Next Generation Access Architecture (NGA^2)
-Evolution and Convergence –

September 6 - 8, 2009
FTTH Conference, Shenzhen China

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Agenda

- EPON Evolution - Standards and Network Architecture
- High Density OLT Design - The Role of Distributed Traffic Management
- Next Generation MDU Design - Scalability, Reliability and Upgradability
- Teknovus 10GEPON Roadmap - Carrier Grade EPON

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EPON Evolution
Standard and Network Architecture

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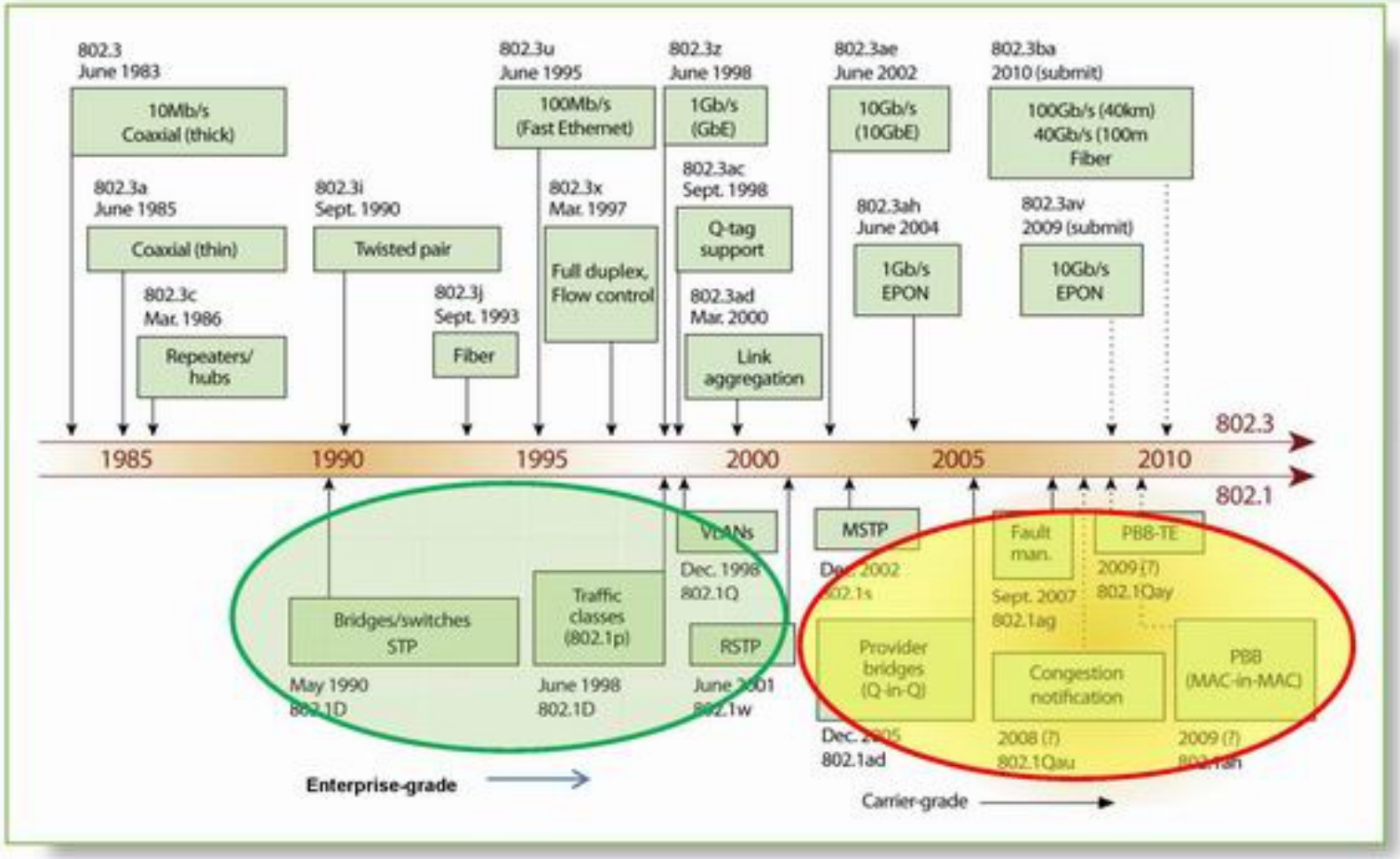
EPON & Ethernet Evolution – A Standard Perspective



EPON Evolves to Becoming "Carrier Grade P2MP Ethernet "

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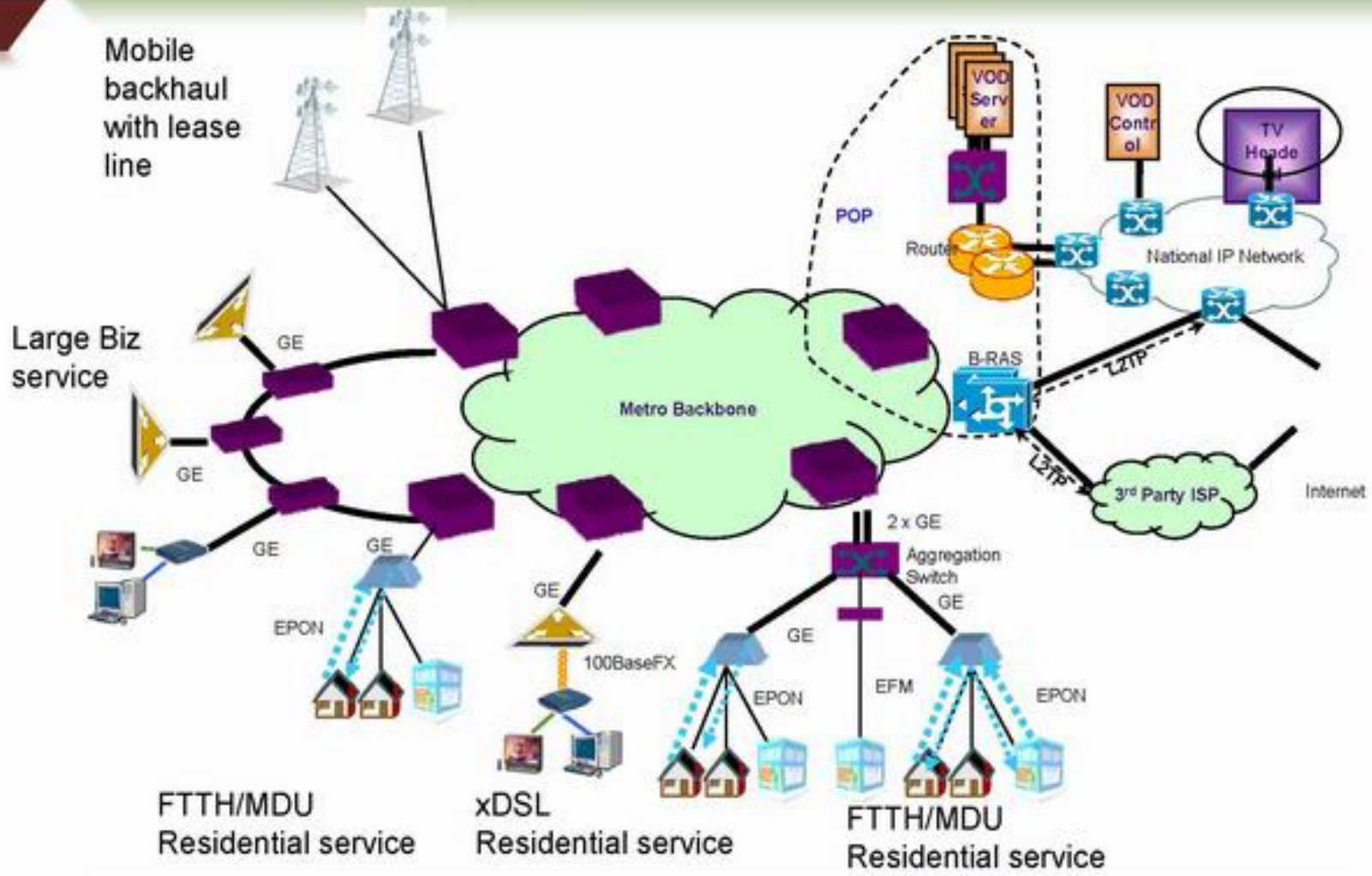
Access Network Today



Parallel Access Networks with Large Metro Backbone

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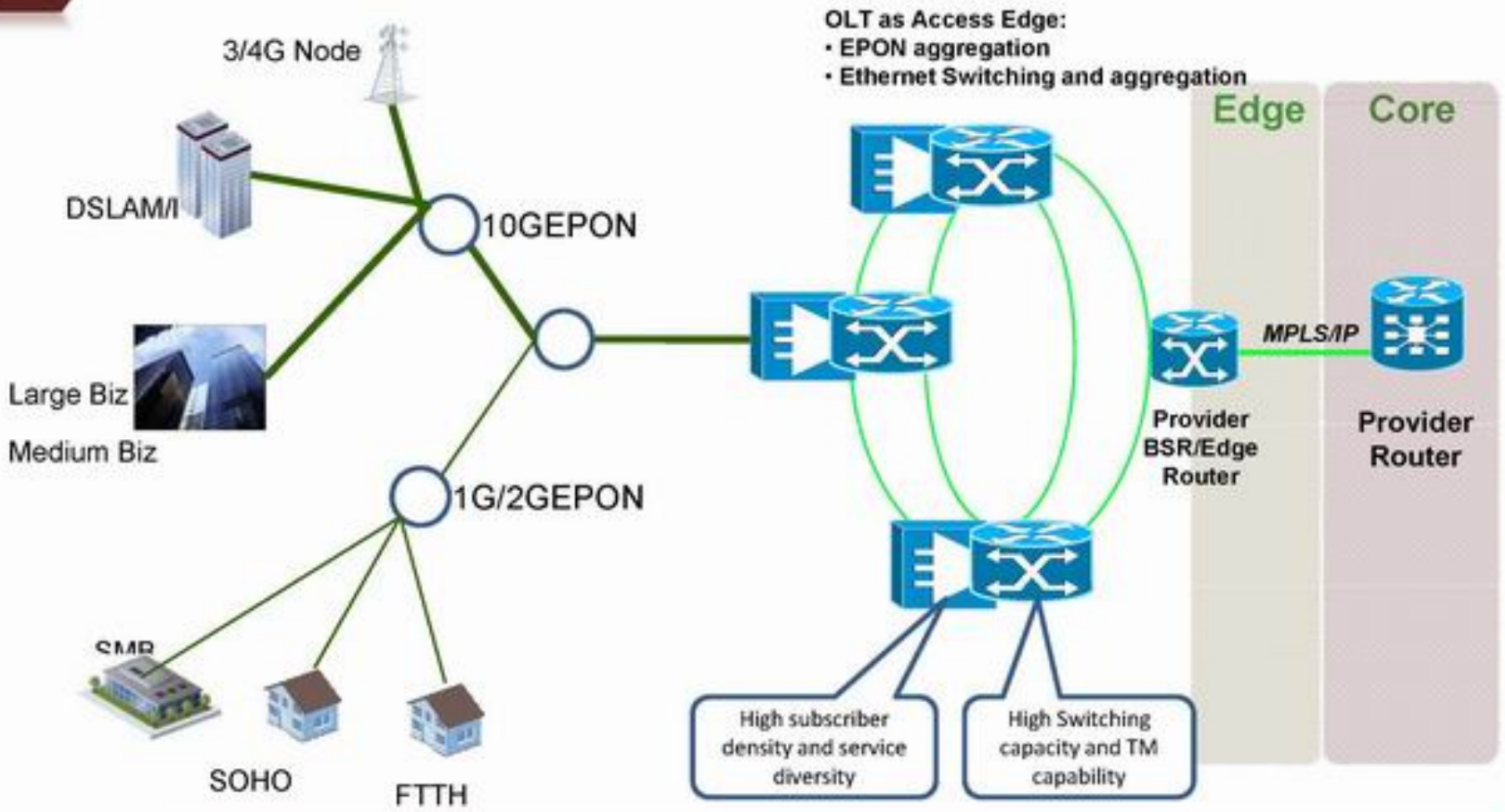
EPON Access Network Evolution – A Network Perspective



