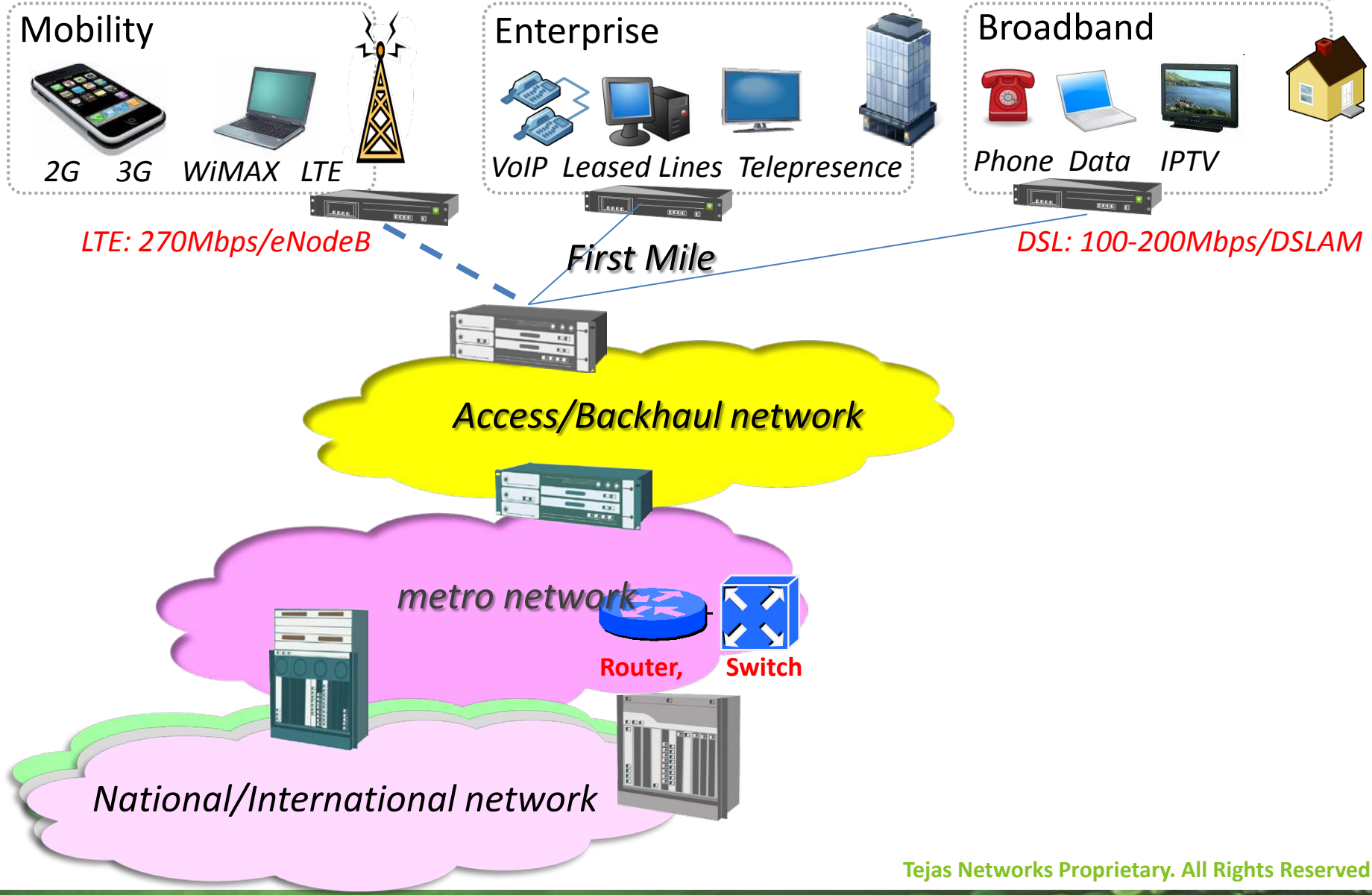
Advances in Optical Transport and Applications to Mobile Backhaul Networks

Dr. Kumar N. Sivarajan
Chief Technology Officer

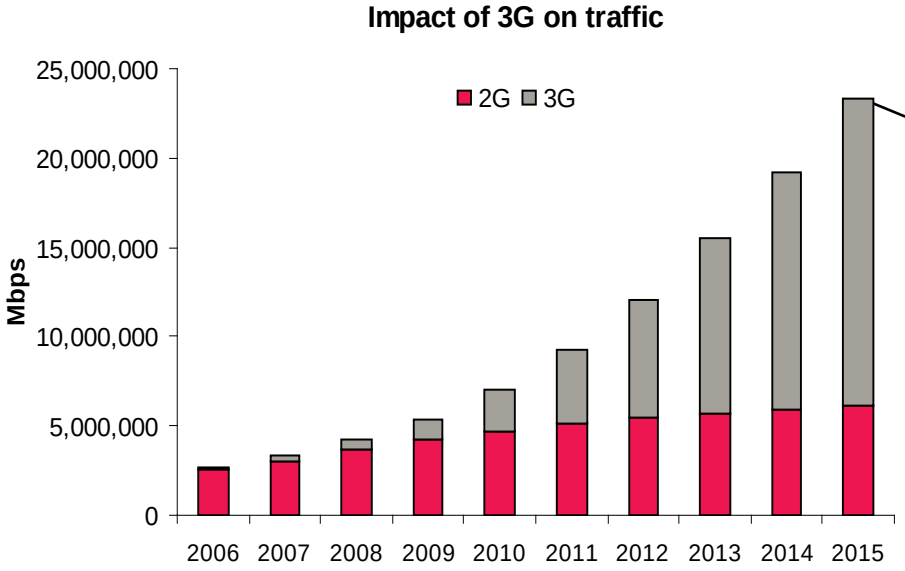
Components of a Backhaul Network

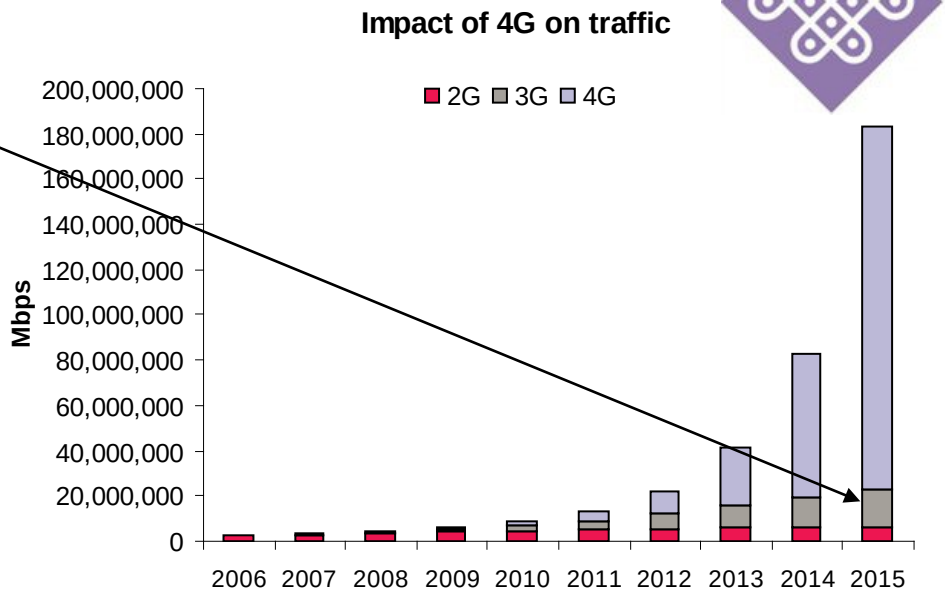


Access, Backhaul & Core Networks

- Core networks consist mostly of large “Internet” routers connected by inter-city, inter-state and international LH-DWDM links—“network of super-highways”
  - Optical fiber is virtually the only medium
- Access networks connect users (mobile, DSL modem, GPON ONU) over three media –wireless, copper, fiber—to network access points (cell tower, DSLAMs, GPON OLTs)
- Aggregation/Backhaul networks connect the network access points to the core network over two media: optical fiber or microwave links
  - Optical fiber is preferred; microwave is used only when there is no fiber
- Backhaul networks constitute the “on-ramps”to the information super-highway
  - Currently, bottlenecks for widespread high-speed broadband availability
- Optical Transport = Optical Backhaul and Core DWDM networks

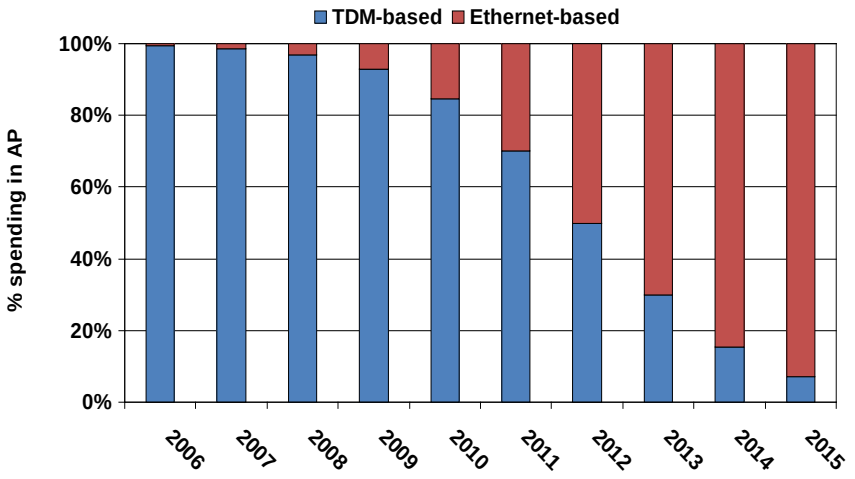
Traffic Trends in Telecom Networks





- 800% increase in data traffic from 4G (2011 – 2015)

•Ethernet data will dominate backhaul
•Optical Transport Networks need to evolve to handle deluge of data traffic



Source: Ovum, Heavy Reading

History of Optical Transport

- Aggregation/Backhaul Networks:
  - PDH and SDH – workhorses of telecom
  - PDH – 2Mbps to 140Mbps, SDH – 155Mbps to 10Gbps
  - Hierarchical, Deterministic, Self-healing, Synchronization, OAMP (Operations, Administration, Maintenance and Provisioning)
  - Terminal Multiplexers, Add-Drop, Cross-connects
- Core Networks:
  - DWDM: Use multiple wavelengths (40—80) on a single fiber
  - More importantly, optical amplification for cost-effective long-haul transport over 1000s of km

The Future of Optical Transport

- Packet Transport: SDH Like Features in Packet Networks
- Optical Transport Network: New Circuit Switching Standard for bulk bandwidth management and data payloads
- Converged Packet Optical: Seamless migration from 100% TDM to 100% Packet on the same box
- High-capacity WDM: Faster, Denser, Longer in speed, capacity and optical reach respectively

Packet Transport

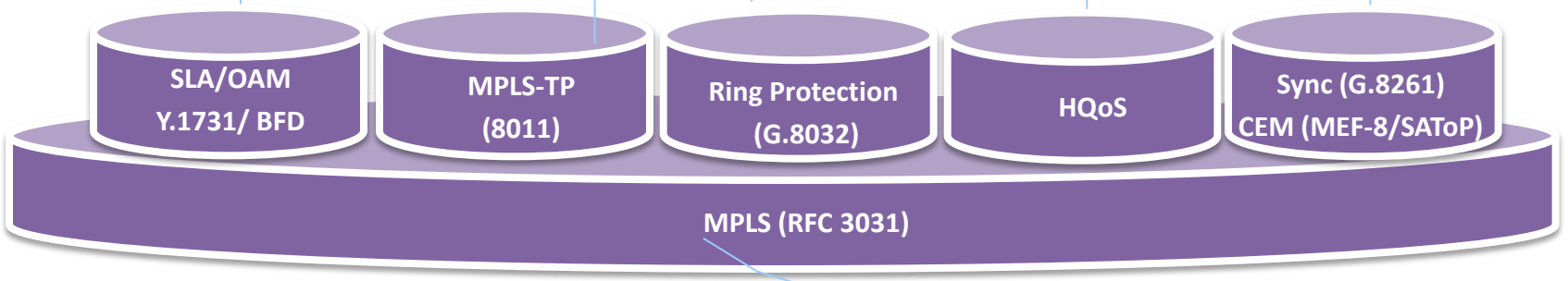
- Connection Oriented Ethernet (Label Switched Paths)
- Provisioned Model
- Sub 50ms path protection (G.8031)

- Sub 50ms Protection in Packet Rings
- Ringlets for segregating traffic

- Fault Detection
- Fault Localization
- Performance Monitoring

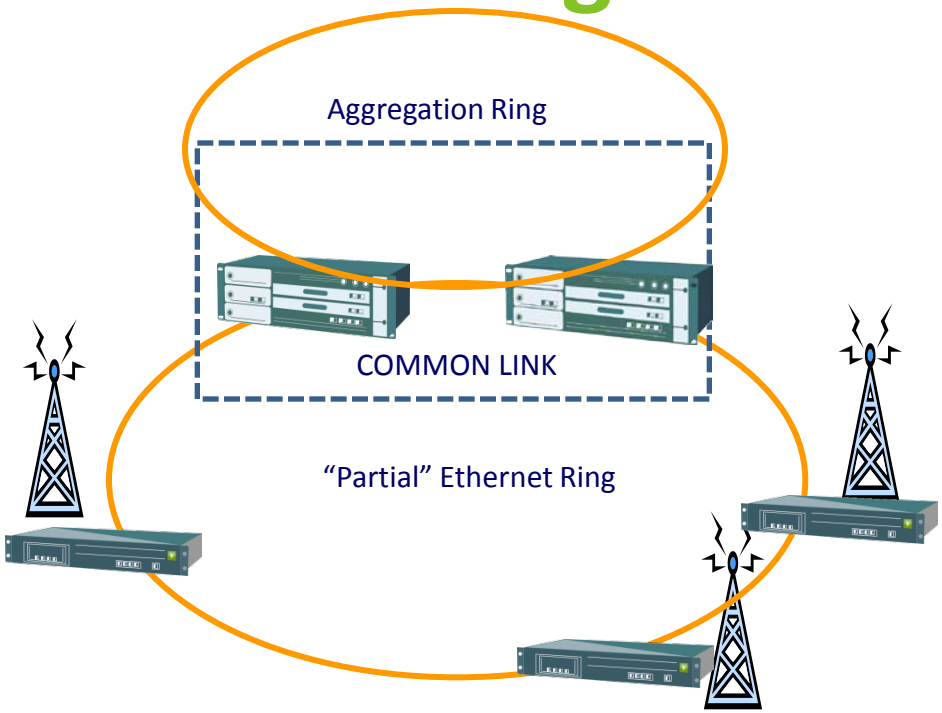
- Multiple Levels of QoS
- SLAs for Trunk, Service and Individual Customers

