NG-EPON

PERSPECTIVE FROM BRIGHT HOUSE NETWORKS
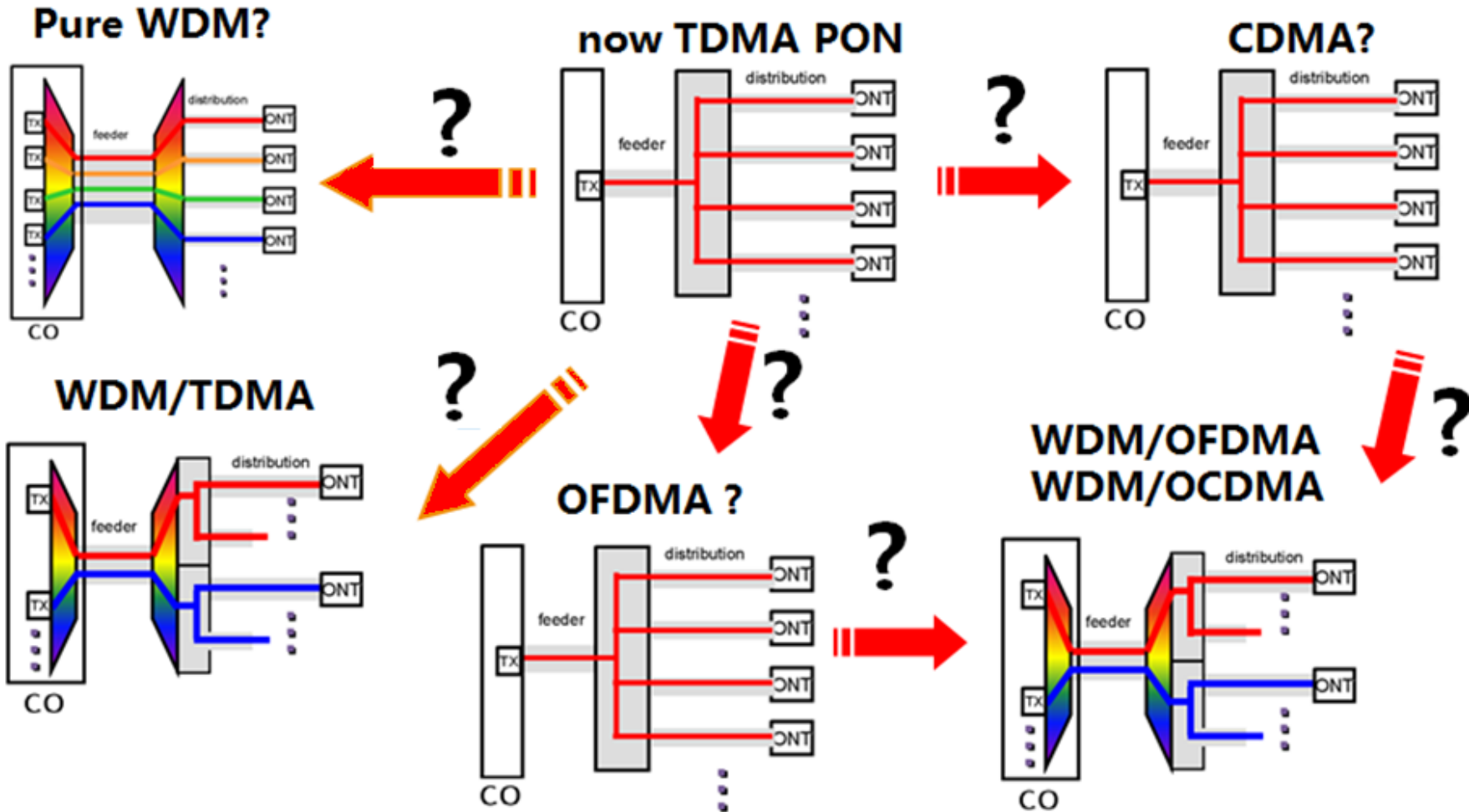
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Rev R07

Many paths forward …

o There are many paths forward possible from current EPON systems

  o WDM-PON, OFDMA-PON, CDMA-PON, and others.