EPON Evolves to Becoming "An Unified Access Technology" & Smaller (or disappearing) Metro Backbone

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Ethernet Based Access Network Evolution Trend

- ***EPON is evolving to become"Carrier Grade P2MP Ethernet "***
- ***Today's Access Network is a Parallel Access Networks with Large Metro Backbone .***
- ***Today's access network is quickly evolving to Becoming "An Unified Access Technology" & Smaller Metro Backbone - Ethernet/MPLS switching, aggregation , MEF service compliancy and QoS enforcement become a mandate function***

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NG High Density OLT Design
The Role of Distributed Traffic Management

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NGA² OLT capacity Requirement and characteristics

- EPON significantly expand the geographically coverage
- High sub density in domestic cities

→ Increase the number of subscribers served by OLT by at least a factor of 10

OLT Configurations	1G PON ports	10GEPON ports (100% for MDU)	FTTH (64)/MDU ratio (256 for 1GEPON, 512 for 10GEPON)	Total subscribers	Total Bandwidth to the switching fabric	Total inputs to the switching fabric
Configuration 1	96	0	10%/90%	22732	96GbpsX2	96
Configuration 2	64	16	20%/80%	22118	224GbpsX2	80
Configuration 3	32	32	40%/60%	22118	352GbpsX2	64
Configuration 4	0	48	0%/100%	24576	480GbpsX2	48

- Typical 2 to 4 10GE uplinks
- Such OLT will have an oversubscription ratio between 5:1 to 20:1

- Such OLT must be TM enabled to handle service flows and subscriber pipes

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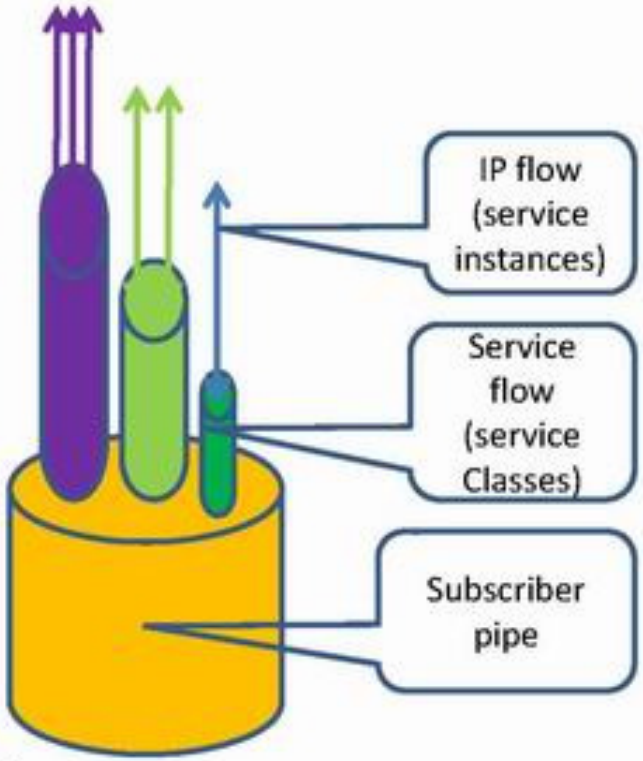
NGA² OLT capacity Requirement and characteristics



OLT Configurations	1G PON ports	10GEPON ports (100% for MDU)	FTTH (64)/MDU ratio (256 for 1GEPON, 512 for 10GEPON)	Total subscribers	Number of queues (4 queues per subscriber)
Configuration 1	96	0	10%/90%	22732	90928
Configuration 2	64	16	20%/80%	22118	88472
Configuration 3	32	32	40%/60%	22118	88472
Configuration 4	0	48	0%/100%	24576	98304

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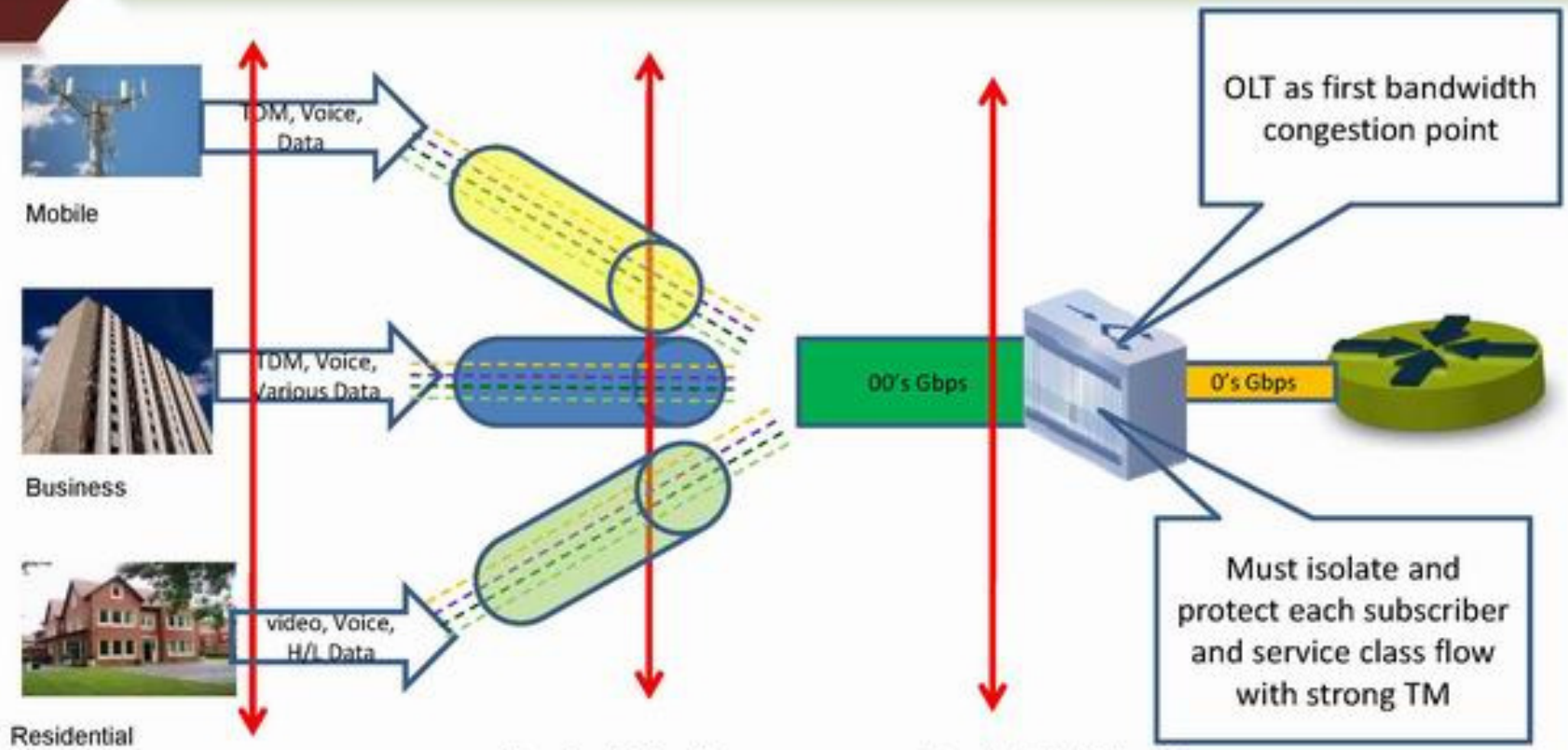
NGA² OLT As Traffic Management Edge



Service Diversity X **Service Velocity**
- 000's subscriber pipes
- 0,000's service class flows

X **Bandwidth Velocity**
- subscriber density
- per sub bandwidth

Such scalability requires distributed TM

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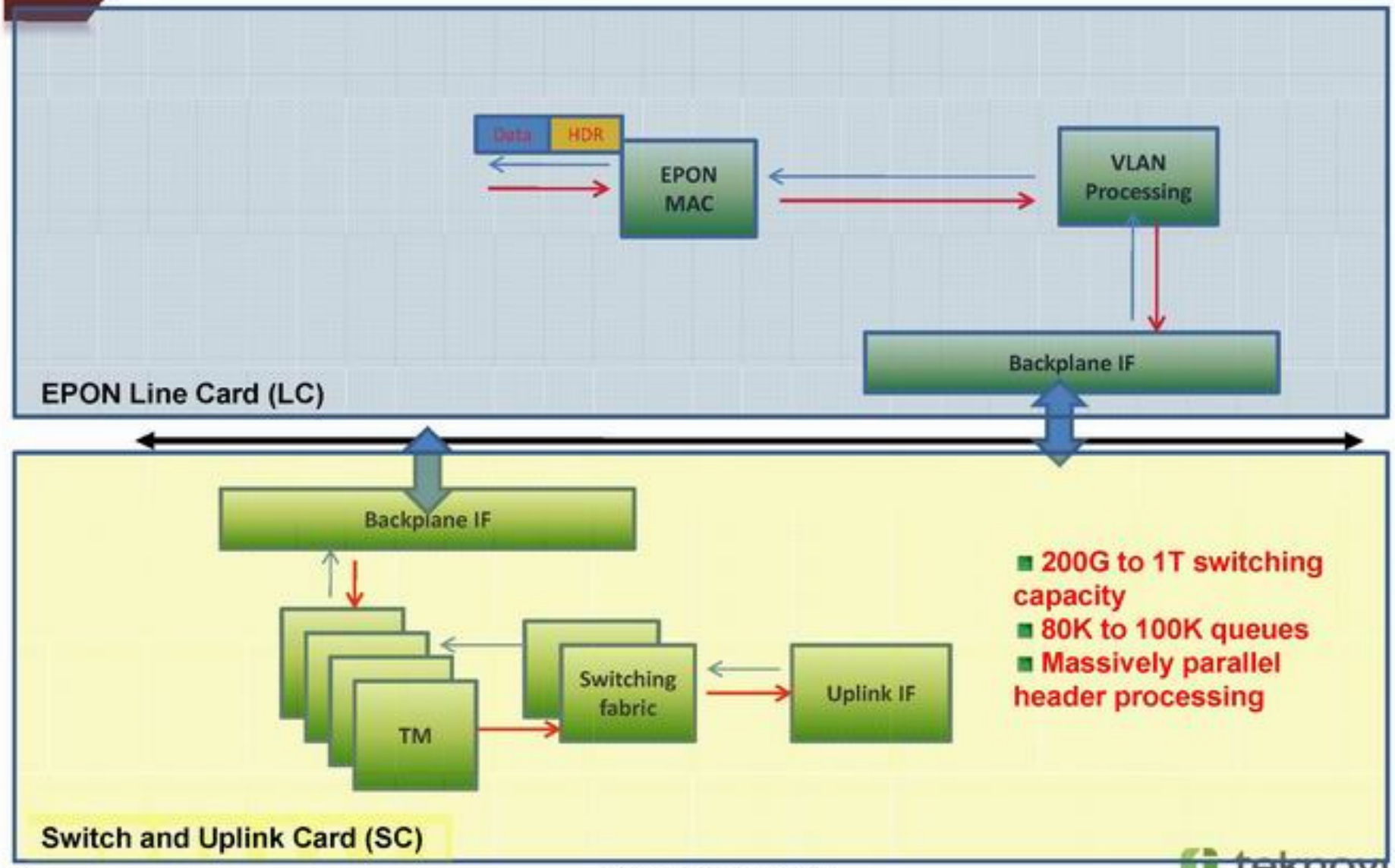
NGA² OLT Design Paradigm - Dumb LC/Intelligent S C