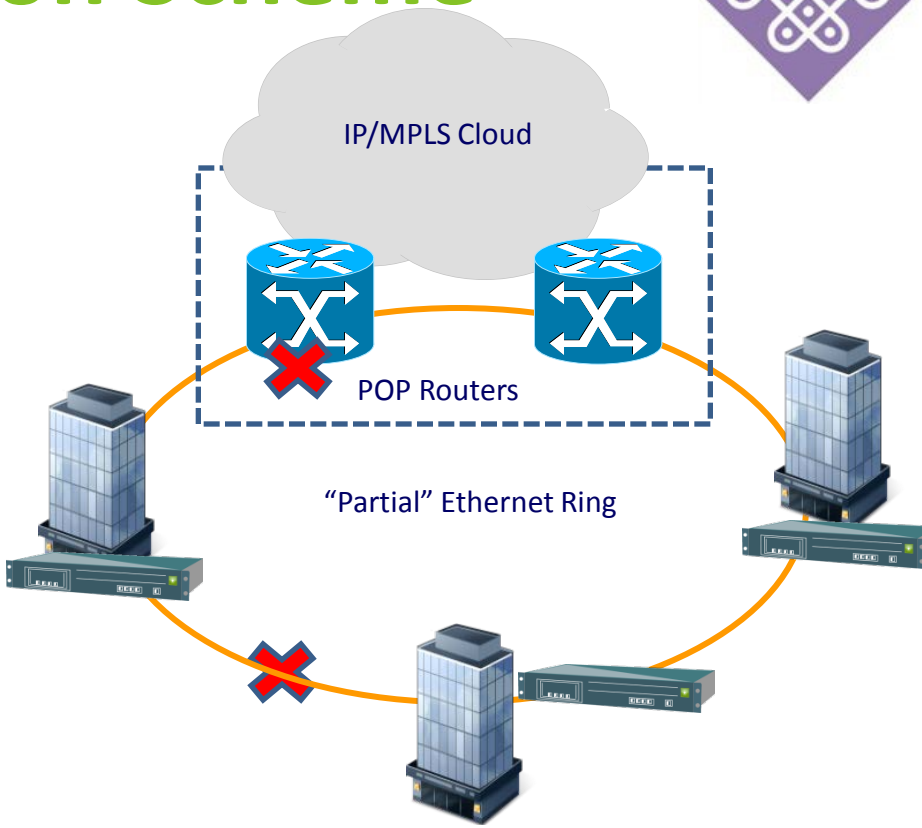
- TDM Support*



- Heart of Carrier-Ethernet based on MPLS
- Provides hierarchy, scalability (number of customers supported, number of services), secure demarcation

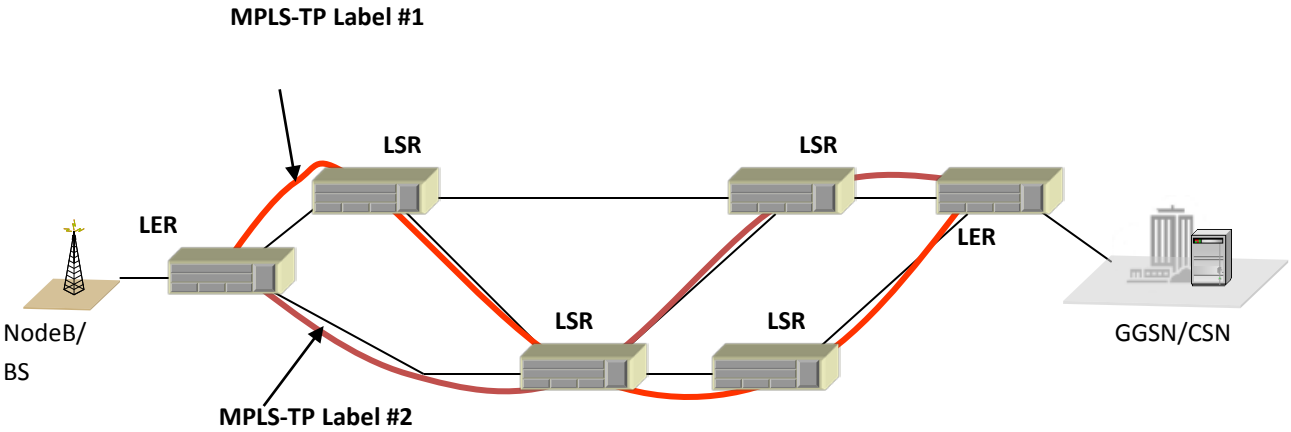
Ethernet Ring Protection Scheme





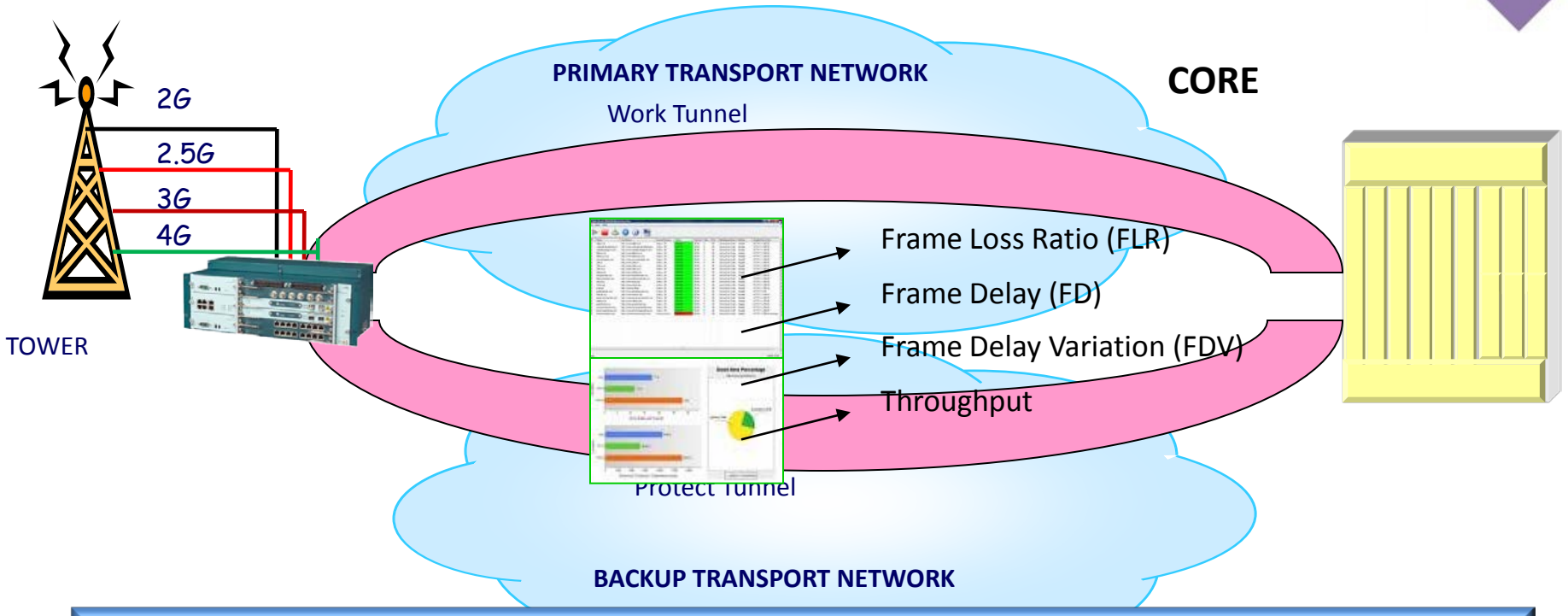
- Provides 50ms protection in Packet Rings
- Standardized by ITU-T in it's G.8032 recommendation
- Logical Ringlets based on groups of VLAN Tags
- Dual homing/dual handoff for gateway redundancy

CoE & Traffic-Engineered Tunnels



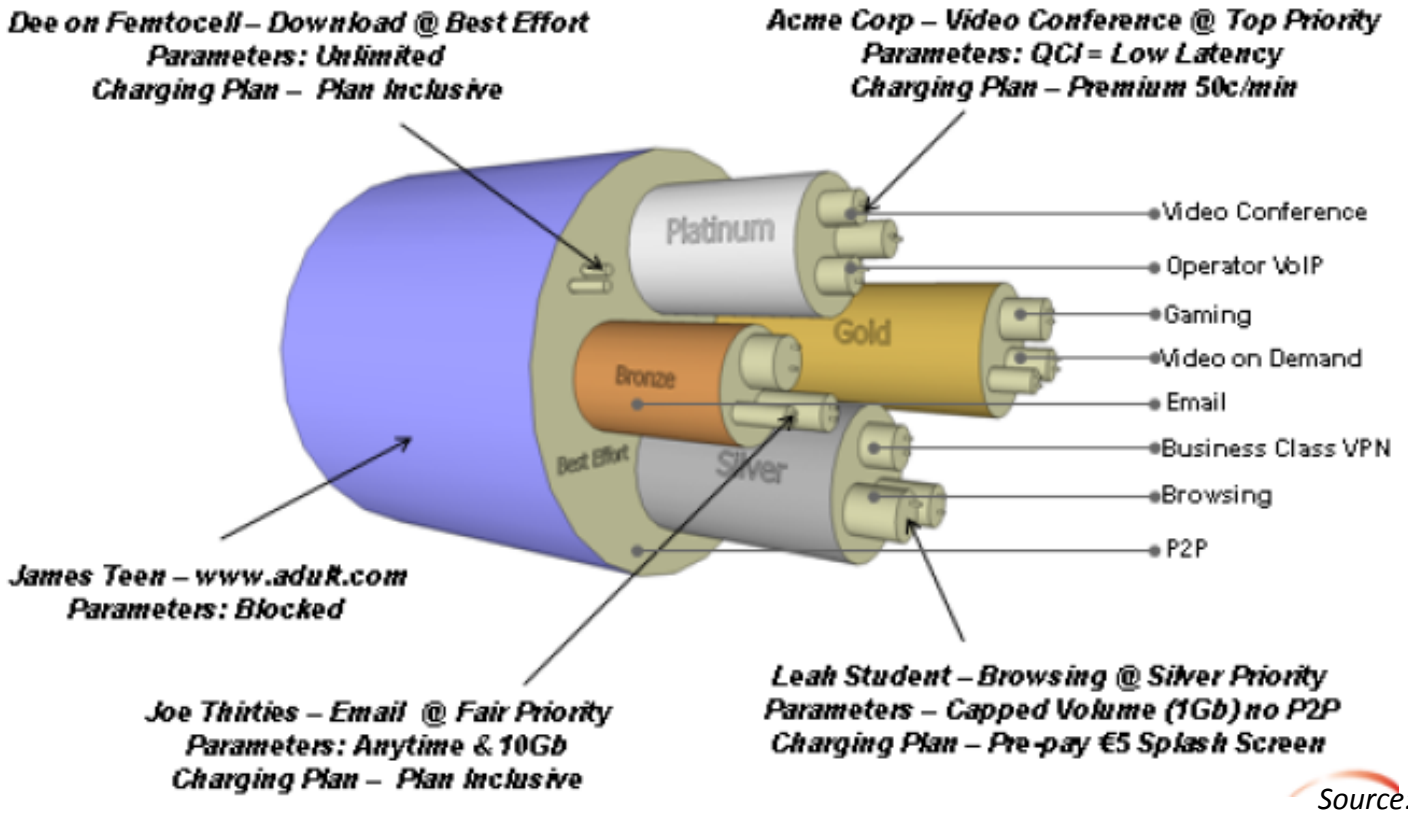
- Label Switched Paths (LSPs) provide connections for Data Traffic
- LSPs provisioned from NMS
- SLA parameters can be applied and monitored for LSPs (CIR, PIR, Latency, Jitter)
- 50ms path Protection through Work and Protect LSPs

Per-Service Fault and SLA Monitoring



- Alarms and Performance Data for packet traffic
- Standardized by IEEE in 802.1ag and ITU-T in Y.1731 standard
- IEEE 802.1ag can run hierarchical connectivity checks, loopbacks, trace routes
- ITU Y.1731 can help track and enforce SLAs based on frame delay, frame loss, throughput and frame delay variation measurements

Deeper Segmentation of Traffic



Source: Lightreading

- Smart revenue/charging models are required to leverage LTE investments – flat rate pricing may no longer cut it
- 3-level HQoS is an enabler for the LTE operator to do deeper segmentation of its customer base and offer profitable tiered pricing plans

