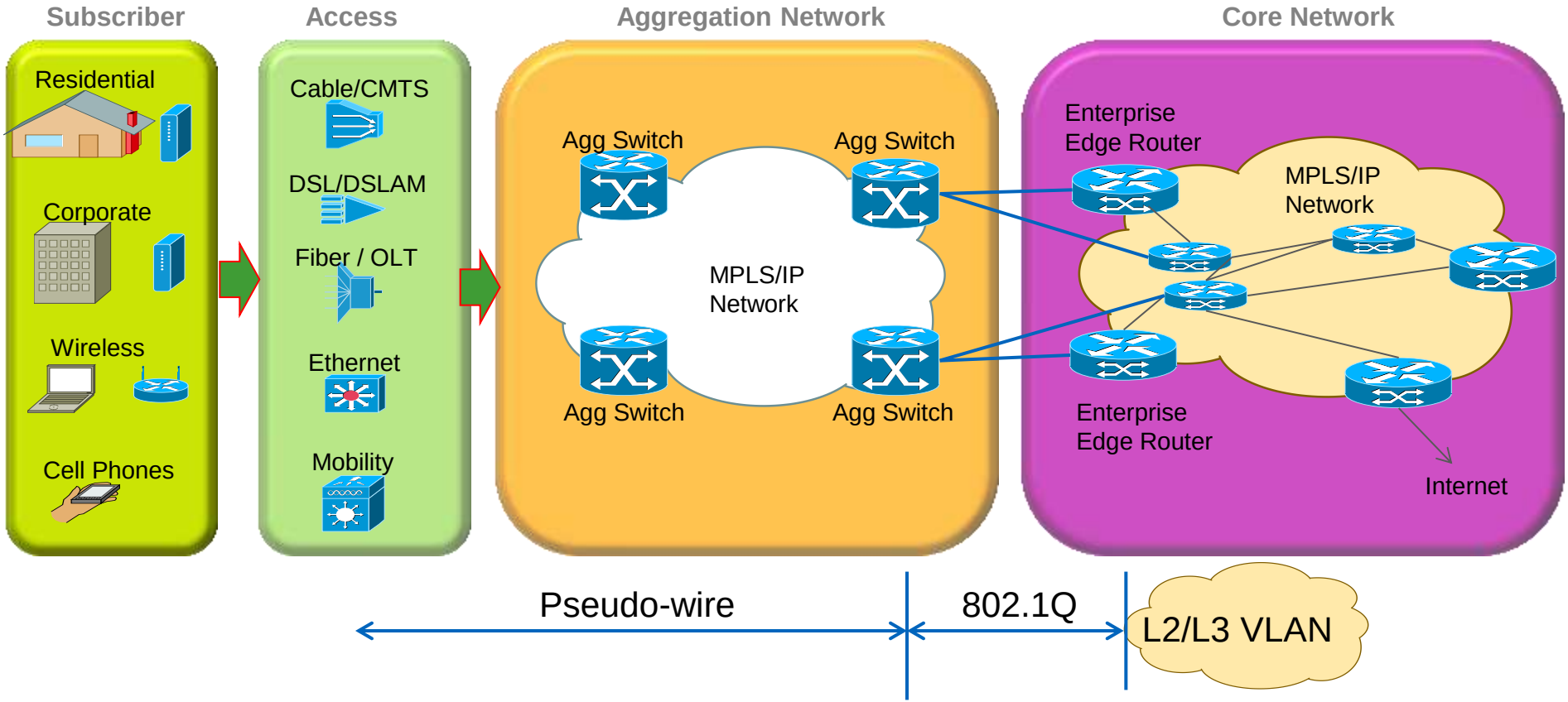
Wholesale Consumer Broadband and Enterprise Services

Consumer Broadband Services

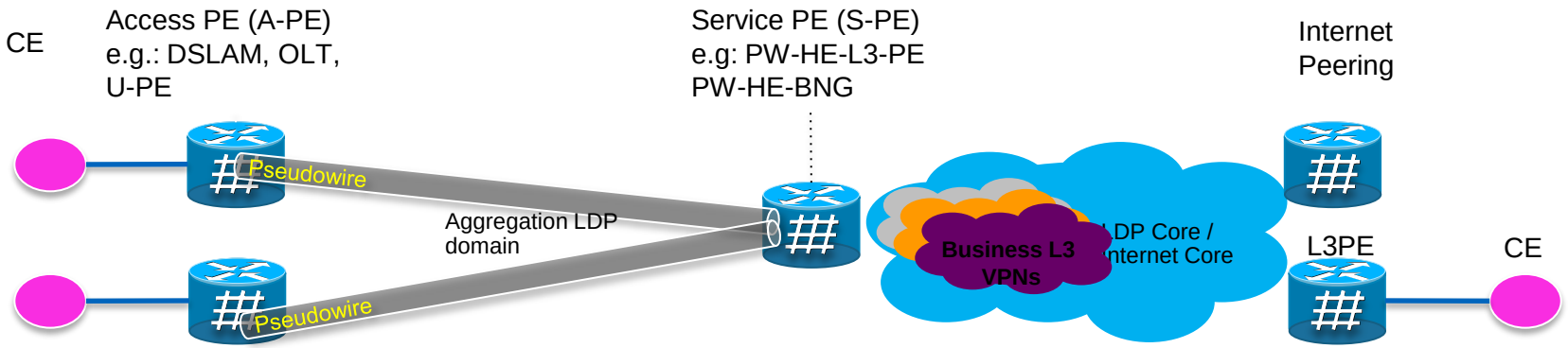
- Centralized BNG
- Distributed BNG



Enterprise VPN and Internet Service (Option-1)



Enterprise Service - Pseudo-wire Head-end (Option-2)



Pseudo-wire Headend Architecture benefits:

- Supports Seamless MPLS end-to-end Architecture: Flexible Edge placement
- Simpler resiliency between L3 PE and aggregating network
- Easy-to-operate service High-Availability through MPLS based network convergence
- Eliminates operationally cumbersome VLAN hand-off

Summary

- Metro Ethernet requirements fundamentally change with LTE/LTE-A and Converged Backhaul.
- **One Network & Many Services**
  - Mobile (2G/3G/LTE), Enterprise and consumer
- **Large Scale**
  - Can support 100K+ Devices
- **Fast Convergence**
  - IGP FC: Simple, sub-second, always required in all areas
  - LFA FRR and Remote LFA FRR: simple <50ms Link and Node
  - BGP PIC : innovation enabling BGP to scale the IGP with simplicity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