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NGA² OLT Design Paradigm – Dumb LC/Intelligent SC

Use of off-shelf commercial chipset

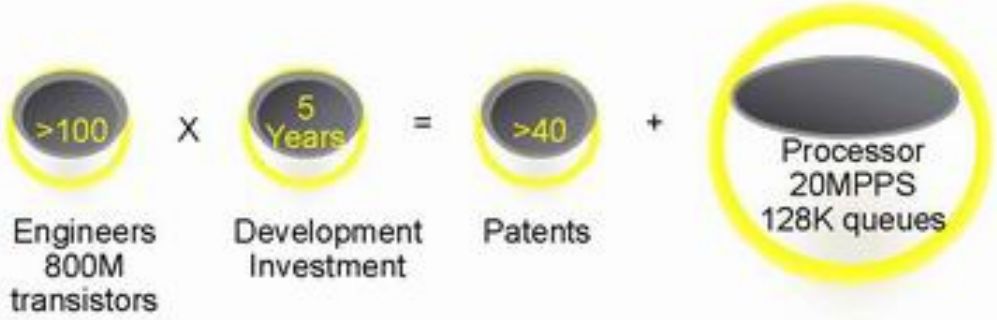
1) Separate Queuing Engine, BW manager, Switch Fabric chips
2) Expensive solution

Chip Description	Sample Switching capacity	Sample Queuing capacity
24Gbps Ethernet Packet processor	24Gbps 2X10G + 24 GEs	Limited
Bandwidth Management engine	20G to 1.2Tbps	Manages multiple Queuing Engine chips
Queuing engine	N/A	Can manage up to 16K queues 16 COS; up to 512MB buffer
Switching engine	40 by 40 cross point switch	
Integrated switching and Traffic manager	20G	Per flow queuing

Clearly neither solution is ideal

Use of in-house purpose built ASIC

1) Not every company can build this technically
2) Huge development effort
3) Very Expensive



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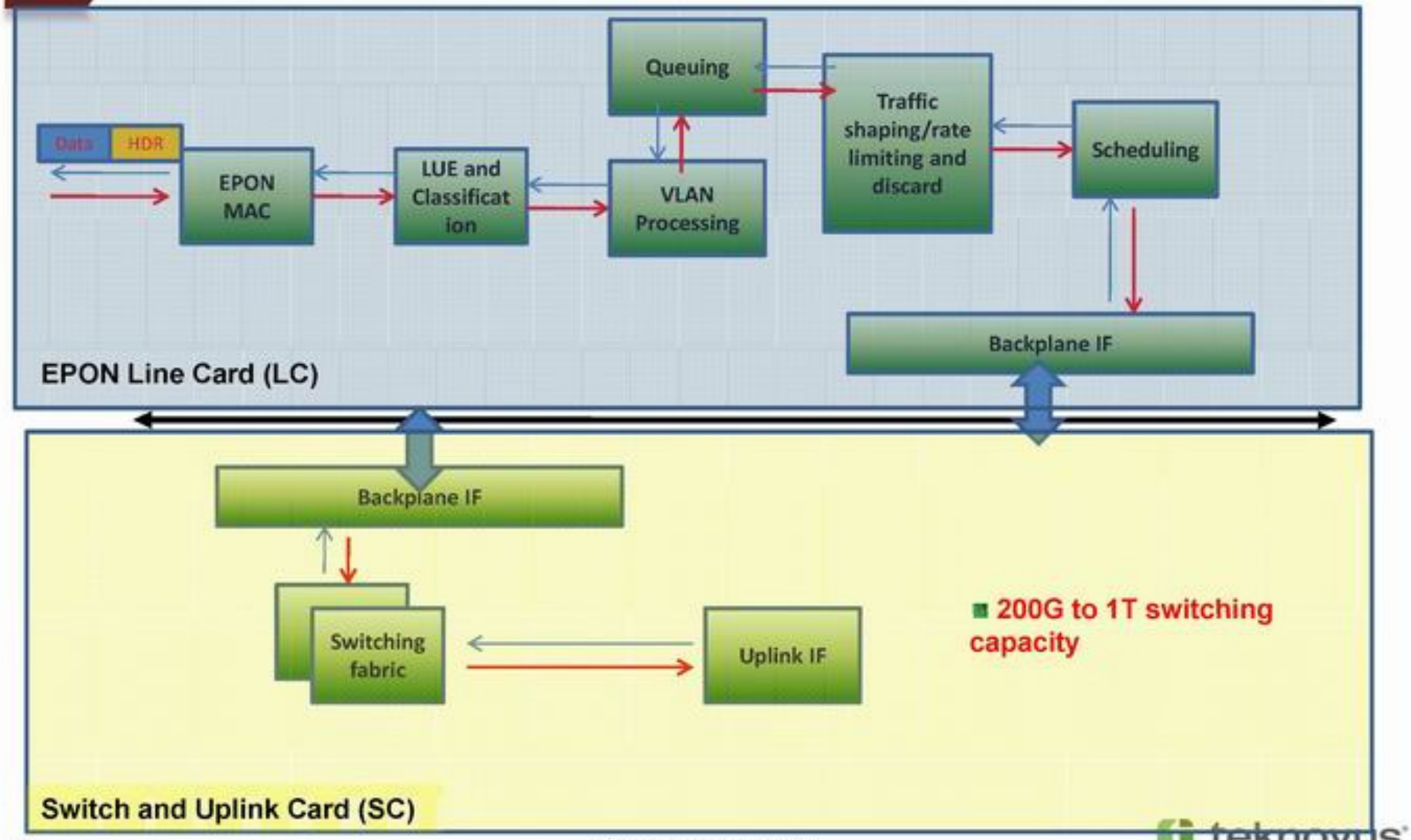
NGA² OLT Design Paradigm - Intelligent LC/Dumb SC



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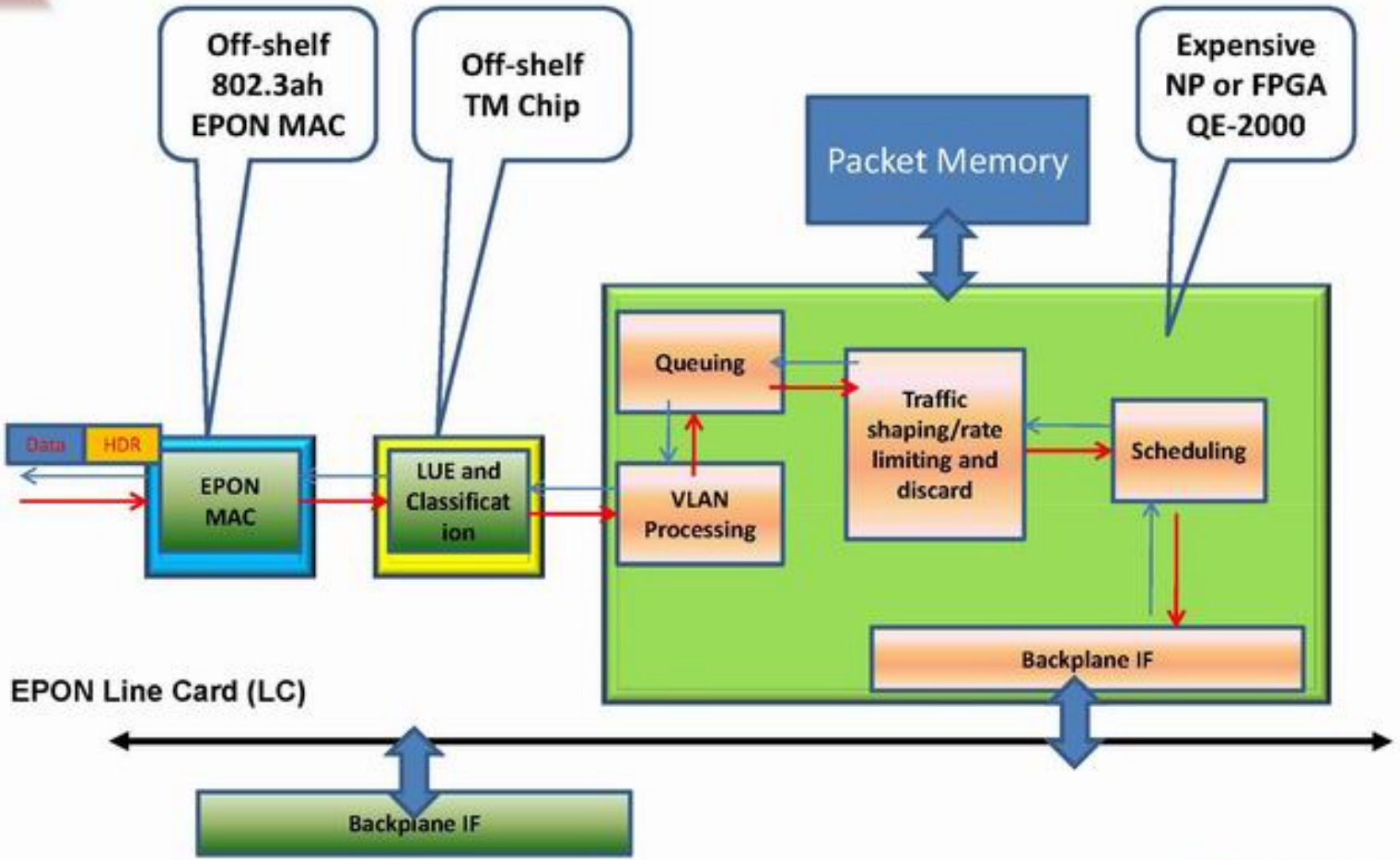
Mapping Functions into Designs – 3 Chips