Time and Frequency Synchronization

	Requirements (air interface)		
Synchronization	Frequency accuracy	Phase (between NobeBs)	Time
CDMA2000	±50 ppb (Macro cell)		± 10µs (± 3µs preferred)
GSM, UMTS-FDD	±50 ppb (Macro cell)		
UMTS-TDD	±50 ppb (Macro cell)	± 2.5µs	
LTE	**±50 ppb (Macro cell)**	**± 5µs for MBMS**	
Mobile WiMAX/TDD	**±50 ppb (Macro cell)**	**± 1µs**	
TD-SCDMA	±50 ppb (Macro cell)	± 3µs	

- LTE eNodeBs and Mobile WiMAX base stations require frequency and phase synchronization information for efficient hand-over of traffic
- LTE provides Ethernet feeds to deliver synchronization – also, TDM can only provide frequency synchronization, not phase
- Time of Day (TOD) synchronization required for accurate SLA monitoring
- **SyncE (ITU G.8261) and IEEE 1588v2 meet these requirements**

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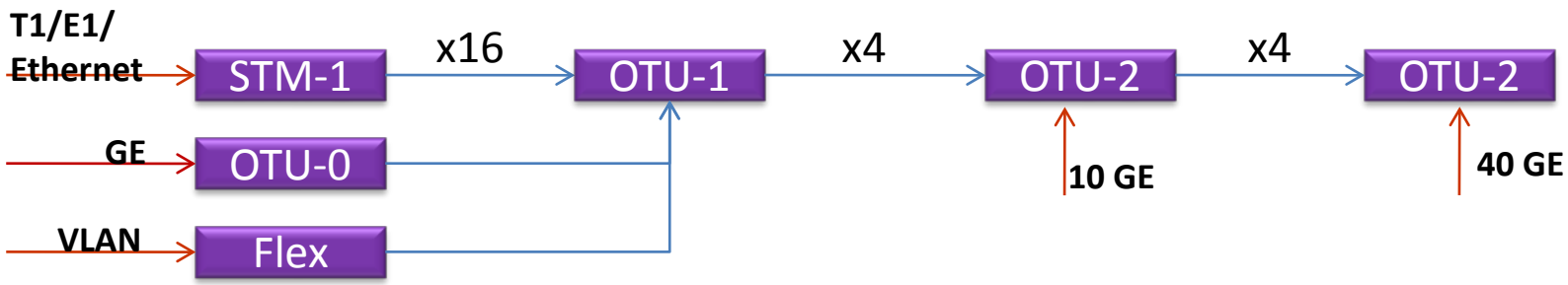
- High-capacity WDM: Faster, Denser, Longer in speed, capacity and optical reach respectively

OTN : Evolution of SDH

What is Optical Transport Network (OTN)

- A brand new TDM standard (ITU G.709)
- Containers for 1, 2.5, 10, 40, 100Gbps of client traffic
- Enhanced FEC
- Six TCM Levels
- Transparent Transport of Client signals (Full STM16/64 frame can be transported transparently as payload)
- ODUFlex: Flexible container for data traffic

OTN Hierarchy



OTN Benefits

Better B/W Management	• Bandwidth management at 1Gbps granularity • 2Mbps (VC12) granularity was too fine, 10Gbps too coarse
Long reach, Lower BER	• Enhanced FEC enables better Error Correction. • Links can be run longer, upto 6.2dB coding gain
Better Network Management	• Tandem Connection Monitoring with 6 levels • Enables the network to be partitioned into 6 hierarchical levels
Bypass IP Transit Traffic	• Lower interface costs on routers • Optimize Router Sizing • Lower Network Latency
Lower Power/Cost **Higher Compactness**	• 30-50% reduction in power • More grooming capacity in same form factor

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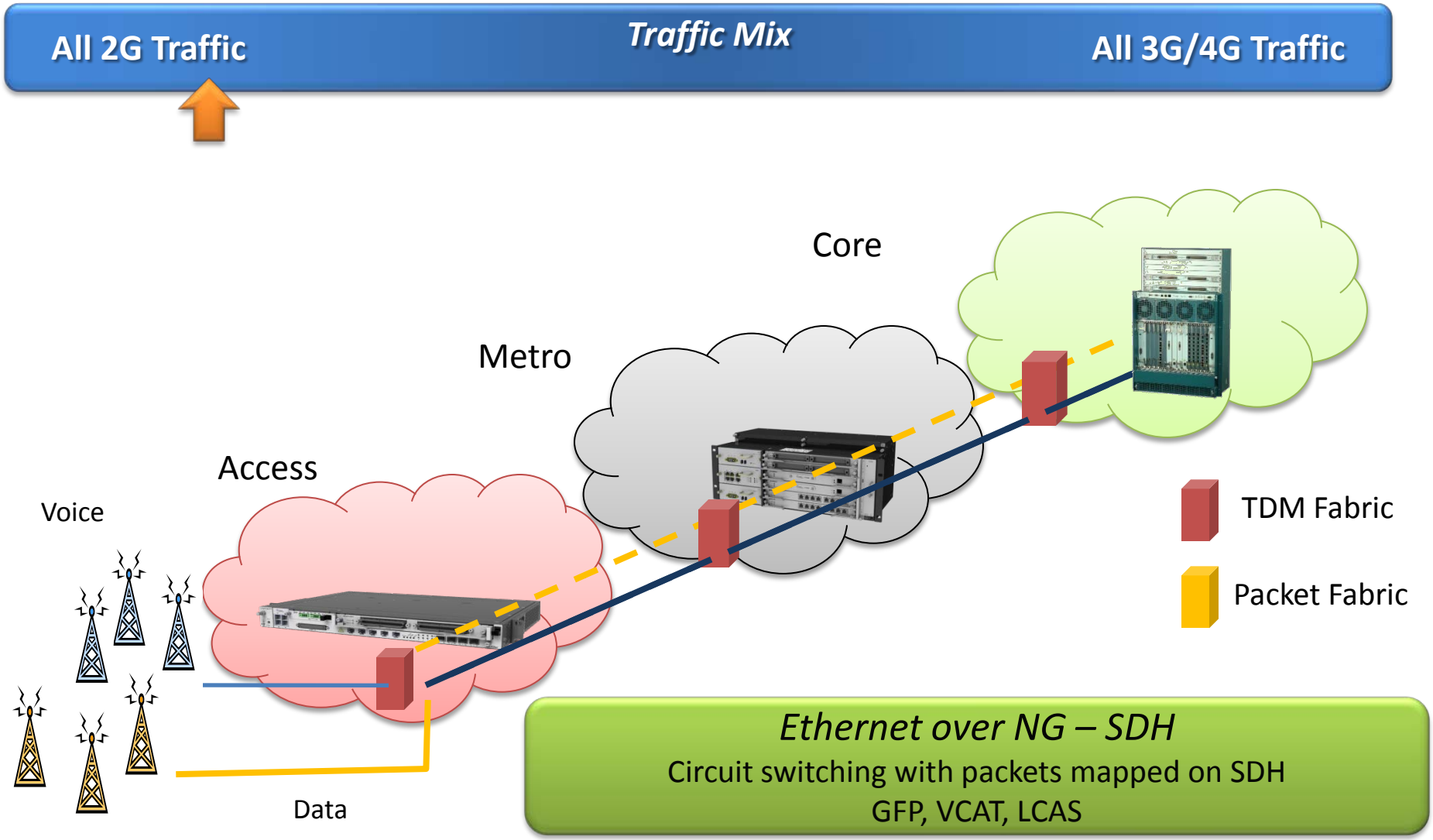
“Pay as you Grow”: 2G->3G->4G

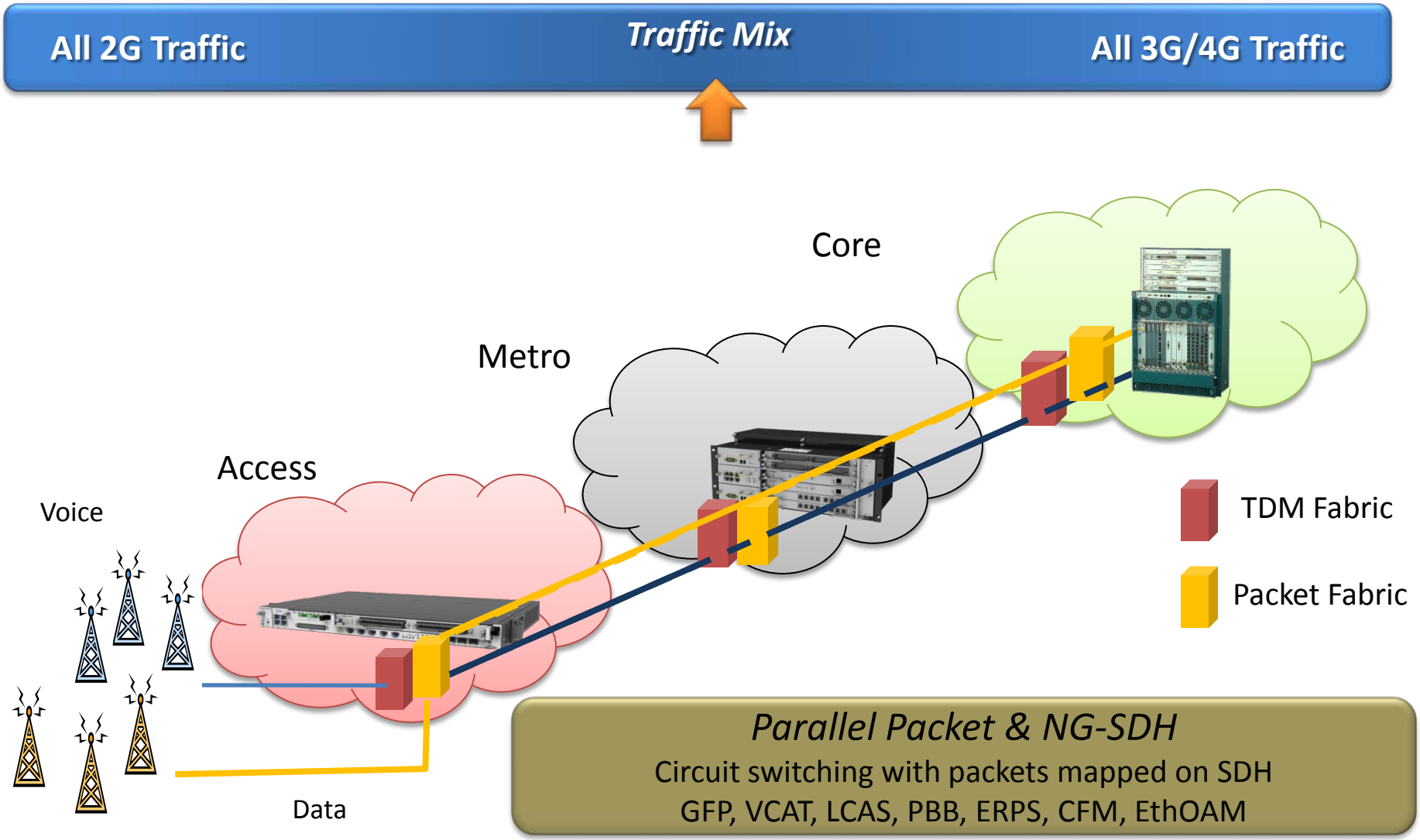


Ethernet over NG – SDH

Circuit switching with packets mapped on SDH

GFP, VCAT, LCAS

“Pay as you Grow”: 2G->3G->4G



Parallel Packet & NG-SDH

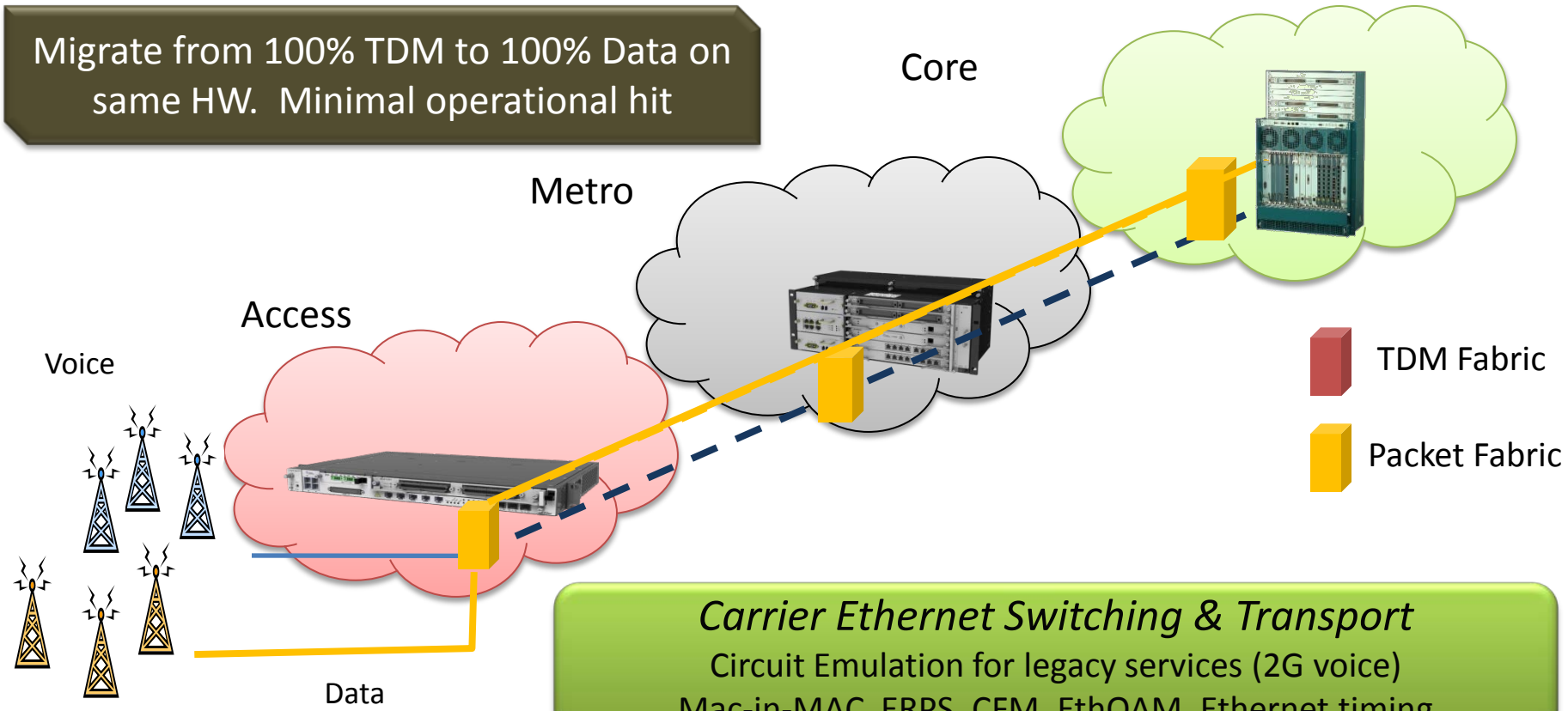
Circuit switching with packets mapped on SDH