  o Different combinations of technologies are also possible

o With so many options available, for an operator with deployed 1G-EPON devices, a few aspects of NG-EPON are critical, classified into the following groups:

  o Device compatibility

  o ODN compatibility

  o Service compatibility

o Individual items are discussed in more detail on next slides

DEVICE COMPATIBILITY

Device Compatibility (i)

o 1G-EPON has been a largely successful optical access technology, deployed in different scenarios around the world.

o In BHN, we use 1G-EPON today for commercial services, providing symmetric links to end customers. Each link is associated with specific SLAs.

  o SLAs for commercial services include bandwidth, up-time, delay, jitter, etc.
  o Typically, we run out of bandwidth on 1G-EPON link before we run out of the available power budget.

o It is likely, that commercial services will be served with 10G-EPON only in the near future, providing more cost-effective bandwidth / investment ratio than 1G-EPON and P2P.

o Similar observation applies to residential FTTx services, which are only ramping up right now, and will likely be served with 10G-EPON in the future.

Device Compatibility (ii)

o MUST: maintain backward compatibility in NG-EPON with 802.3av-compliant 10G-EPON, i.e., allow 802.3av-compliant 10G-EPON devices to be operated on the same ODN as NG-EPON

o MUST: maintain backward compatibility in NG-EPON with 1G-EPON, i.e., allow 1G-EPON devices to be operated on the same ODN as NG-EPON. These 1G-EPON devices are compliant with industry-standard, narrow-band upstream option (20nm ONU transmitters).

o SHOULD: revisit 1G-EPON specs and create narrow-band options for 1G-EPON ONU transceivers, following industry best-practices.

    o Optics vendors offer narrow-band ONU optics (20nm) at no premium.

    o 100% of deployed SFP-ONUs are DFB-based. Grand majority of ONUs supporting PX20 power budgets and beyond are equipped with DFB lasers.

    o PX10/PRX10/PR10 optics is rarely used due to very limited power budget and very small premium relative to PX20/PRX20/PR20 devices

Device Compatibility (iii)

o Development of OLTs capable of operating in 1G-EPON, 10G-EPON, and NG-EPON mode does not seem really necessary:
  - o no operator is likely to repurchase ports that have been already paid for

o It is more likely that OLT ports will be deployed with separate 1G-EPON, 10G-EPON, and NG-EPON capabilities and then WDM multiplexed into a single trunk fiber using external WDM filters
  - o this is the approach adopted today by most operators to deploy 1G-EPON and 10G-EPON over the same ODN

o Triple-mode OLT is an overkill for practical deployments.

o Dual-rate NG-EPON / 10G-EPON might be worth considering if cost increase is very small.

o High port density on front plate and coexistence on the same ODN are two key components for device compatibility!

ODN COMPATIBILITY

ODN Compatibility (i)

o PON ODN design and deployment is one of the most expensive elements of the FTTx deployment in terms of labor cost

    o material-wise it is comparable to coax

o Any changes to the ODN are labor-intensive, disruptive to existing services and connected customers, and usually require extended periods of service-down time.

o Once deployed, current generation of fiber cables are expected to be in service for at least 30 years.

o Native support for OTDR tools is required, especially during the construction and troubleshooting phases.

    o For contractual reasons, even production networks are regularly scanned for defects, "weak" spots, potential issues, etc. to be addressed during maintenance windows ahead of time.

ODN Compatibility (ii)

o Underground deployment is preferred as long-term investment approach. CAPEX is higher than in the aerial approach, but long term OPEX is reduced.

  o This is especially true in areas where aerial cables are subject to extreme weather conditions and needs to be rebuilt frequently.

o Deployment of special fiber types after the ODN has been designed and put into the ground is very difficult and expensive.

o If new fiber types are required for NG-EPON, its deployment will be delayed, and alternative technologies, e.g., stacking of multiple TDM-PONs, will become more attractive.

o At least 3-4 CWDM bands should be left open for P2P Ethernet overlay over PON.