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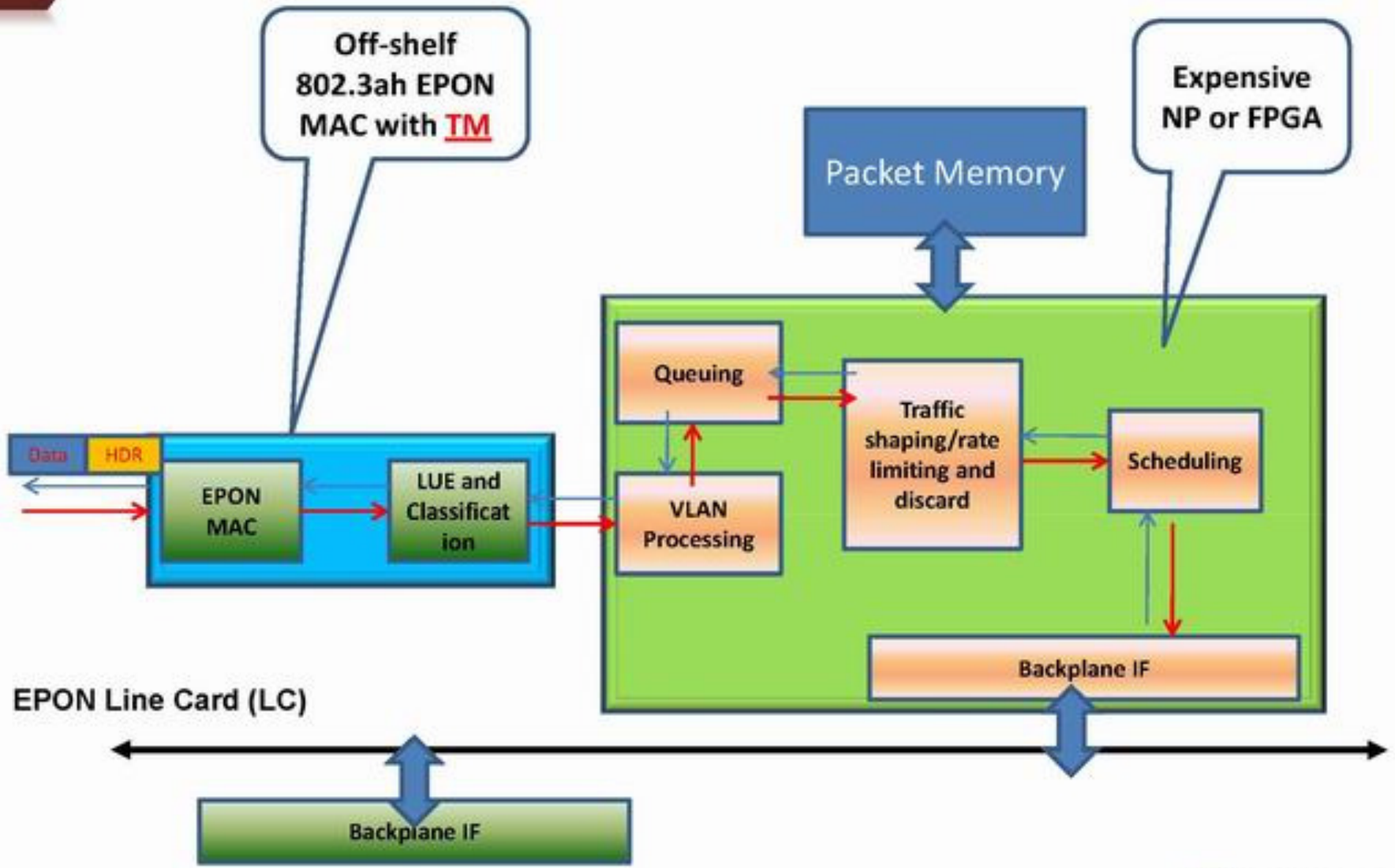
Mapping Functions into Designs – 2 Chips



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Next Generation OLT Architecture Trend

- ***Carrier Access Network evolution mandates the higher density, metro-aggregation capable EPON CO system***

- ***To scale with line card density and the increasingly important end-to-end QoS requirement, intelligent line card with TM built-in is critical for next generation OLT architecture.***

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NG MDU Design
Scalability, Reliability and Upgradability

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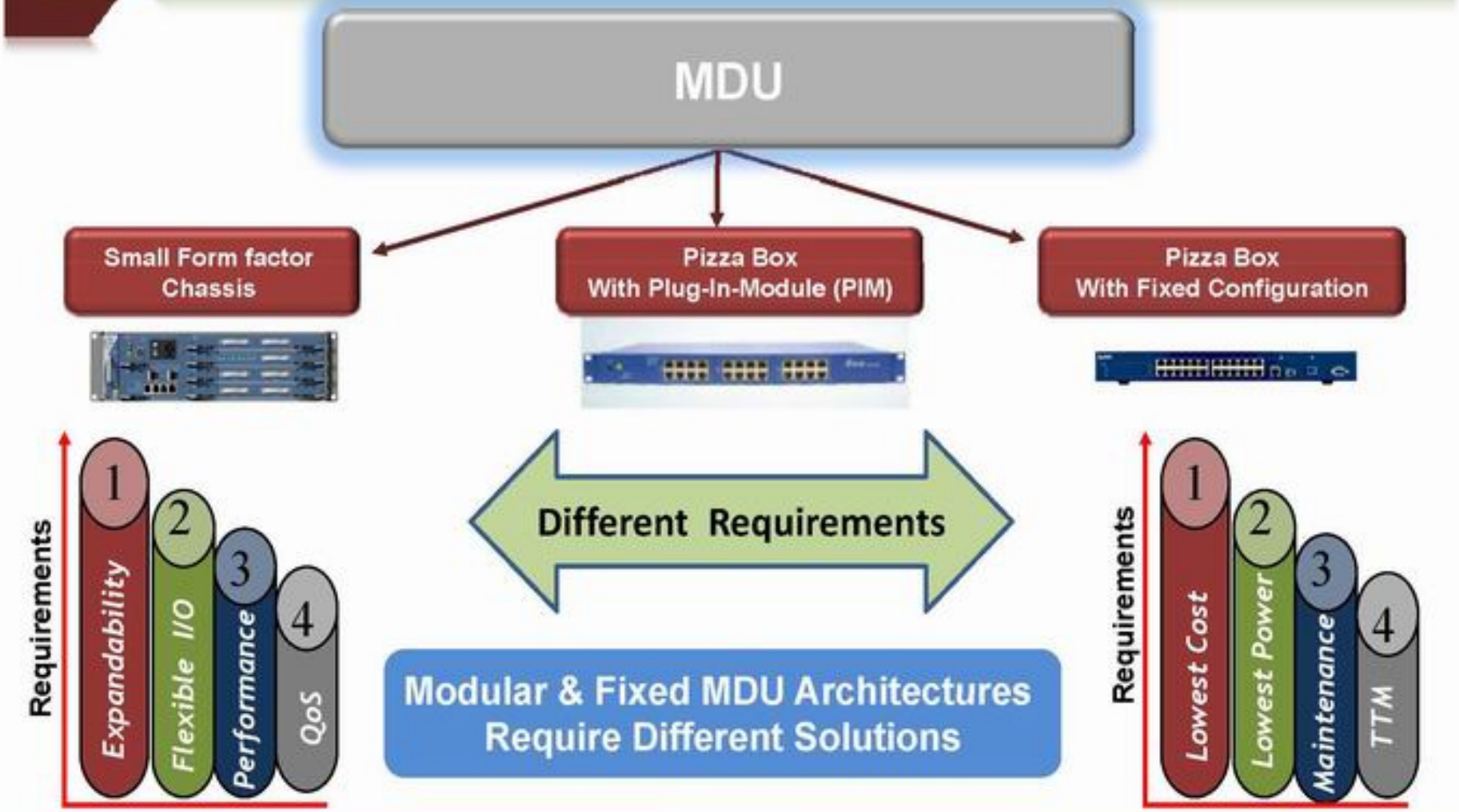
EPON MDU Market Segmentation



Discrete High-Performance EPON ONU + NPU for Modular MDU Systems

Integrated Single-Chip EPON MDU SoC for Pizza Box MDU Systems

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EPON MDU System Requirements

Scalability from 1G to 10G

1G, 2.5G, 10G EPON
1G & 10G Co-Existence
High Performance / Low Latency
Scalable IPTV Processing

Security & Reliability

CTC Encryption
VLAN Processing
Protection Switching
Optical Monitoring
High Availability
Access Control

Quality of Service

Multiple CoS
Policing / Shaping
Traffic Classification
SLA Enforcement
Congestion Avoidance

Characterized Software

Proven EPON S/W
Open Platform
Customizable Switching S/W

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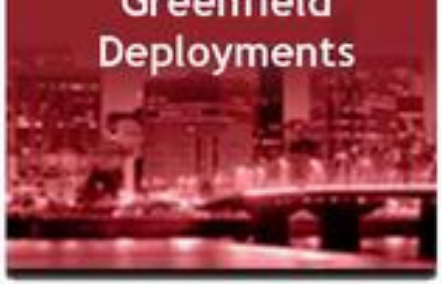
Teknovus EPON Solutions for MDU

Cost & Performance Optimized Platform Solutions for MDU's Enabling OEMs to Differentiate, Reduce System Cost, and Accelerate Time to Market

Proven Worldwide EPON Deployments & IOP Experience	Single Chip MDU SoC with Turnkey Carrier Grade S/W	Scalable 1G to 10G MDU Solutions	Support for both EPON + xDSL & EPON + LAN MDU Deployments
⇩	⇩	⇩	⇩
Carrier EPON Compliant Fixed & Modular MDU Platforms	Lowers OEM Risk, CapEx & OpEx	Future Proofing OEMs for Supporting Higher B/W Applications	OEMs Can Target Both Brownfield & Greenfield Deployments



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Dragon™ EPON MDU Product Family

1G to 10G Scalable Single-Chip EPON MDU SoC Solutions

PERFORMANCE

Dragon™ 10G-B
- Integrated 10G EPON
- 16x GE UNI
- Integrated GE PHY

Dragon™ 10G-A (TK4718)
- Integrated 10G EPON & Switch
- 24 FE UNI
- DSL & Ethernet Deployments

Dragon™ 1G (TK3718)
- Integrated 1G EPON ONU & Switch
- 24 FE & 3x GMII
- Supports DSL & Ethernet Deployments
- SMII & PHY Outputs
- Dual CPU Architecture

There is a Dragon™ Inside !