GFP, VCAT, LCAS, PBB, ERPS, CFM, EthOAM

“Pay as you Grow”: 2G->3G->4G

All 2G Traffic — *Traffic Mix* — All 3G/4G Traffic

Migrate from 100% TDM to 100% Data on same HW. Minimal operational hit



Carrier Ethernet Switching & Transport

Circuit Emulation for legacy services (2G voice)

Mac-in-MAC, ERPS, CFM, EthOAM, Ethernet timing

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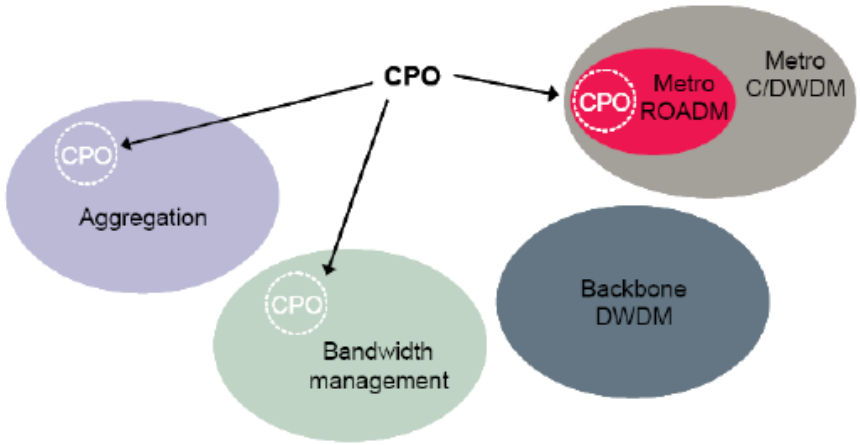
DWDM: Industry Developments

- Shift in spending from stand-alone WDM to integrated platforms with SDH, OTN, WDM, Packet Switching



Source: Ovum, with thanks to NEC America for illustration approach

DWDM: Industry Developments

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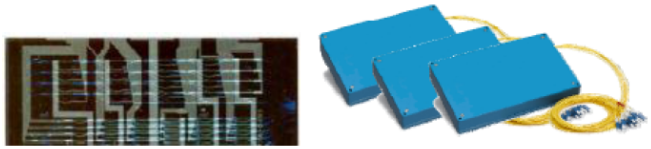
- Multi-degree WSS ROADM for realizing dynamic optical networks for new services - VoD, HDTV, BoD etc



Colorless & directionless ROADM enhancements required to truly deliver optical mesh. Tuneable filters arrays, 1 x22 add/drop WSS, NxN WSS are key enabling technologies (*source: JDSU*)

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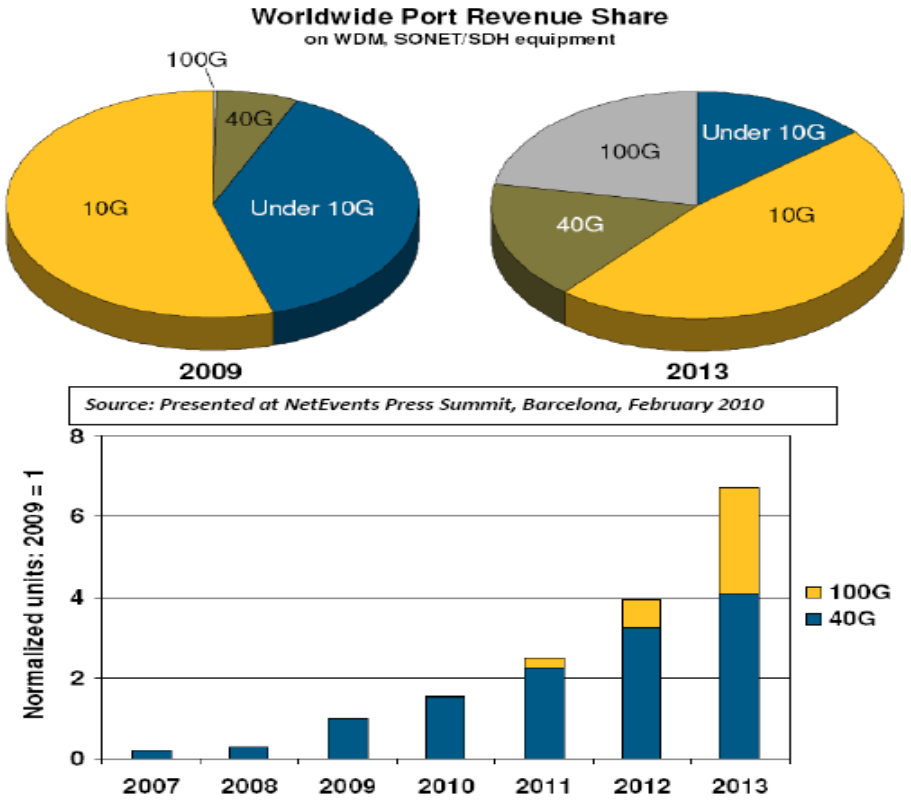
- Multi-degree WSS ROADM for realizing dynamic optical networks for new services - VoD, HDTV, BoD etc
- 40/100GE interfaces for high speed connectivity, 100G getting commercially deployed, 400G emerging

Advanced Modulation Techniques

- DPSK, DQPSK for 40G
- DP-QPSK Coherent (Standardized for 100G)



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- Multi-degree WSS ROADM for realizing dynamic optical networks for new services - VoD, HDTV, BoD etc
- 40/100GE interfaces for high speed connectivity, 100G getting commercially deployed, 400G emerging
- Traditional MSPP/DWDM boundaries are blurring – WDM lambdas from MSPP/IP platforms for infrastructure unbundling

Sprint Completes First Transatlantic Native 40-Gbps IP-Over-Dense-Wavelength-Division Multiplexing Link

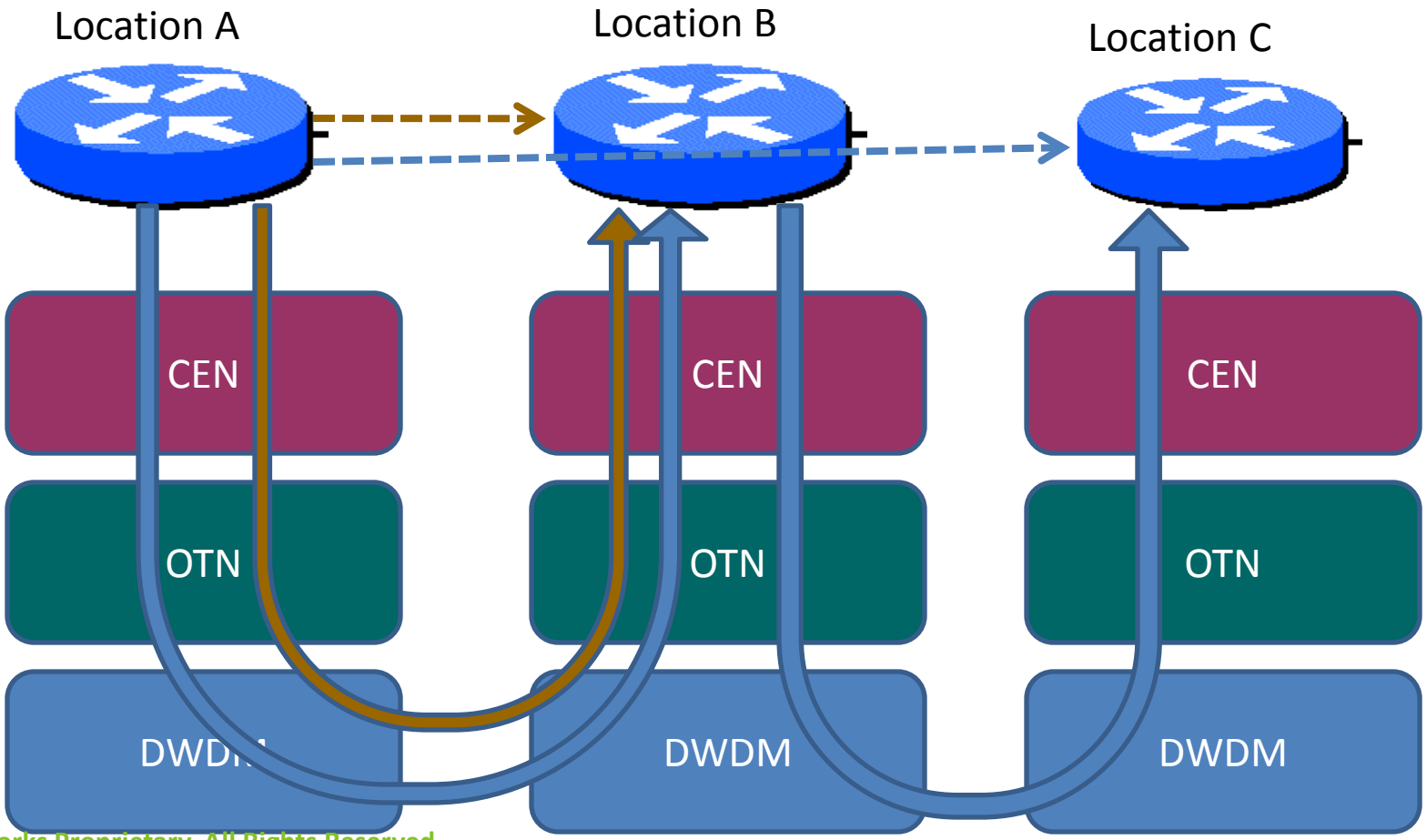
Trial Demonstrates How Capacity Can Be Added Using Existing Dense Wavelength Division Multiplexing (DWDM) Systems

Managing Transit Traffic

A majority of network traffic on any node is transitory

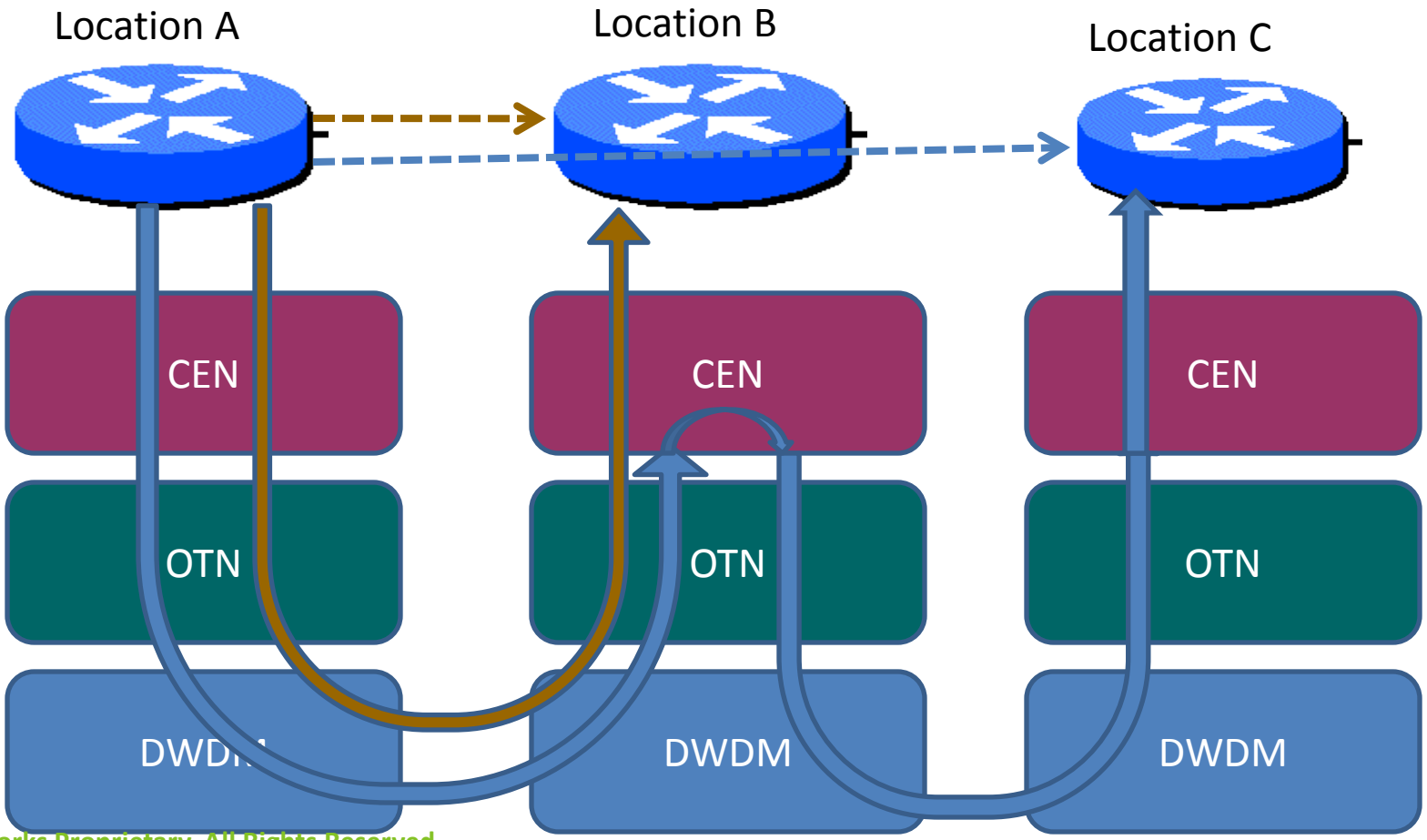
Routing capacity at “B” should handle (A=>B) plus (A=>C) traffic