ODN Compatibility (iii)

o MUST: maintain backward compatibility with 10G-EPON ODN, in terms of supported power budgets, fiber type, and distance.

o MUST: support the same power budgets as 1G-EPON and 10G-EPON today for seamless upgrade to NG-EPON

o SHOULD: allow for the more efficient spectrum use than in 1G-EPON (i.e., do not allocate 100nm of spectrum any more)

o SHOULD: allow for future additions of more wavelength channels if WDM-like approach is selected (i.e., add channels to existing OLT if needed, rather than design new equipment)

o SHOULD: allow for P2P Ethernet overlay (trunk fiber sharing)

o MUST: support external OTDR

o SHOULD: support embedded OTDR per OLT port

SERVICE COMPATIBILITY

Service Compatibility (i)

- 1G-EPON today and 10G-EPON in near future will carry either exclusively commercial services, residential services, or the mix of different service types.

- Voice, Video, and High-Speed Data are three primary service types today. Voice and Video consume more than 60% of network capacity today.
  - They are likely to remain primary service types in the future.

- New service types are quickly emerging: home automation & security, mobile backhaul, cloud services, remote data backup, streaming video games from remote servers (next-gen consoles), etc.

- Machine-to-Machine (M2M) is on the rise as well
  - This type of traffic will become increasingly important when smart-homes, remote home control, etc., become more common.

Service Compatibility (ii)

o The existing, but especially new and emerging applications put new requirements on latency, time sync between connected clients, and peak throughput (burst).

o Video services will become dominated by VOD, IPTV, and OTT video distribution platforms (see the Netflix effect on next slide)

o HD+ Video (WHD, UHD 4k, UDH 8k) are likely to have more effect on networks than the failed promise of 3D TV

o Providing more than 1Gbps per subscriber is hardly justified, even with multiple HD+ video streams running simultaneously per home. However, latency, packet loss, and peak throughput requirements are much more stringent.

o Support for large frames (4k and above) is also needed, especially for mobile backhaul, as well as all forms of M2M traffic, where no human interaction is required

Effect of Netflix & Co.

Table 1 - North America, Fixed Access, Peak Period, Top Applications by Bytes

Rank	Upstream		Downstream		Aggregate	
	Application	Share	Application	Share	Application	Share
1	BitTorrent	52.01%	Netflix	29.70%	Netflix	24.71%
2	HTTP	8.31%	HTTP	18.36%	BitTorrent	17.23%
3	Skype	3.81%	YouTube	11.04%	HTTP	17.18%
4	Netflix	3.59%	BitTorrent	10.37%	YouTube	9.85%
5	PPStream	2.92%	Flash Video	4.88%		
6	MGCP	2.89%	iTunes	3.25%		
7	RTP	2.85%	RTMP	2.92%		
8	SSL	2.75%	Facebook	1.91%		
9	Gnutella	2.12%	SSL	1.43%		
10	Facebook	2.00%	Hulu	1.09%		
	Top 10	83.25%	Top 10	84.95%		

SOURCE: SANDVINE NETWORK DEMOGRAPHICS

Application by bytes
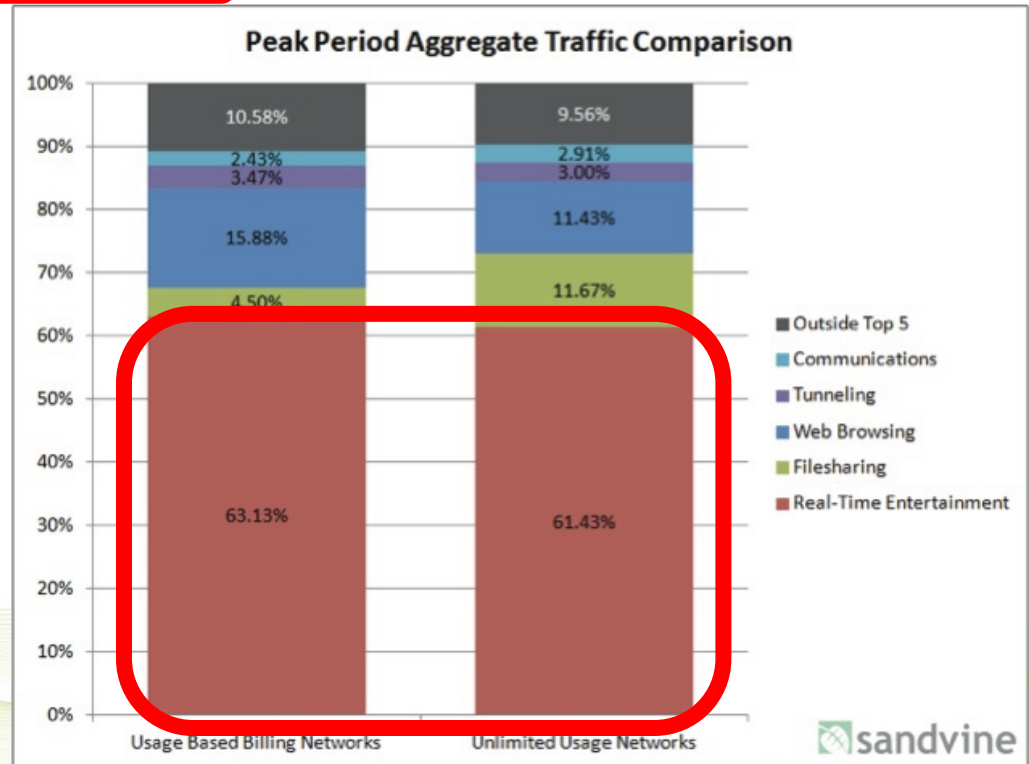
Aggregate traffic profile
Netflix, YouTube, etc. are
"Real-Time Entertainment"