2009' Q3 2010' Q2 2011' Q1

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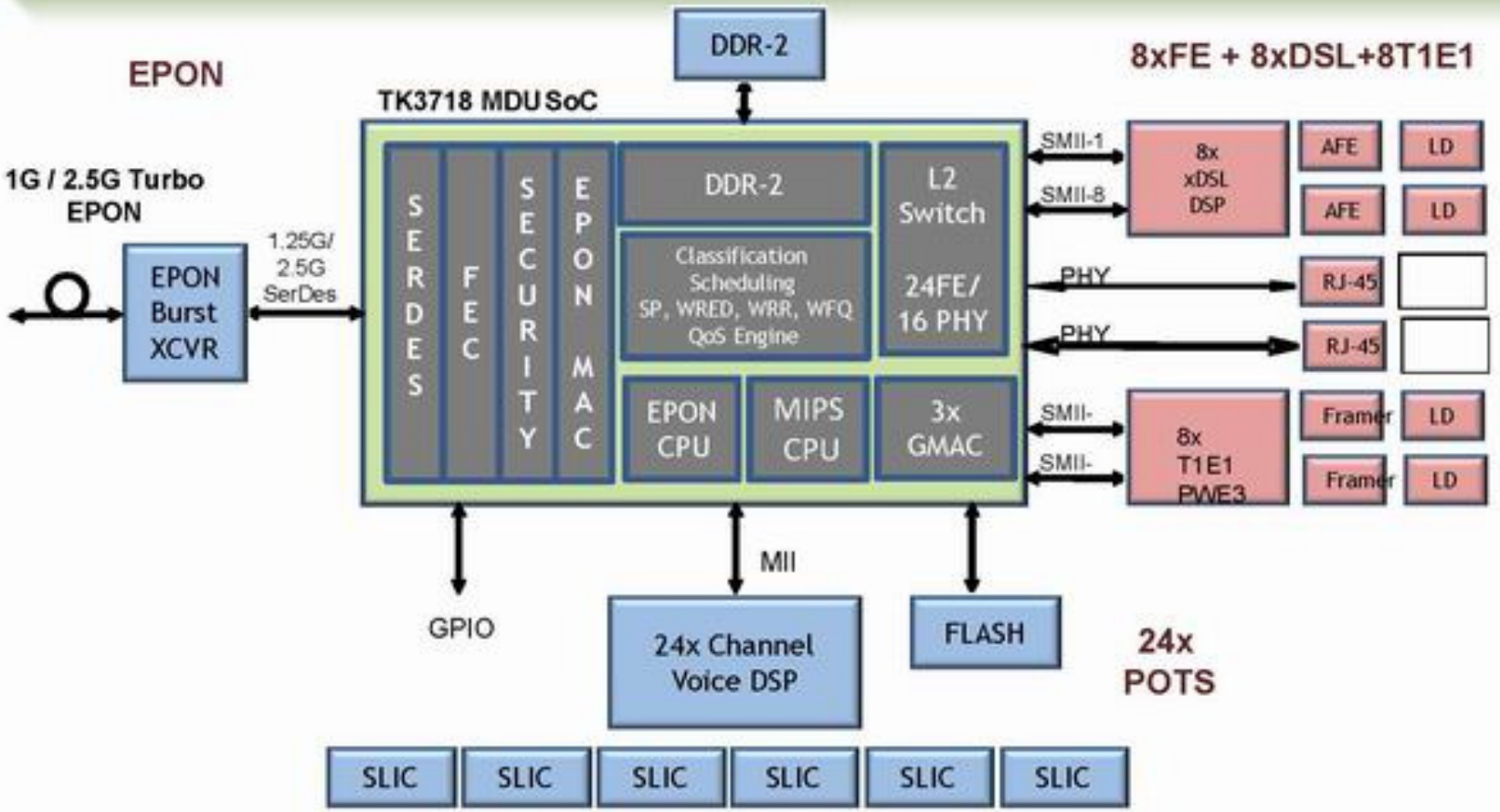
Pizza Box MDU with Plug-In-Modules (PIM)



- Cost optimized FE PIM with integrated PHY
- Strict QoS and clock transport for TDM and Cellular backhaul, and Voice
- Hot Swappable PIMs for in-service upgrade/change

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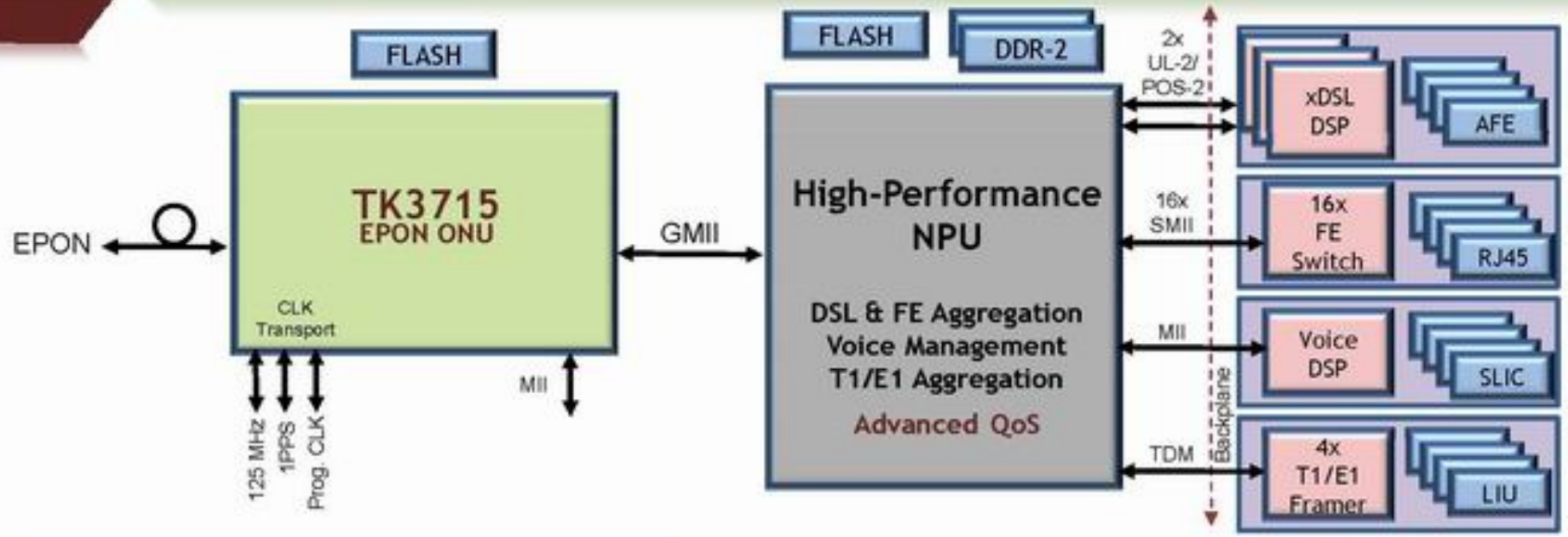
Small Form Factor Chassis MDU with Backplane



Best in Class EPON ONU

- Auto-sensing 1G/2.5G Turbo-EPON ONU
- Ultra-low power @ 725 mW
- CTC 2.1 IOP Compliant w/ OAM & Triple Churning
- Per-Class SLA Mgmt using Multiple-LLID w/ 8 LLIDs
- Traceable 1 PPS and 125MHz Ref Clock Transport
- CTC Type A, B, C Protection Switching
- Integrated DDMI -based Optical Monitoring
- Deep Packet Classification and Queuing
- IPTV Multicast Filtering/IGMP snooping v1/v2/v3
- Flexible LLID to VLAN Mapping

Programmable High-Performance NPU

- Simultaneous Ethernet, DSL, Voice Mgmt, and TDM Processing
- High-Density DSL: 2x UL-2/POS-PHY for 48x VDSL-2/ 96x ADSL-2+ ports
- Embedded CPU for OAM, xDSL, and chipset and line card management
- TR-101 Compliant Solution
- Integrated Traffic Management, VLAN , Policing, and Security
- ATM AAL5 SAR termination w/ Up to 576 bi-directional AAL5 VCCs
- Interworking functions supporting PPPoA/PPPoE and IPoA/IPoE
- WFQ, WRR and Strict Priority scheduling for QoS management
- Per flow-based queue length management with WRED dropping
- Per flow-based dual Leaky Bucket shaping for egress data rate

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MDU Strategy Summary

- Flexible silicon solution targeting different equipment type is key to achieve success for segmented MDU market

- For modular or pluggable system, the following needs determines that a single EPON MAC best fits solution:
  - Flexibility - Fit into a modular system partitioning that can enable a series of applications
  - Scalability - Enable carrier to smooth upgrade from 1G to 10G by simply swapping the PON interface module
  - Reliability - Capabilities such as equipment protection switching

- For fixed platform, fully integrated chip provides most optimum solution:
  - Economics - cost competitiveness to enable low CapEx
  - QoS - Support multiple services with a minimum class based service isolation

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Teknovus 10GEPON Roadmap
Chipset, Technology and Solution

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10GEPON Status Update

- Teknovus actively participates and leads 802.3av 10GEPON standardization which is set to announce the completion on September 10th, 2009 - a very significant milestone
- Teknovus leads a dozen of worldwide carriers and key OEMs for 10GEPON service trial
- Teknovus provides FPGA based (both symmetrical and asymmetrical)10GEPON solution today - this has been designed into over 70% key OEMs products already.
- Teknovus is on track to deliver 10GEPON ONU ASIC Q1/2010 with carrier grade10GEPON OLT to follow.