Actual Traffic Path



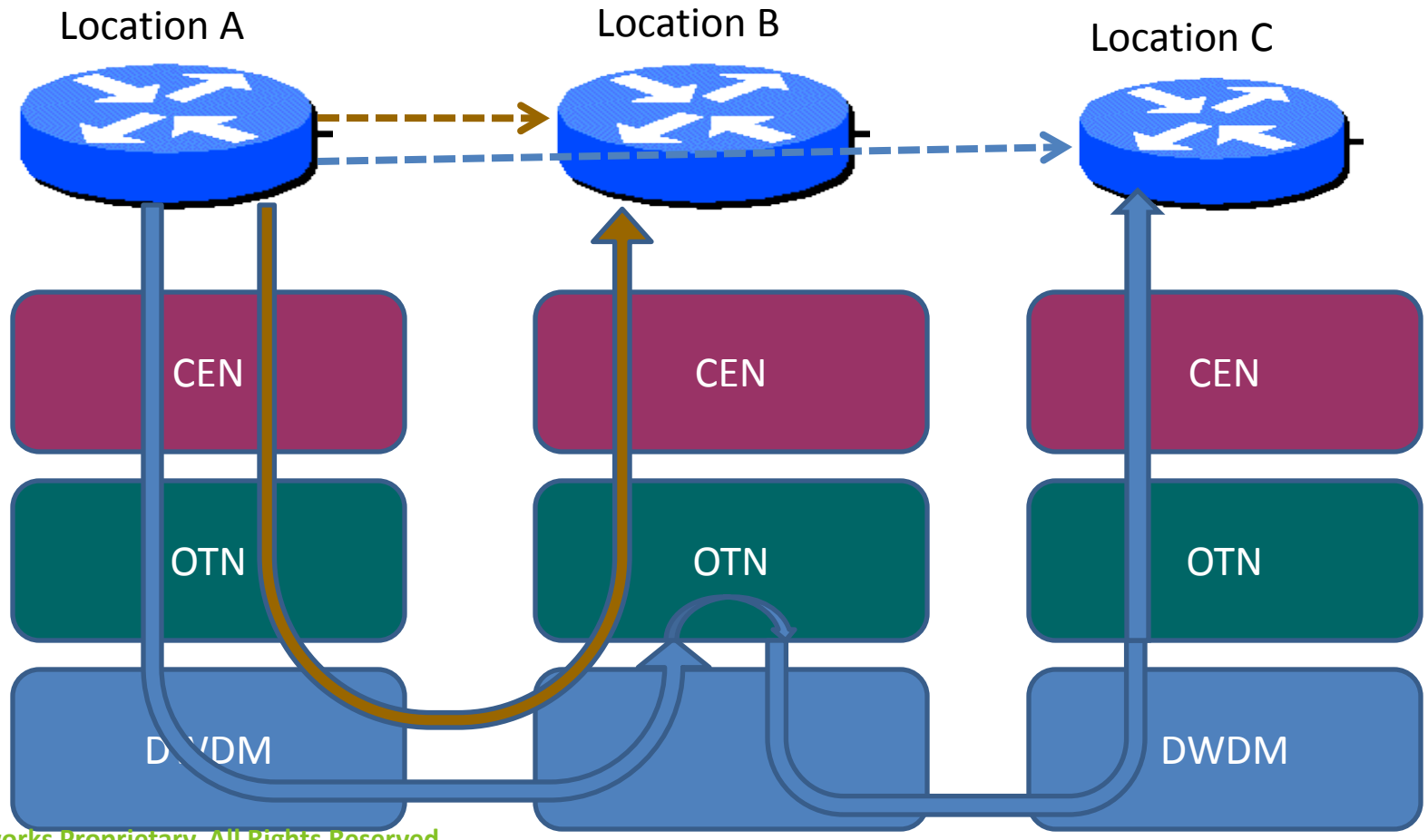
Bypass at Layer 2

- Bypass at as lower layer as possible
- Bypass at Carrier Ethernet Layer (Layer 2 Switching)



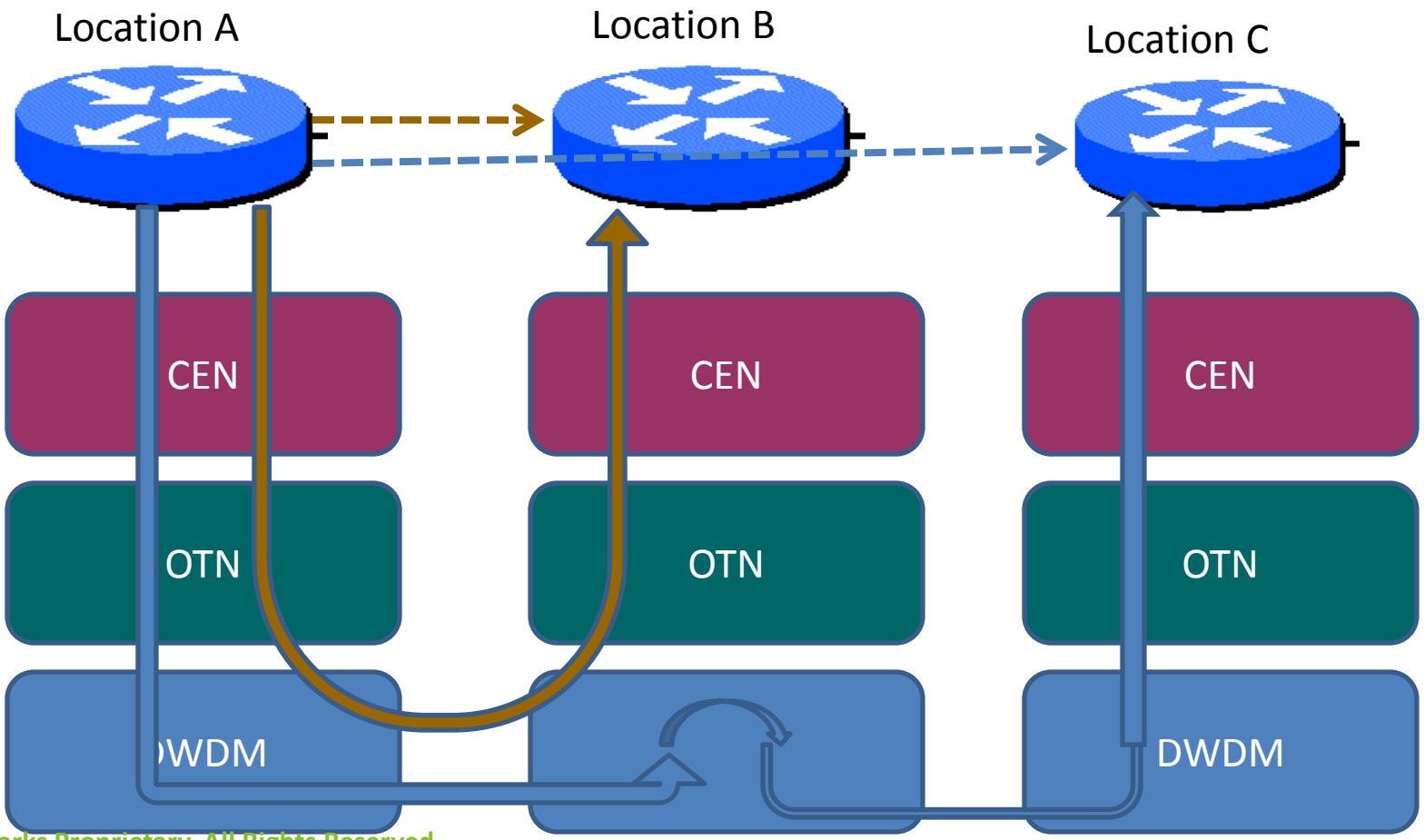
Bypass at OTN Layer

- ODU Grooming at 1Gbps granularity



Bypass at WDM Layer

- ROADM grooming at wavelength level (10G/40G)



Which Bypass?

Traffic between individual source-destination pairs determines which type of bypass is the best

DWDM Bypass

- Granularity of 10Gbps. P2P traffic should be 10Gbps or beyond

OTN Bypass

- Granularity of 1Gbps. Best for P2P traffic between 1 to 10Gbps

Carrier Ethernet Bypass

- Best for P2P traffic between individual pairs not exceeding 1Gbps

Typically networks start with low traffic between location pairs and grow.
Hence the need to progressively move transit traffic to lower layers

Mobile Backhaul Networks

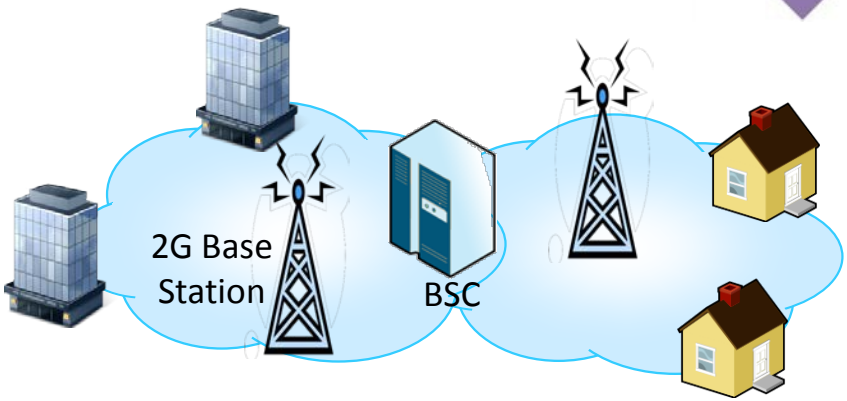
Dr. Kumar N. Sivarajan
Chief Technology Officer

Outline

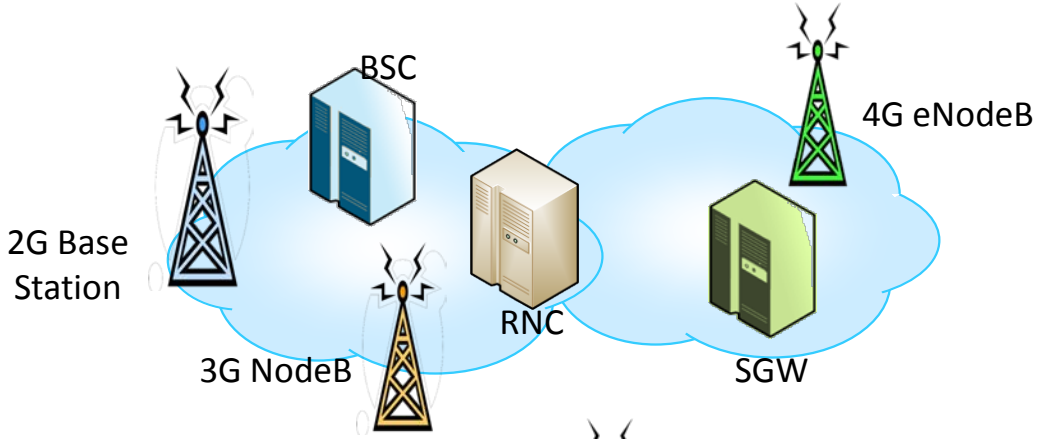
- Mobile Backhaul Scenarios
  - 2G Expansion
  - 2G => 3G => 4G Upgrade
  - Greenfield 4G Deployment

Mobile Backhaul Scenarios

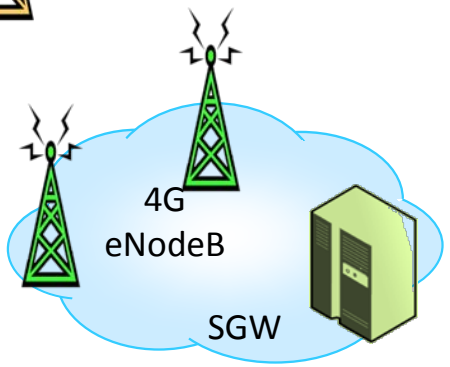
2G Expansion
Voice connectivity, Rural Expansion