Peak Period Aggregate Traffic Comparison

- Outside Top 5
- Communications
- Tunneling
- Web Browsing
- Filesharing
- Real-Time Entertainment

Usage Based Billing Networks: 10.58%, 2.43%, 3.47%, 15.88%, 4.50%, 63.13%

Unlimited Usage Networks: 9.56%, 2.91%, 3.00%, 11.43%, 11.67%, 61.43%

sandvine

Figure 11 - Usage Based Billing Peak Period Aggregate Traffic Comparison

Machine-To-Machine (M2M)
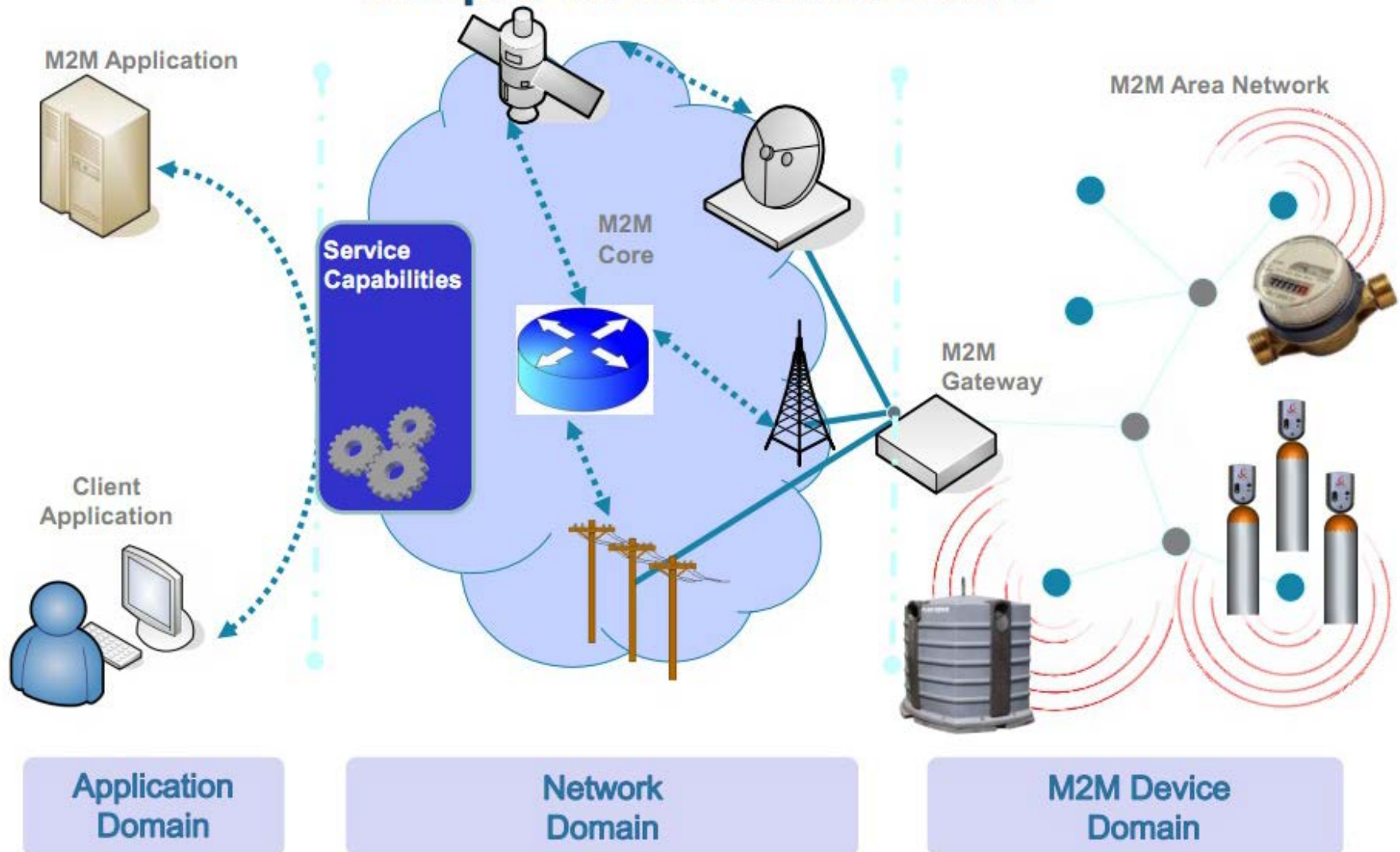
Smart Home
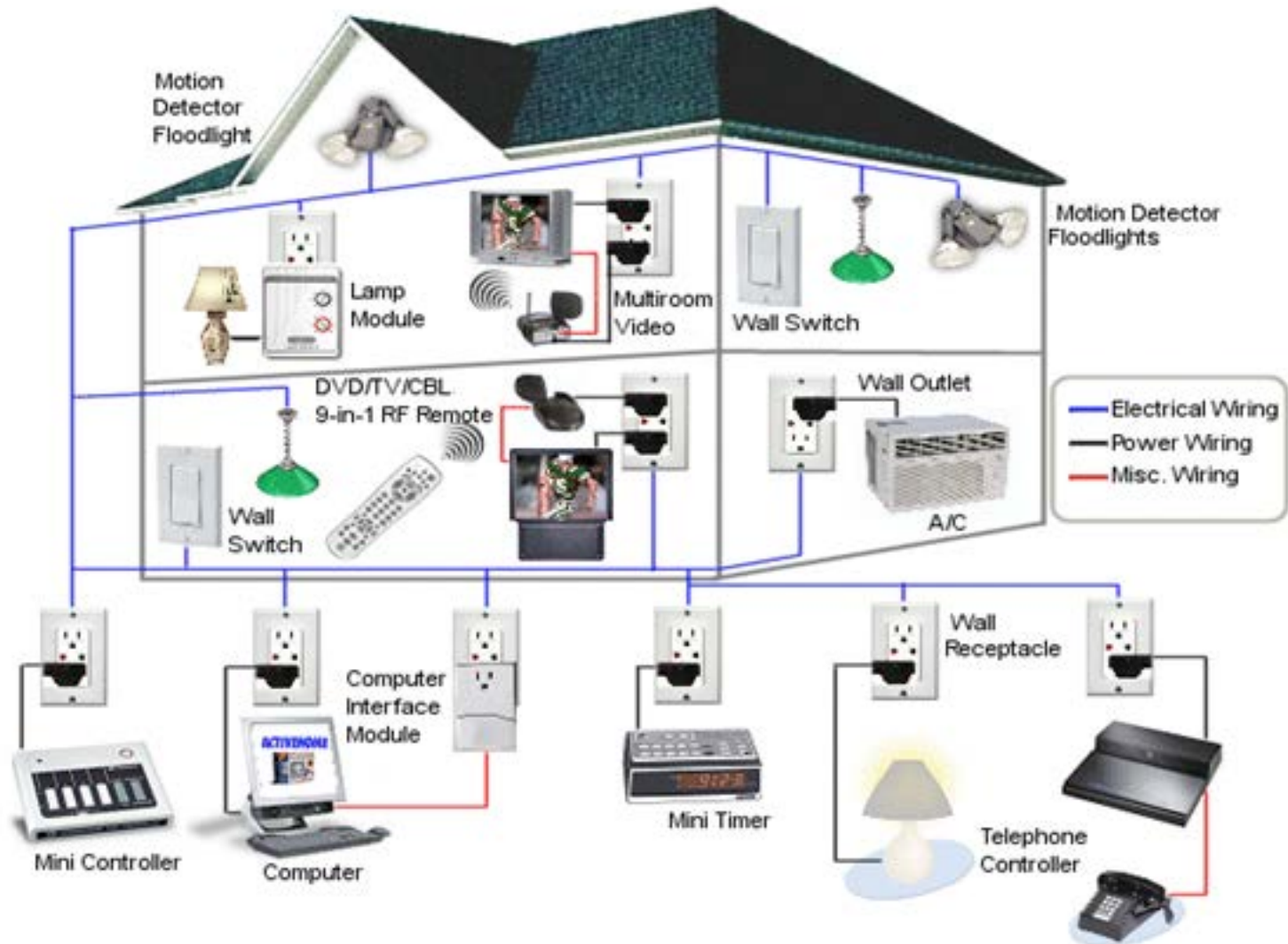
Service Compatibility (iii)