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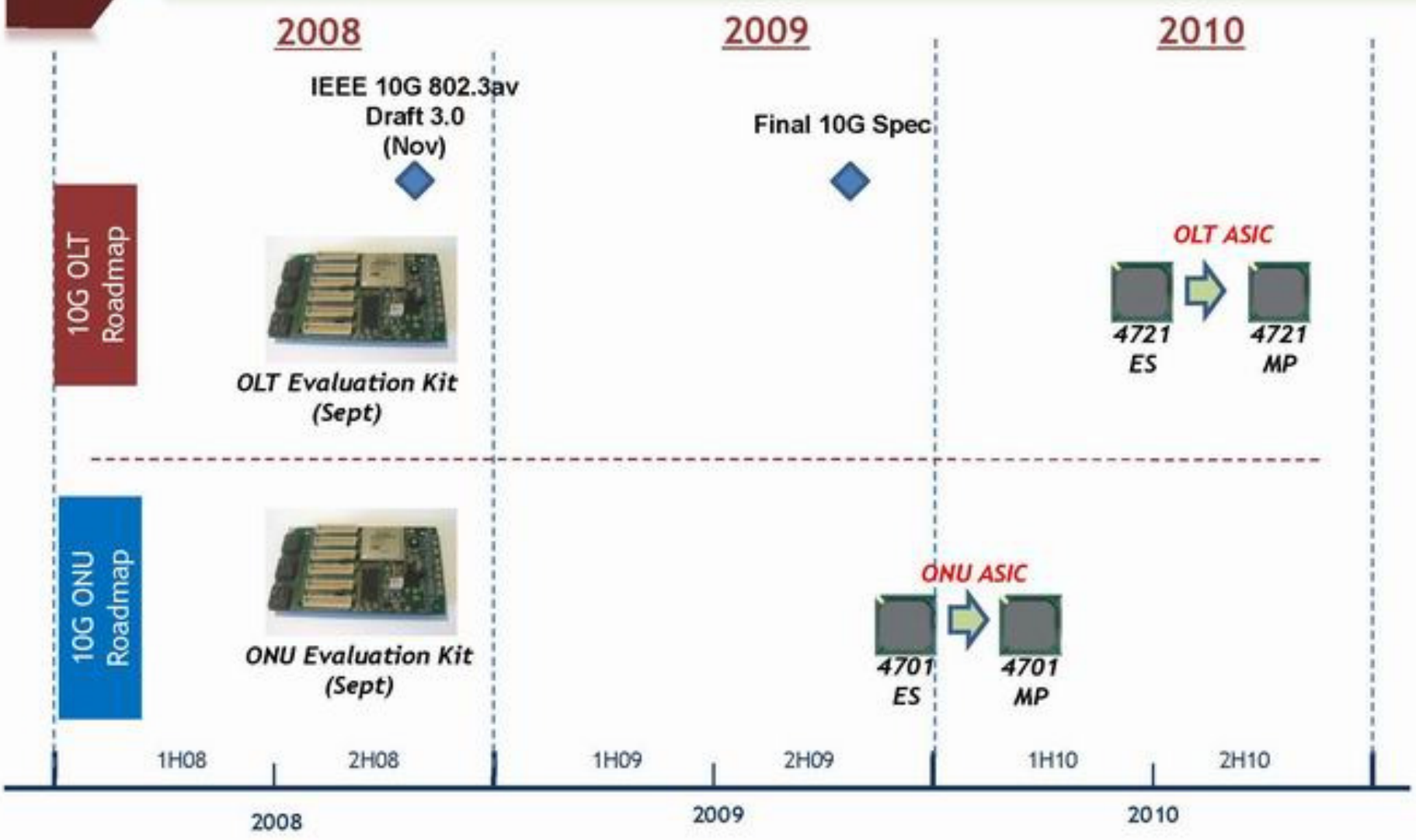
10G Timeline



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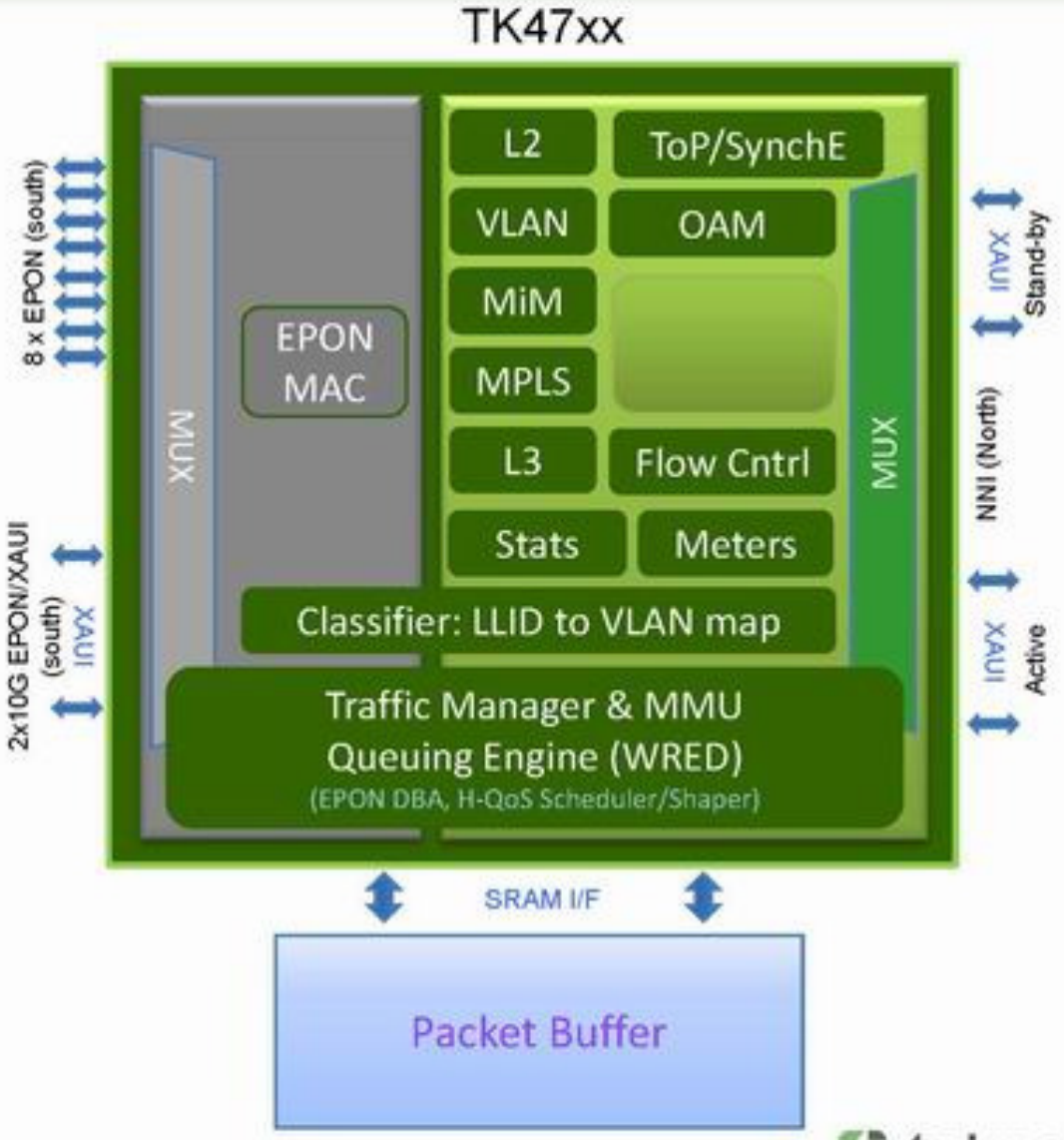
Next Generation 10G OLT Architecture

Key Features

- LER-lite (PE-s lite)
  - Virtual Switch Routing
  - L2.5 Services
    - QiQ Cross Connect
    - MPLS
    - MiM
  - Traffic Management
    - H-QoS
    - Policing
    - WRED
  - OAM HW off-load
  - SynchE & ToP
- LIM MODE
  - EPON OLT LIM
  - Active Ethernet LIM
- ROLT MODE
  - Active Ethernet
  - NT Co-processor/Proxy
- Virtual Routing
  - IPv4
  - IPv6
  - Inner working



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Carrier Ethernet Priorities

EOAM	Fault Monitoring/Protection
	Performance Monitoring
L2.5	Stacked VLAN
	MPLS and MAC in MAC
Traffic Manager	Policing/Metering, Admission Control
	H-QoS (Hierarchical Scheduling)

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Features Overview

CO OLT

- 10G EPON
- Provider Bridging (QiQ)
- VLAN Cross Connect
- WRED
- Policing (2R3C mark)
- MEF TM (3L ingress)
- OAM (CCM per VLAN)
- XAUI back plane I/F
- UNI-type1

Remote OLT

- 2x10G EPON or 8xG
- MPLS-TE and PBBT-TE
  - VPWS/E-LINE
- 3L H-QoS scheduler up
- OAM (Y.1731/802.1ag)
- MEF 3L egress & ingress
- TM with H-QoS 3 level up
- OAM (CCM per EVC)
- XAUI/10GE w/Flow Cnrl
- UNI-type 2

Provider Edge-lite

- 2x10G EPON or 16xG
- Active Ethernet w/LAG
- MP-MP L2/L3 VPNs
- E-LAN/ VPLS
- TM H-QoS (3 level up)
- TM H-QoS (3 level dwn)
- OAM (PM per service)
- UNI-type 3
- Virtual Routing
- L3 MPLS (RFC-2547)
- H-VPLS
- L3 tunnels (GRE/IP-IP)
- Advanced Filtering

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Thank You

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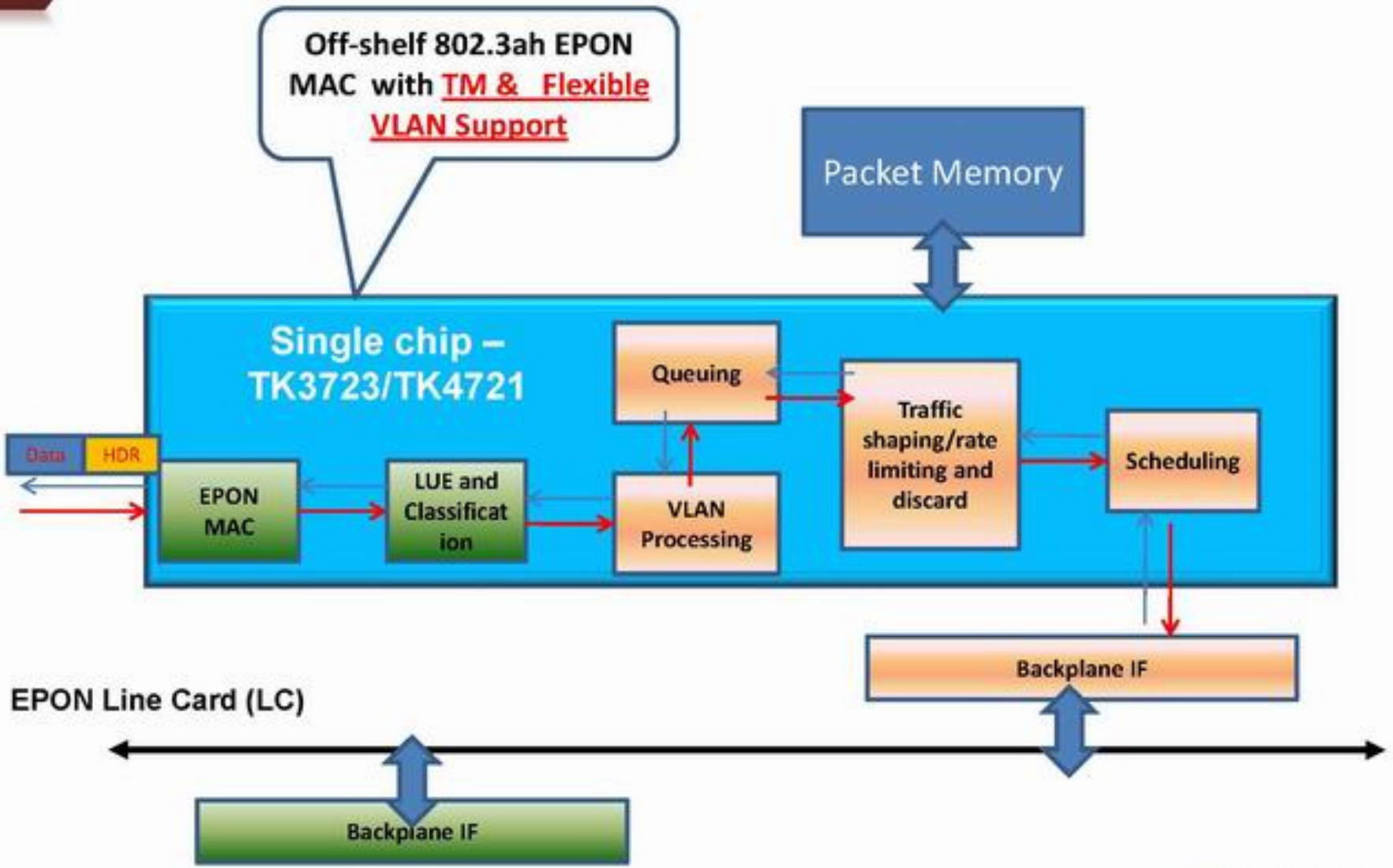
Mapping Functions into Designs – 1 Chip