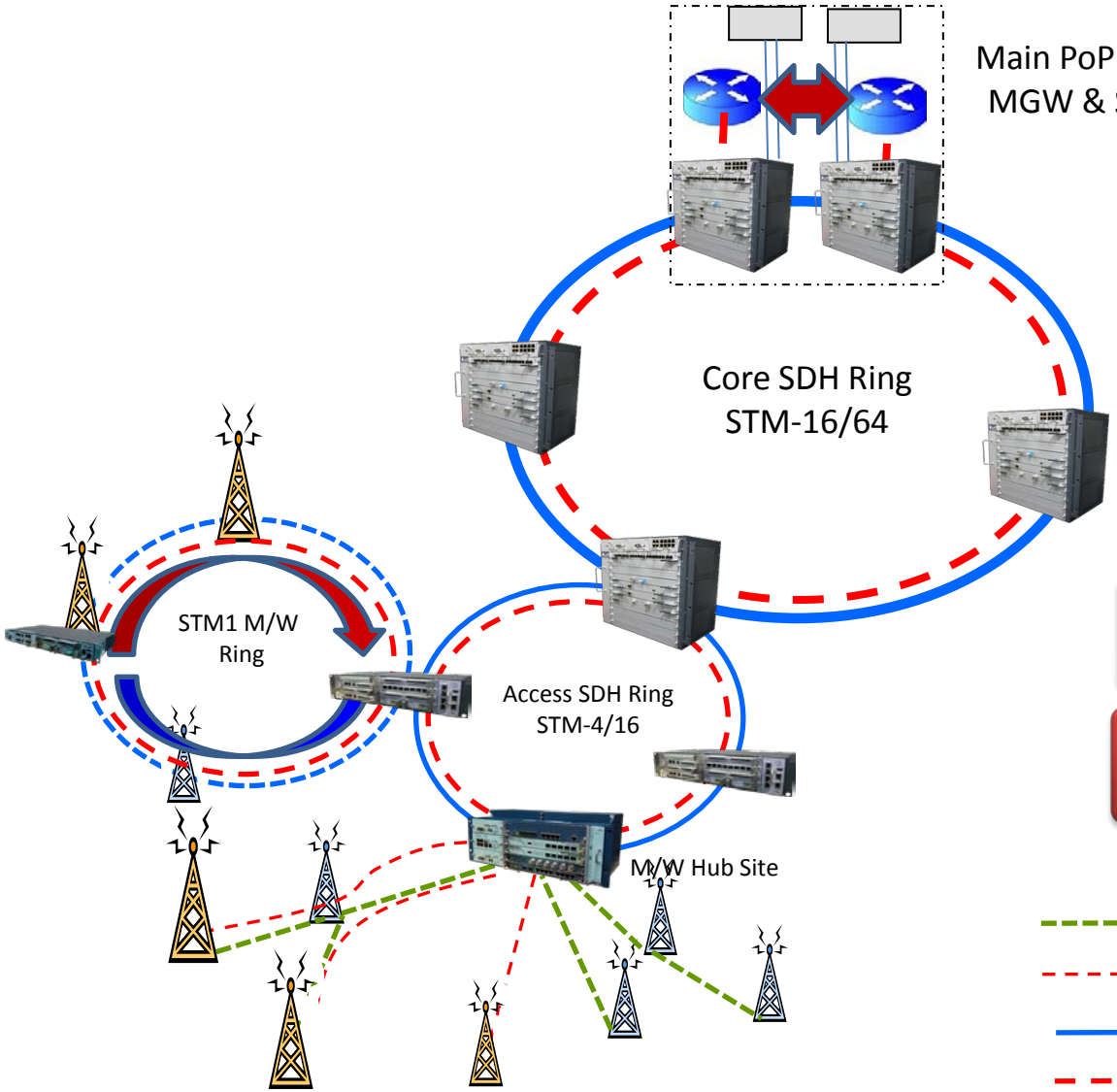
2G => 3G => 4G Upgrade
2G operators rolling out 3G and LTE Services



Greenfield 4G Rollout
Primarily Data Services



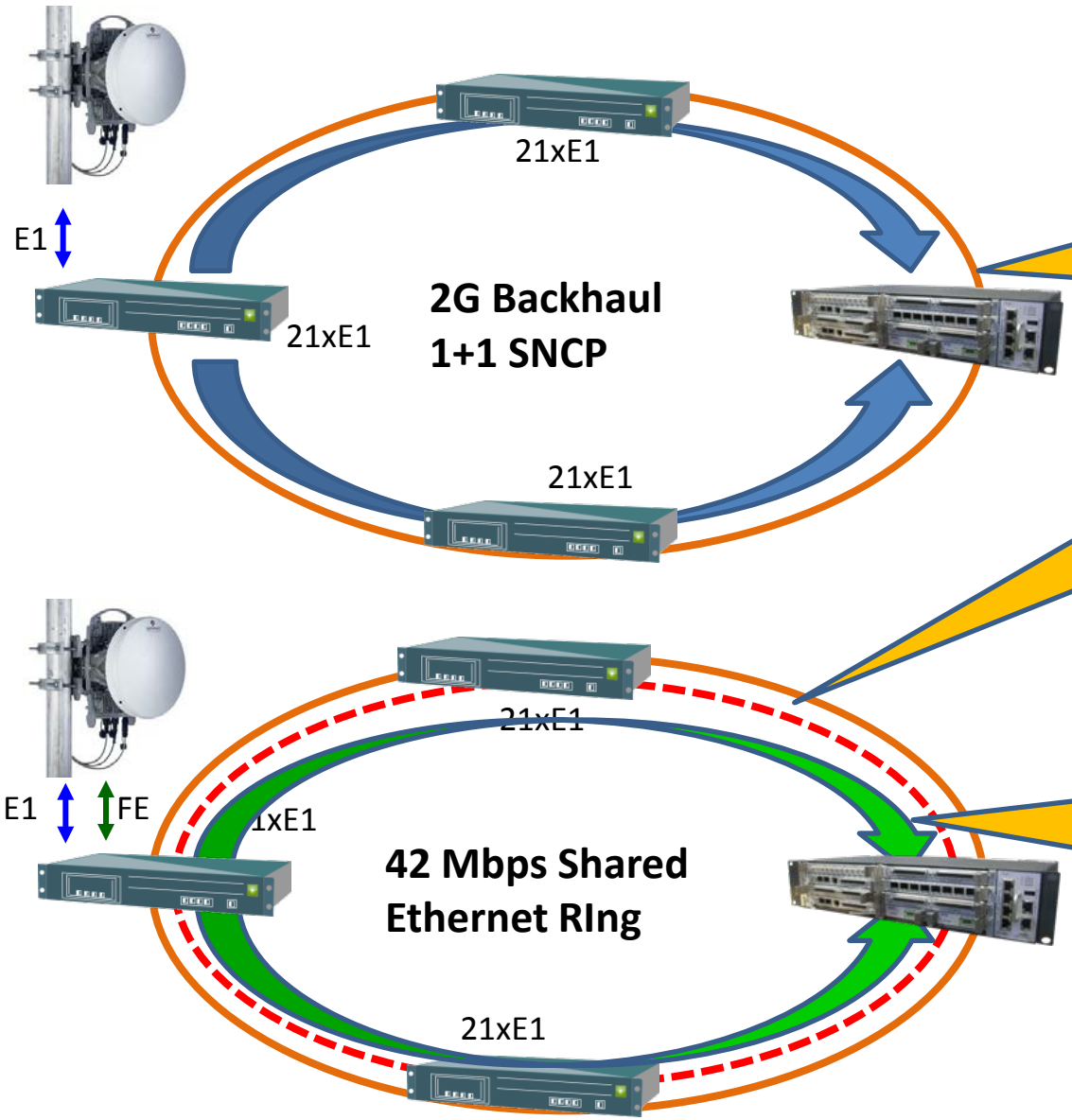
2G => 3G Migration (Expansion Market)



- EoPDH Aggregation
- Overlay Packet Ring over TDM
- Double data bandwidth (LCAS, DBPR, ERPS)
- Dual Homing (Open ERPS)
- 50ms Ring Protection

PDH Microwave
EoPDH Microwave
SDH (Fiber)
EoSDH
2G BTS
3G NodeB

ERPS with DBPR



2G
- 21xE1 from each BTS
- Ring fully used up

3G
- Use 21 **protect** VC12s to build a shared Ethernet Ring

Double Bandwidth
Use both sides of the packet ring to get peak of **84Mbps**

Outline

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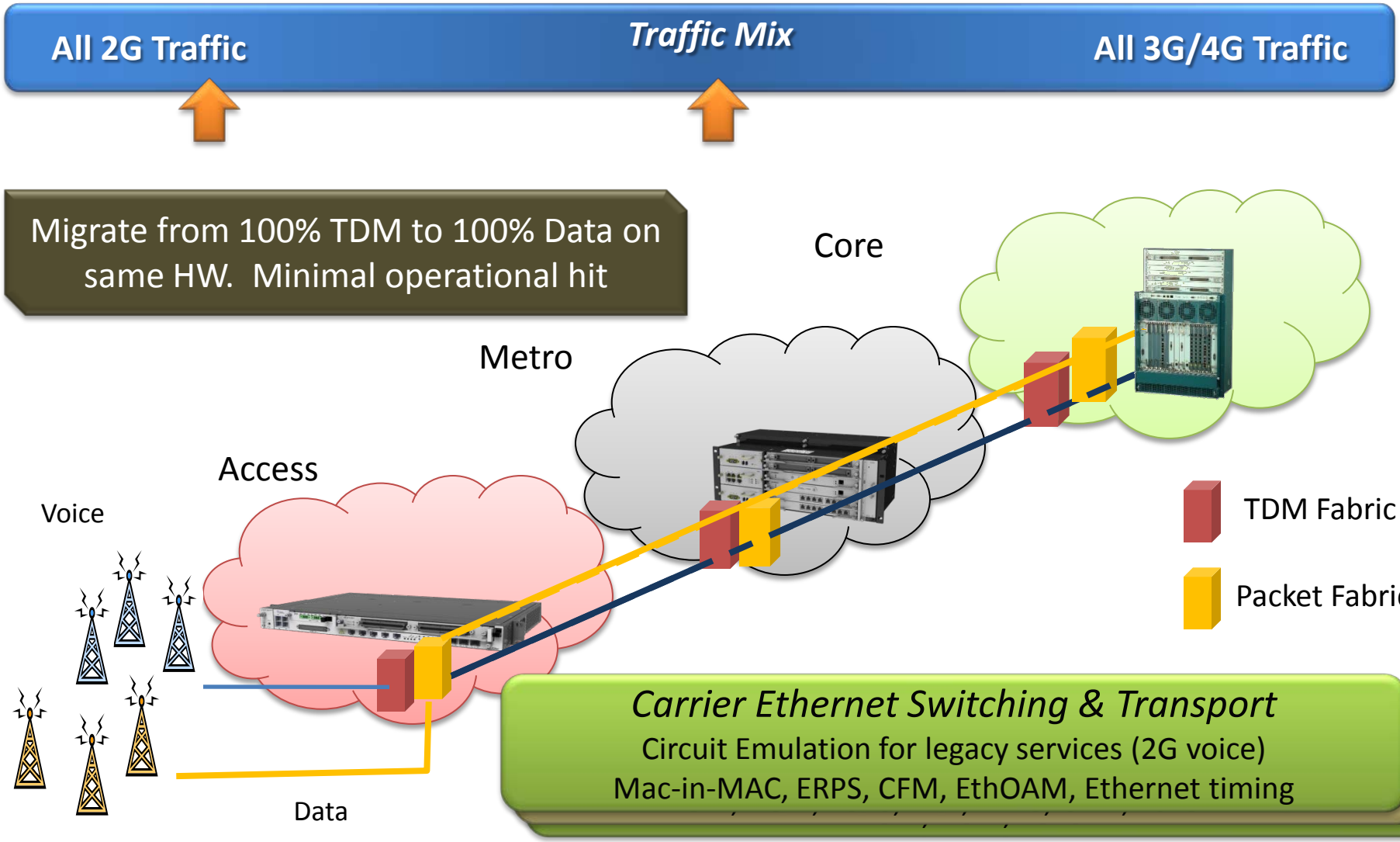
  - 2G => 3G => 4G Upgrade
  - Greenfield 4G Deployment

Packet Optical Transport Platforms



Benefits of POTP

Smooth & Disruption-free Migration	• No disruption of revenue generating 2G services
Reduced Capital Investments	• Re-use existing hardware • Build as you grow (Add modules only when they're needed)
Reduced Operational Expenses	• Maintain only one network for multiple services • Advanced Packet Transport for easy provisioning, monitoring and maintainence of data services
Green Technology	• Lower Network Power Consumption • Dynamic Network Optimizations Possible (Move traffic to lower layers. Eg IP=>Ethernet, Ethernet=>OTN, OTN=>DWDM)

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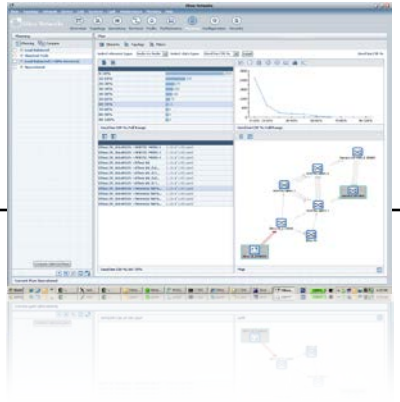
Greenfield 4G Network (Pure Packet)



Wireless Backhaul

E2E Planning, Provisioning, Service management & monitoring

1GigE

1x10GigE

IPTV

Packet CPE (FE + NxGigE

DSLAM

1x10GigE

Nx40GigE (Ring)

10GigE

1GigE

Aggregation (10GigE Packet ADM)