o MUST: support the existing service types, supported natively by EPON today, i.e., differentiated classes of service, with the ability to employ per service class scheduling

o SHOULD: support time & frequency distribution at PHYsical layer, rather than at MAC Client (aka IEEE 802.1as).
   o Next gen mobile backhaul is more demanding than IEEE 802.1as can deliver today

o SHOULD: be able to deliver a burst of at least 1 Gbps per ONU for applications that are peak bandwidth sensitive

o SHOULD: be able to offer a sustained bandwidth of at least 1 Gbps per ONU (if configured so by the operator).

o SHOULD: support Jumbo Frames (YES !) up to ~9200 octets.

CLOSING THOUGHTS

NG-EPON coexistence and services

o Design scalable technology, from 40G to 100G and beyond.

  o Operators do not want the hassle of NG-EPON1, NG-EPON2, etc.

o Coexistence with 10G-EPON and 1G-EPON on the same ODN.

o Ideally, 10G-EPON ONUs to be supported by NG-EPON OLT

  o consider reusing 10G-EPON technology now that these devices become widely commercially available

o WDM-PON has limited benefits over P2P Ethernet as P2P front panel densities go up and cost per Mbps drops.

  o Dark fiber exhaustion is not a problem in new builds anymore.

o TDM-PON is ideal for residential applications

  o No residential customer is ever given bandwidth guarantee SLAs

  o Existing DBA implementations also allow for rock solid SLAs for commercial customers

Data Rates

o Ideally, NG-EPON should benefit of existing 10G-EPON technology (TDM-PON) and WDM transport technology to increase the overall MAC level capacity of NG-EPON

o The need to support shared 40G/100G would be welcome
  o Ideally, an NG-EPON ONU should support 1G, 10G, 40G+ data rates, depending on hardware capabilities
  o During the device discovery and registration phase, the OLT discovers the ONU capabilities and then configures the ONU and itself accordingly.
  o Wavelength tuneability / agility on NG-EPON ONUs will be welcome, though not mandatory.
  o If dedicated 40G or 100G link is needed at customer premises, an operator will run dedicated P2P link

Thoughts on NG-EPON (ii)

o Support embedded or external OTDR at the PHY layer
  - o Do not occupy spectrum used typically by commercial OTDR systems

o Consider retiring support for RF overlay at ~1550nm
  - o There is very little potential for its use in the future for broadcast content distribution services with IP return channel
  - o All services are moving to IP anyway, and 1550nm band could be used for transport purposes (upstream / downstream)

o Make FEC in NG-EPON optional, to allow operators not limited by power budget reap additional bandwidth from the link

o NG-EPON should reuse the concept of logical links (LLIDs), allowing to map into DOCSIS Service Flow concepts with ease
  - o This includes multicast LLIDs as well
  - o Consider removing the mode-bit in NG-EPON, since it is ill-defined anyway

Thoughts on NG-EPON (iii)

o PHY level time & frequency transport is critical for next-gen mobile backhaul services, localization services, etc.

o Physical layer encryption should become mandatory (likely a task for 802.1 to adapt 802.1X mechanisms to EPON)

THANKS !