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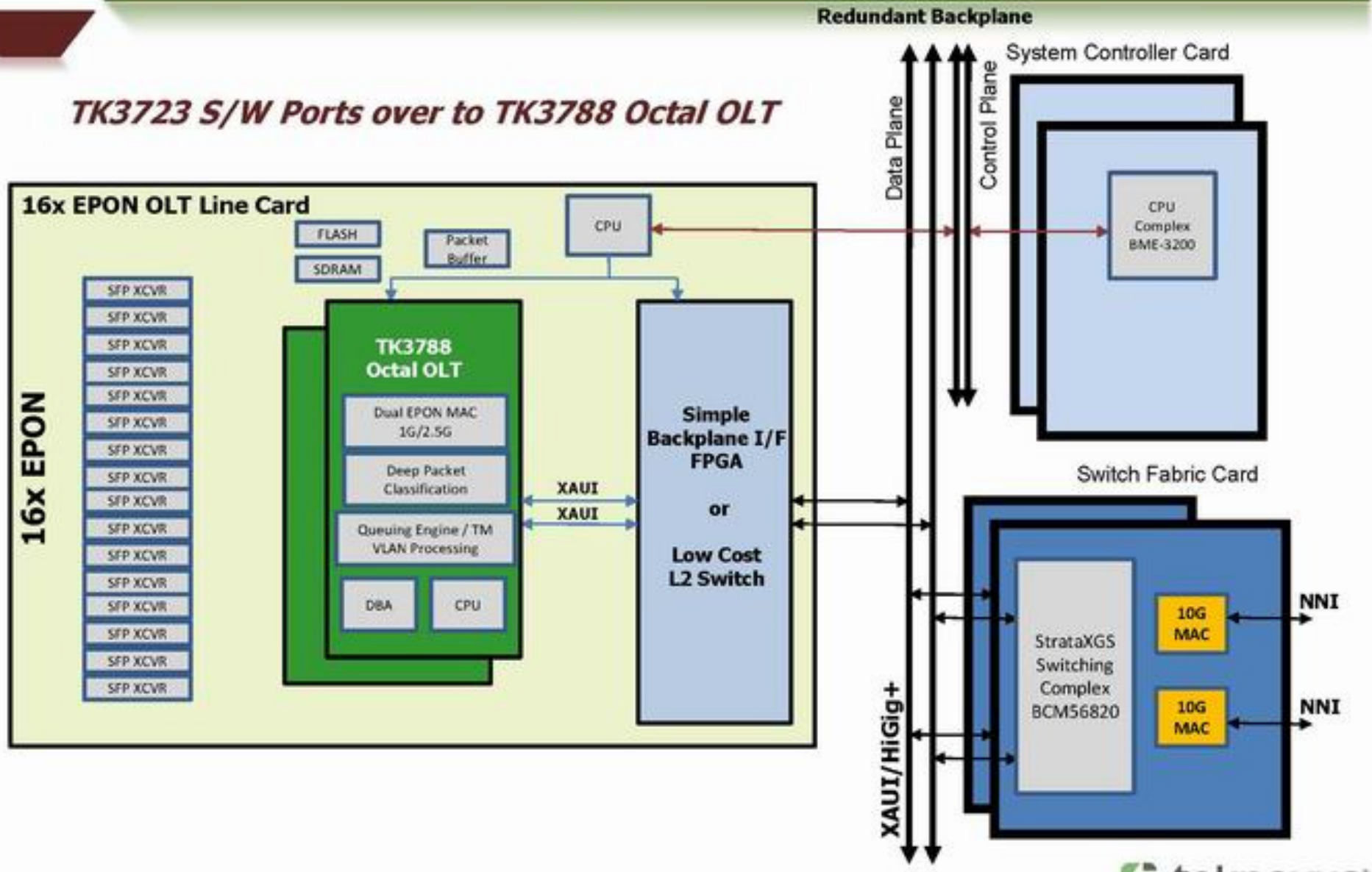
A²N OLT – 16x 1G/2G Line Card with TK3788



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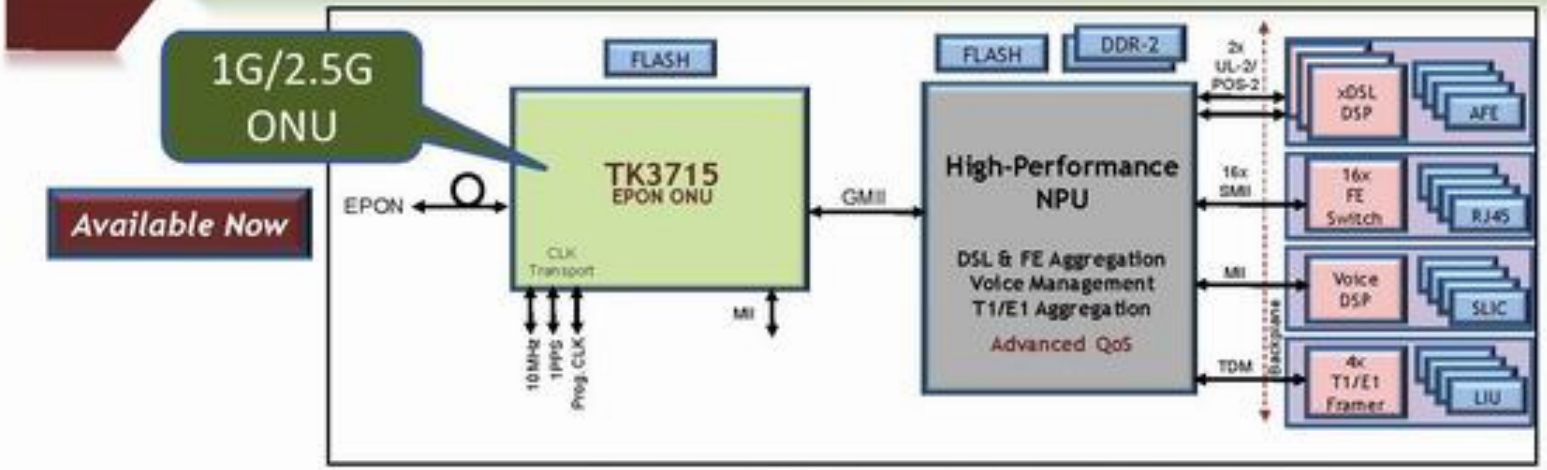
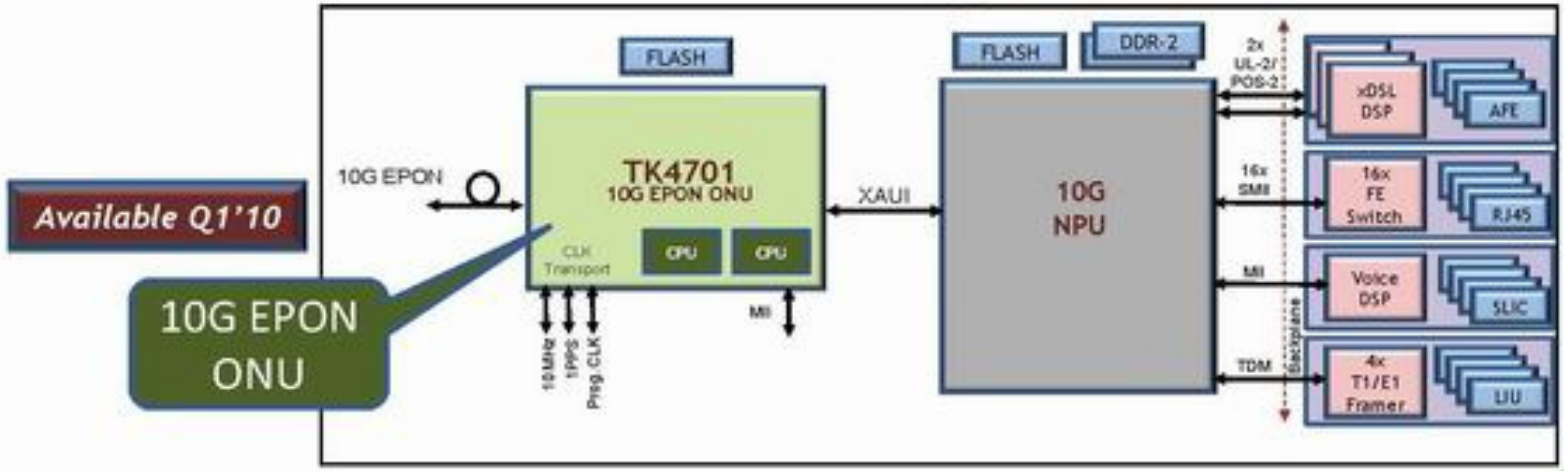
Upgradability from 1G to 10G EPON