Packet Aggregation n x 40GigE

Enterprise

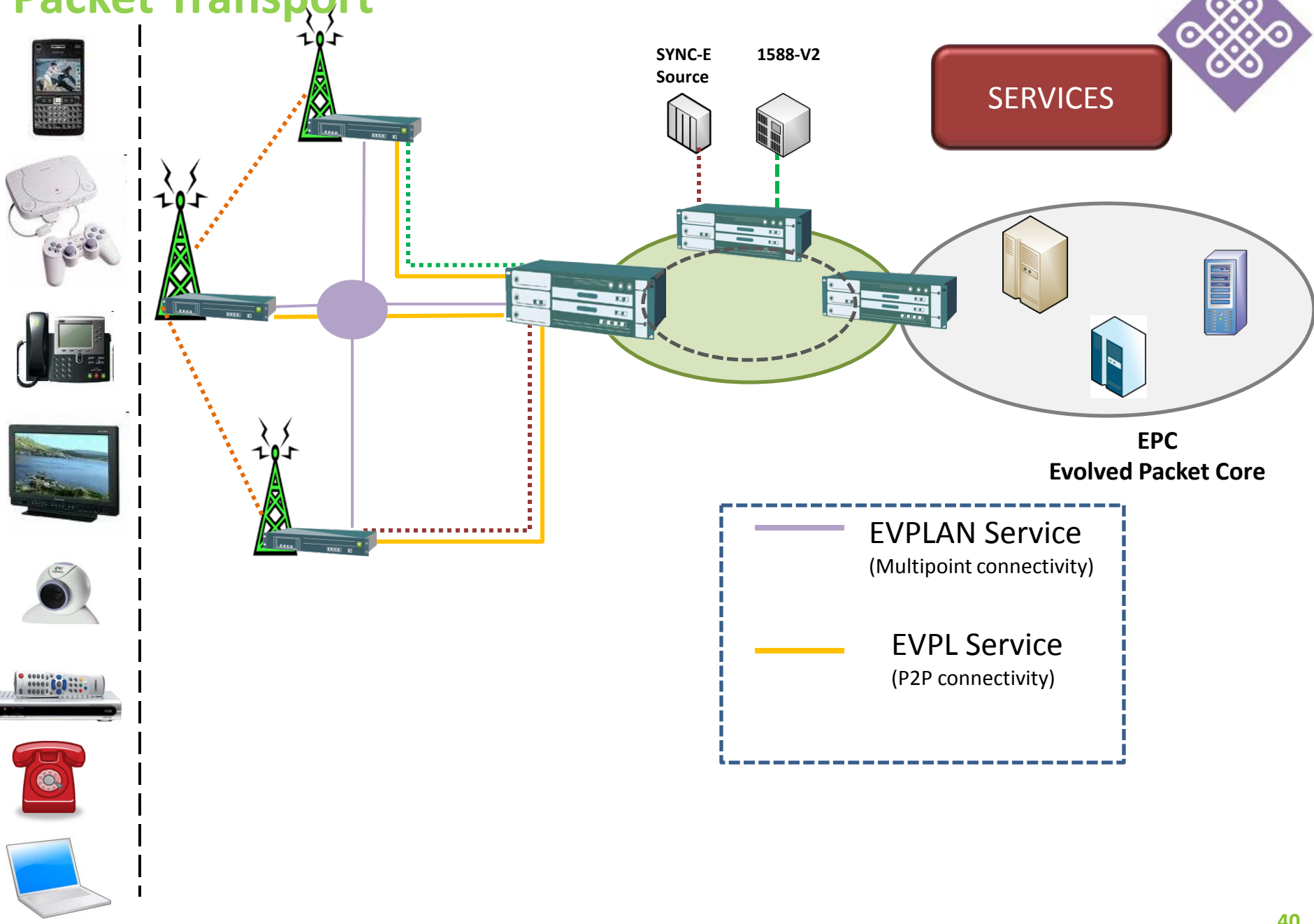
Access

Aggregation Level 2

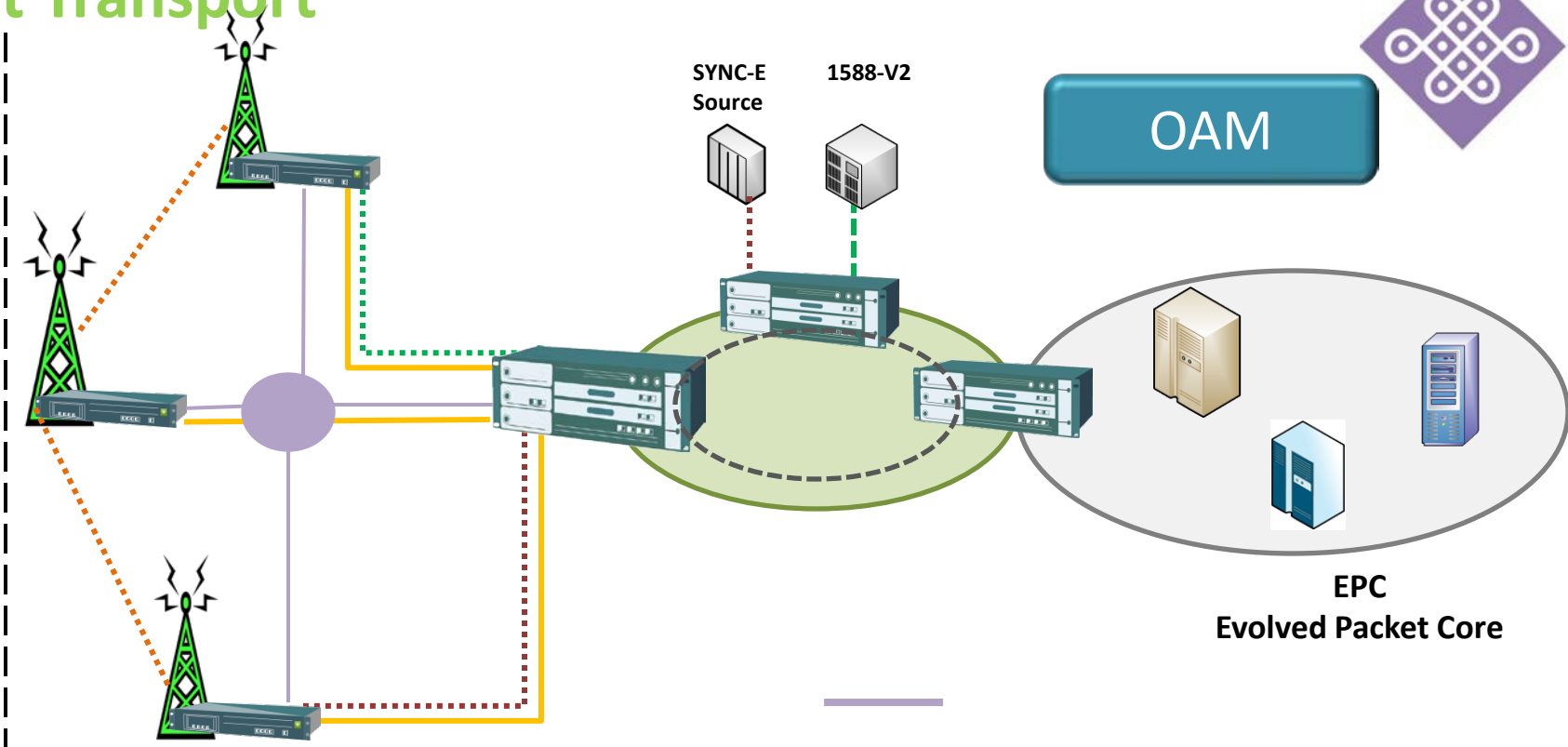
Aggregation Level 1

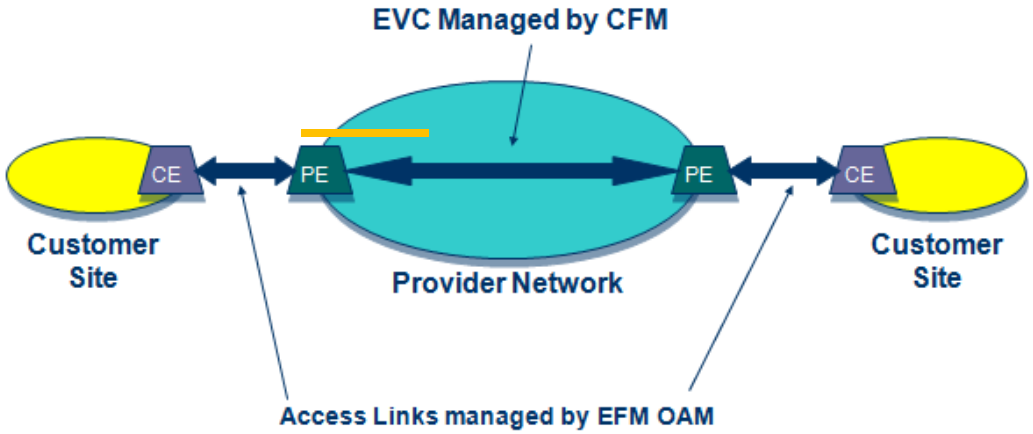
Core

Packet Transport



Packet Transport



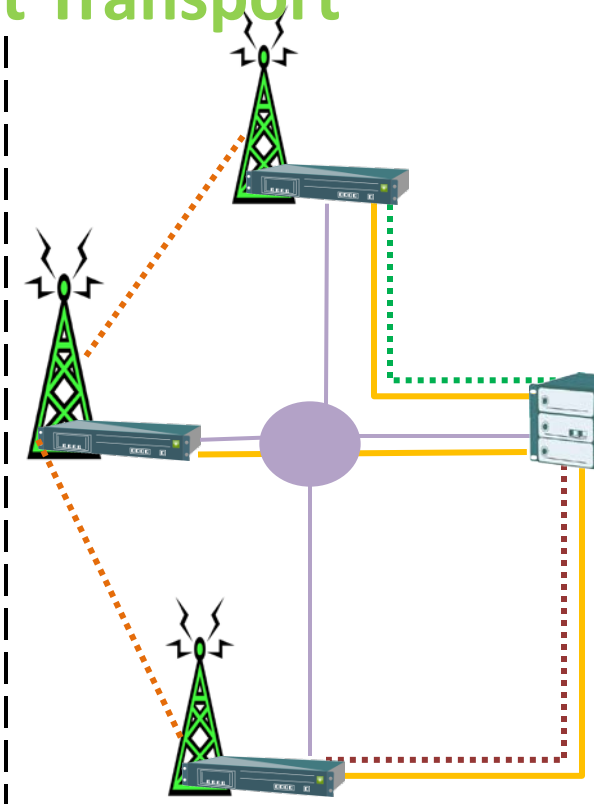


Packet Transport





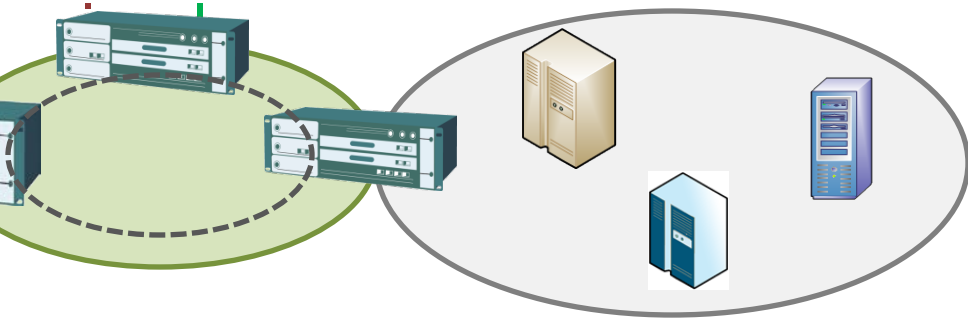


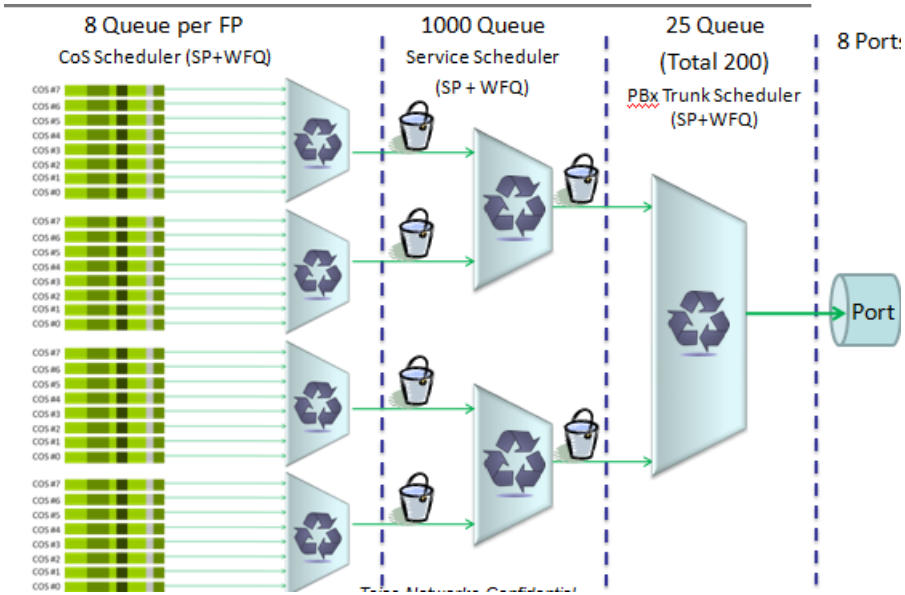
SYNC-E Source

1588-V2

HQoS



EPC
Evolved Packet Core



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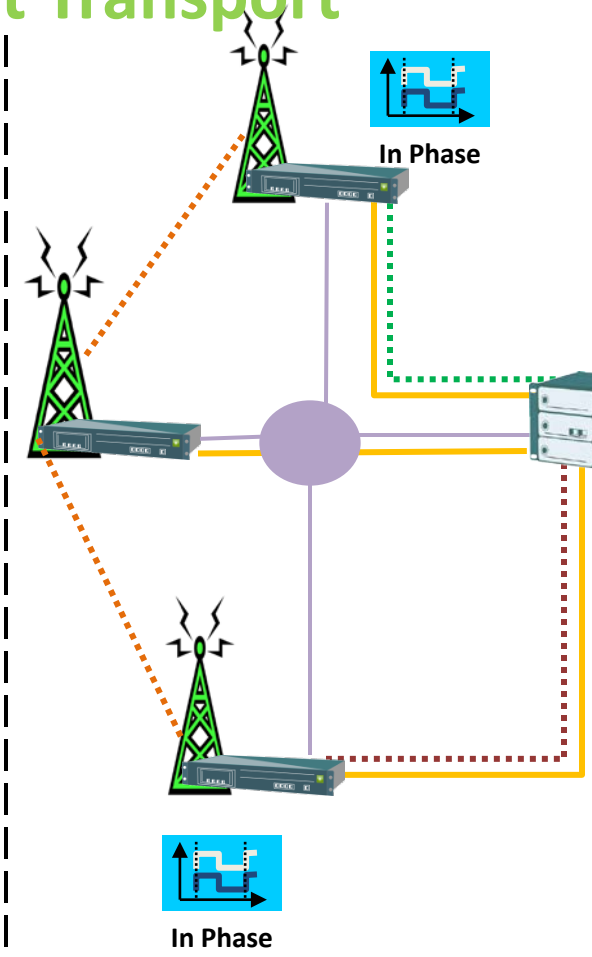
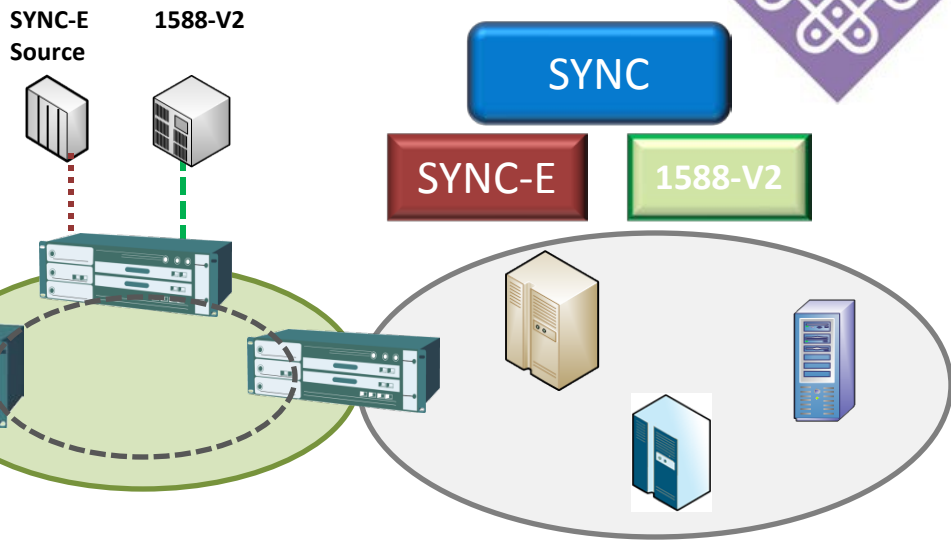
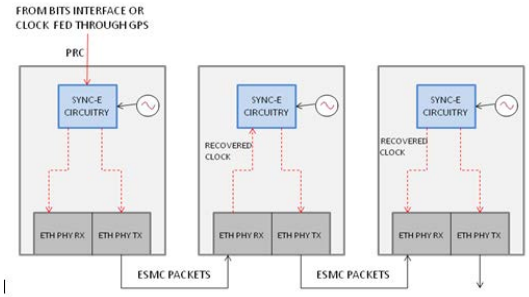
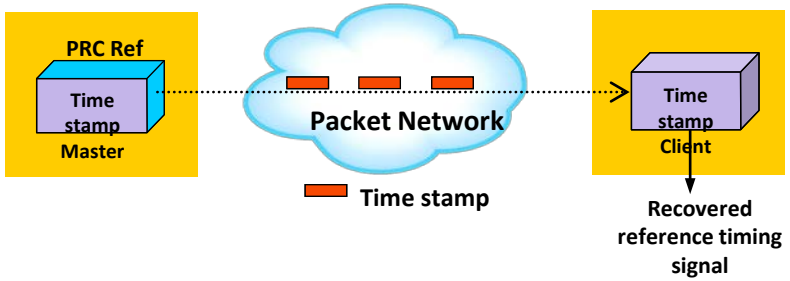
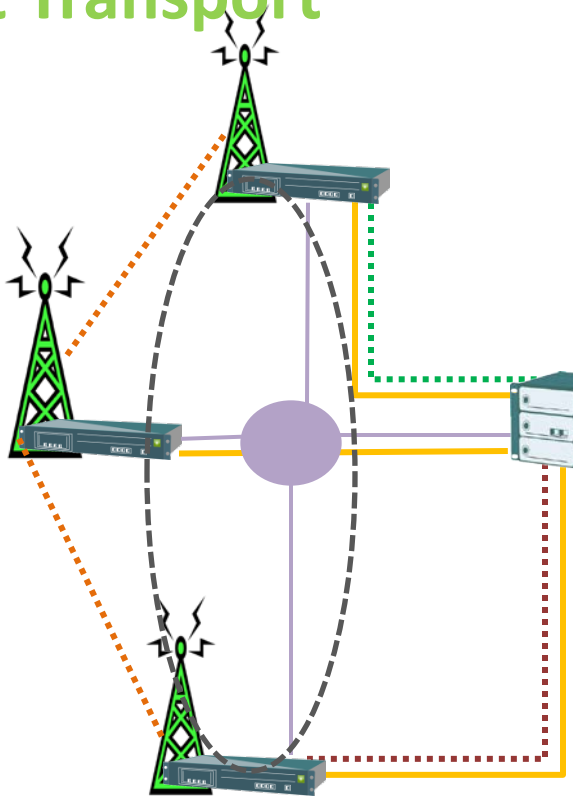








Packet Transport



In Phase

SYNC-E Source

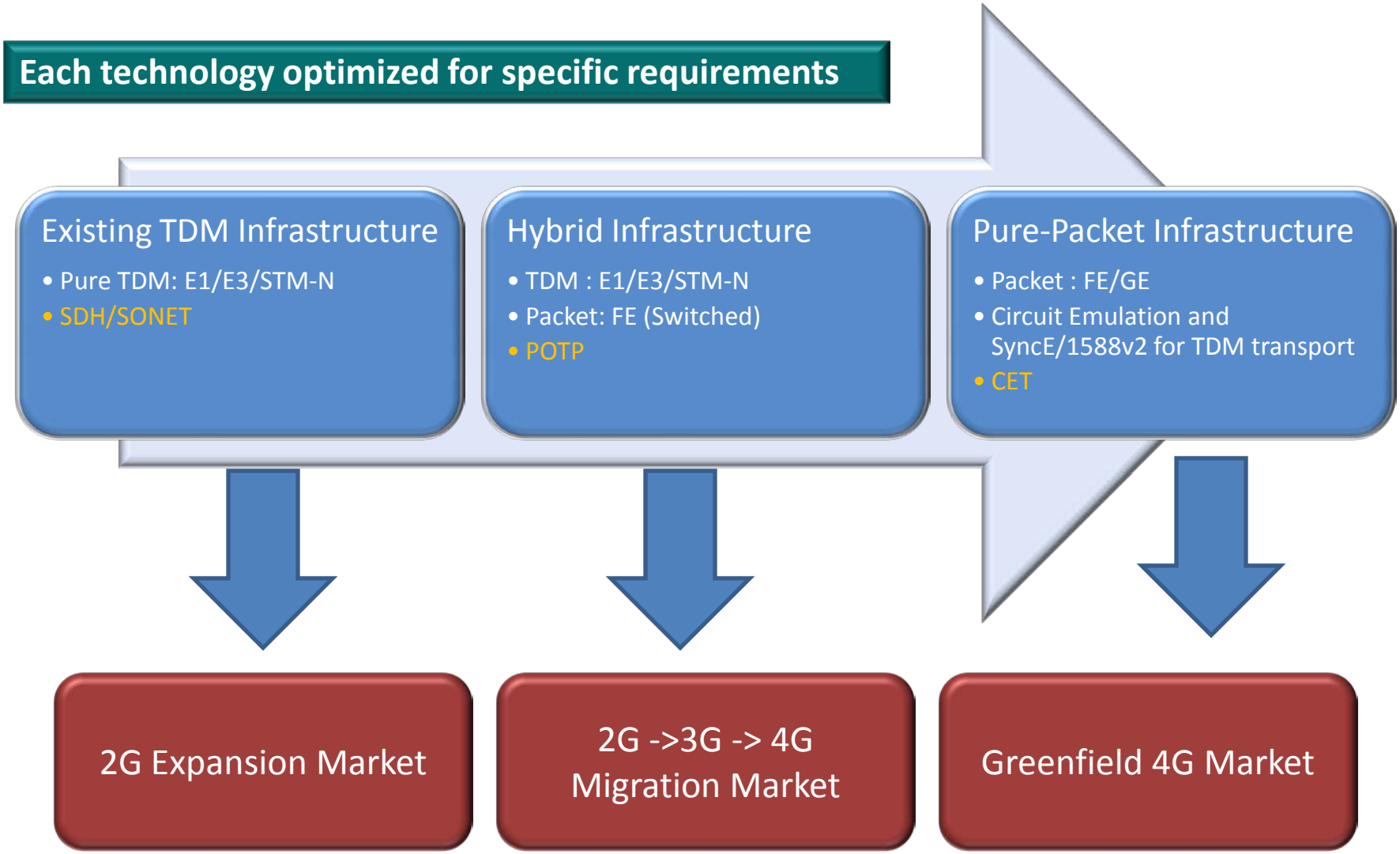
1588-V2

ERPS

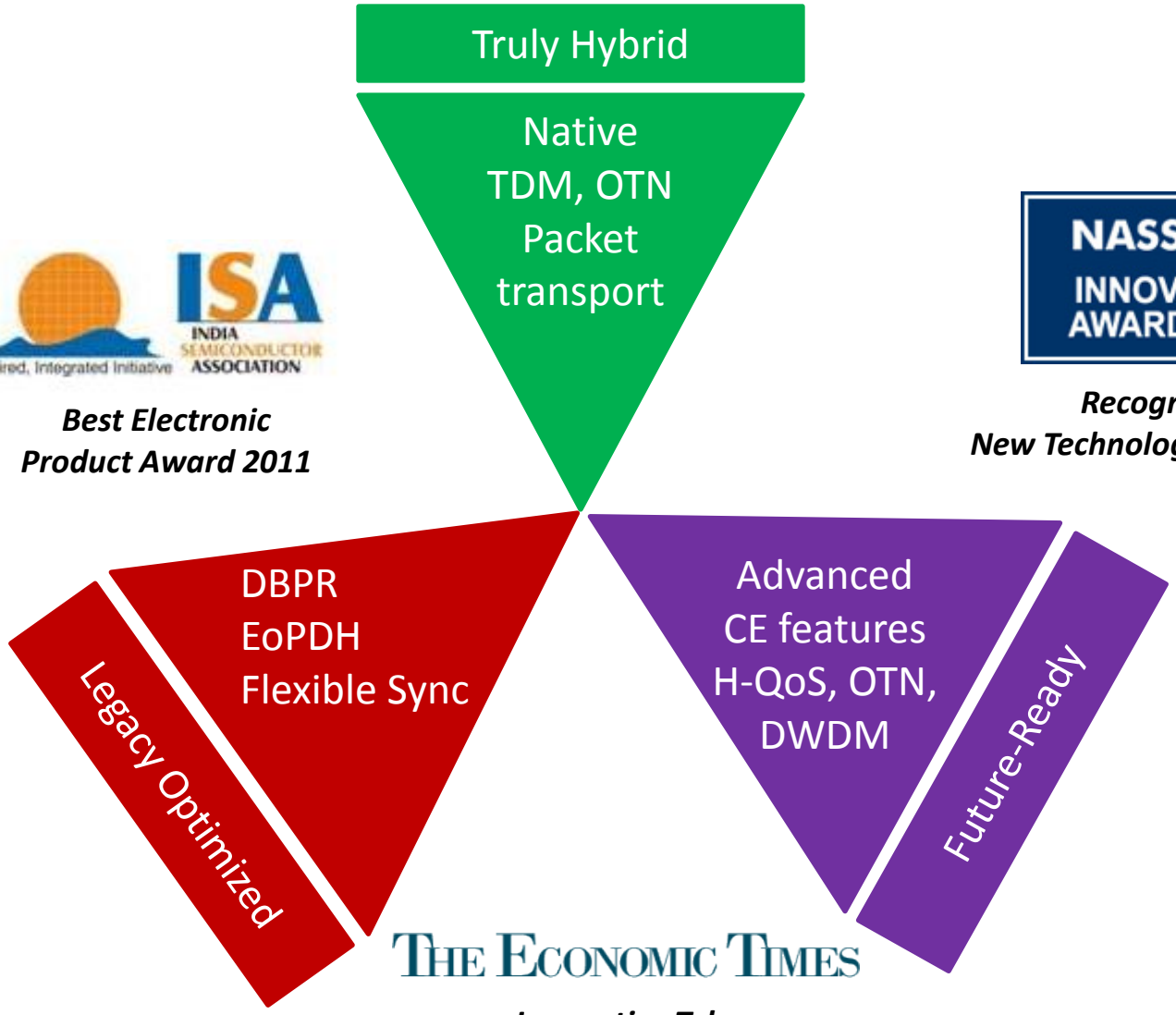
EPC
Evolved Packet Core

To Summarize

Each technology optimized for specific requirements



Tejas XTN – Next-Gen Transport Platform



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Tejas XTN Product Family

TEJAS XTN

TDM/OTN XC

320G

80G

40G

10G

TJ1600

TJ1400

TJ1400

6G

30G

320G

Packet XC

One Optical Family for Diverse Transport Scenarios

About Tejas

Product Company from India

- Based in Bangalore
- Invested over 500 crores
- 11 Years into Optical Networking
- 700+ Employees

Strong R&D Focus

- 30+ Products
- 50+ Patents
- Technology expertise in Optical, Carrier Ethernet and DWDM

Globally Deployed Product Base

- 200,000+ systems shipped
- Over 562,000 Ethernet ports shipped in last year alone
- Winning world's largest tenders in SDH/Optical Networking

Leader in Mobile Backhaul

- Tejas products chosen by India's leading mobile vendors
- 75% of India's BTSes use Tejas Equipment

Thank you!