Scalable Migration to 10G EPON with Full Backward S/W Compatibility



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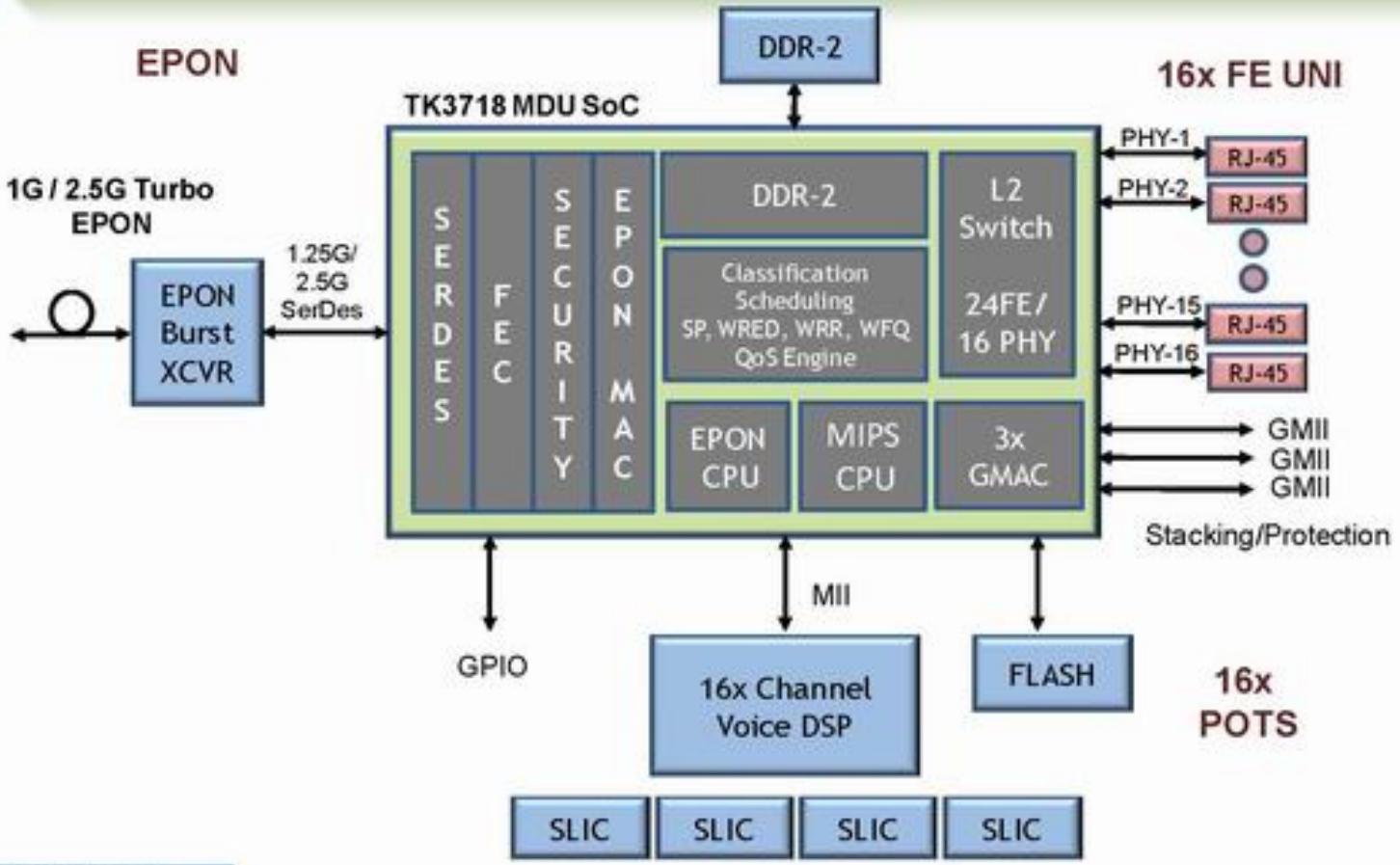
Pizza Box MDU with Fixed Configuration



TK3718 rBOM (16FE)	
Flash	$1.10
DDR2	$ 2.00
Optical Module (1G)	$12.00
Total rBOM	$15.10

- Cost optimized with integrated PHY
- Lowest power consumption for FAN-less deployment
- Proven EPON solution and L2 switch solution

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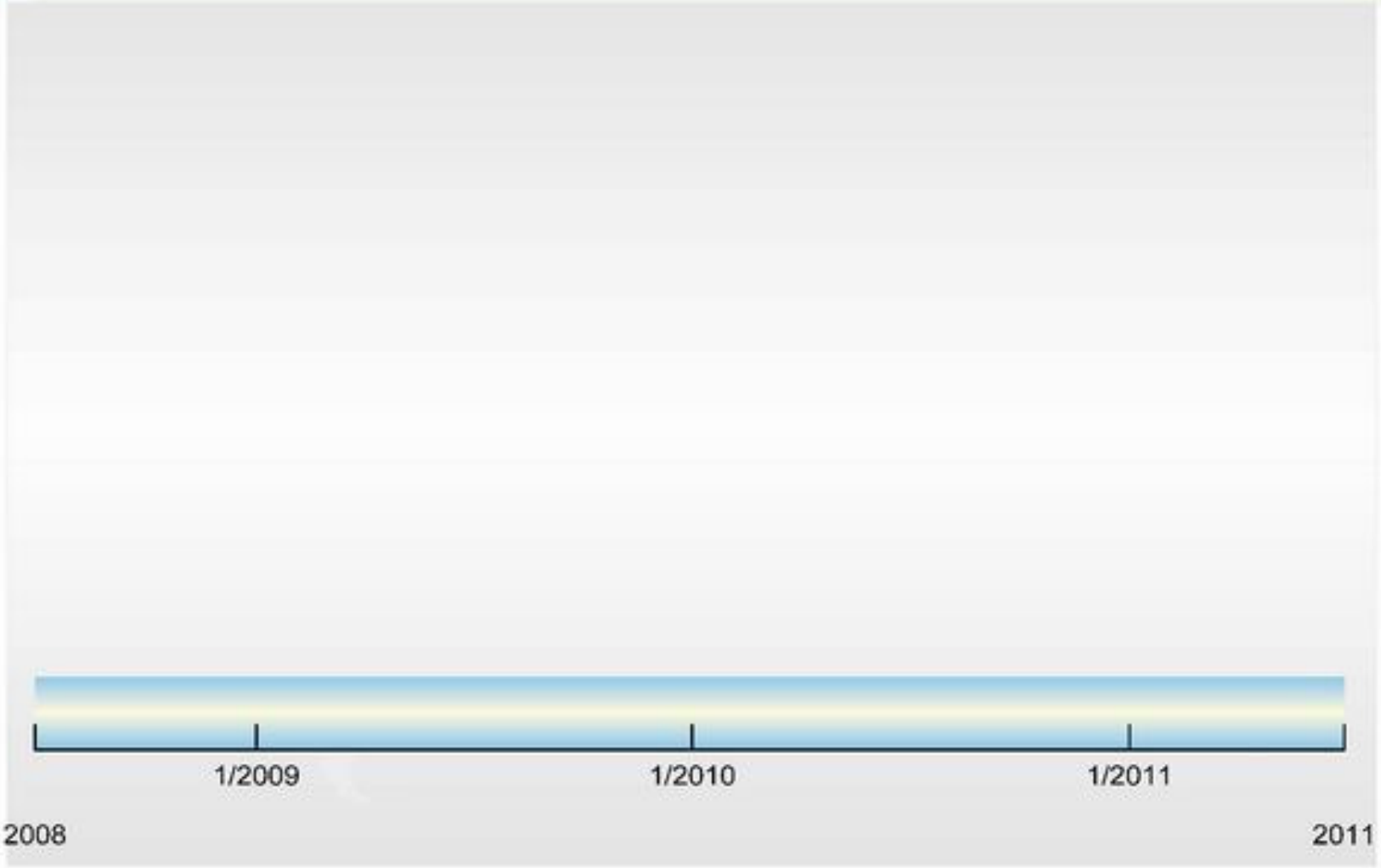
Teknovus Key Carrier Class Technology Roadmap



*** Currently being proposed by ITU-T SG15/Q2 and GPON Vendors. Teknovus is actively participating.**

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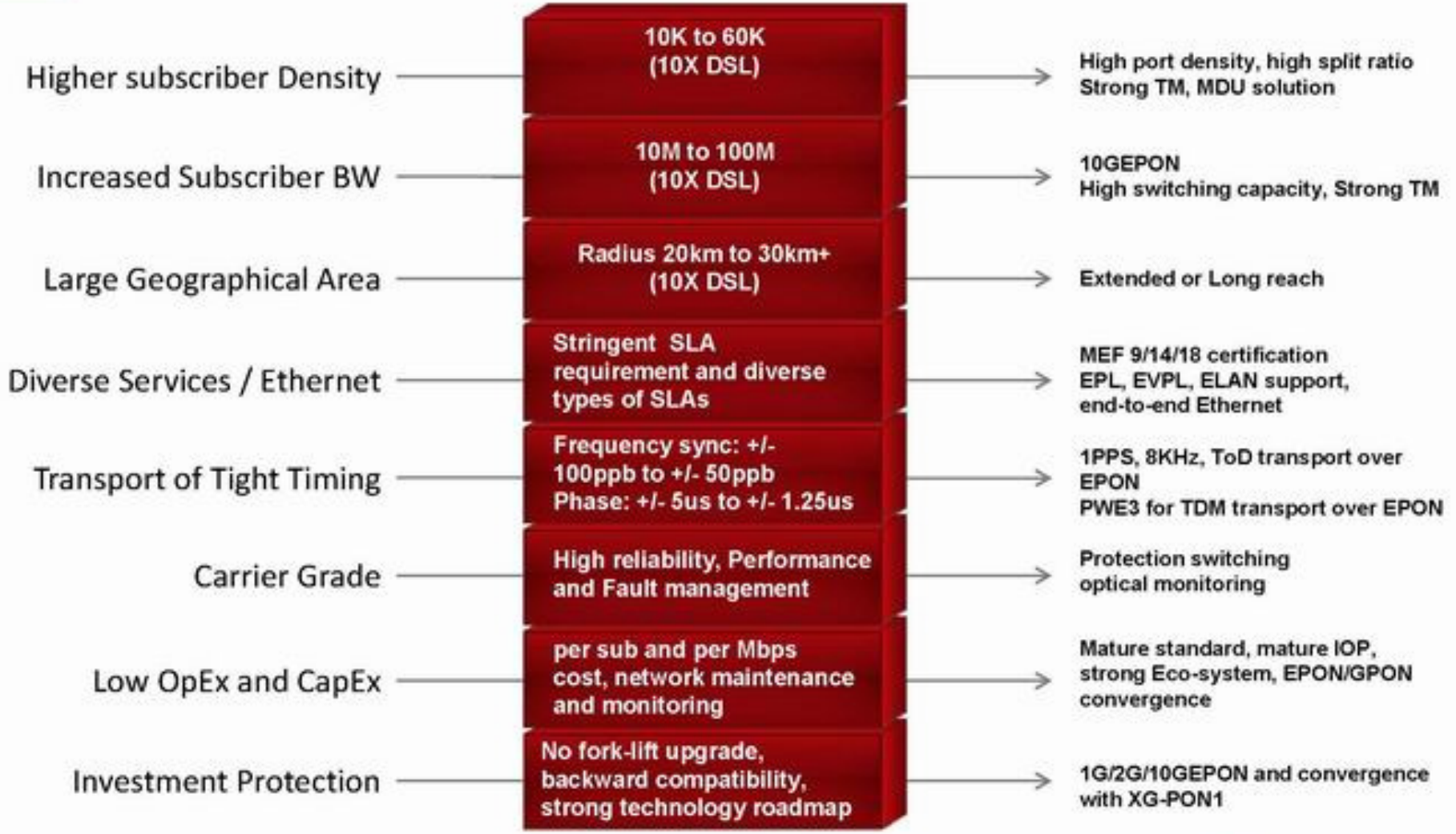
Requirement and Technologies for NGA²



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