2010-7-2

Network Architecture Evolution in Ultra Broadband Era

- L3 Aggregation is the Trend

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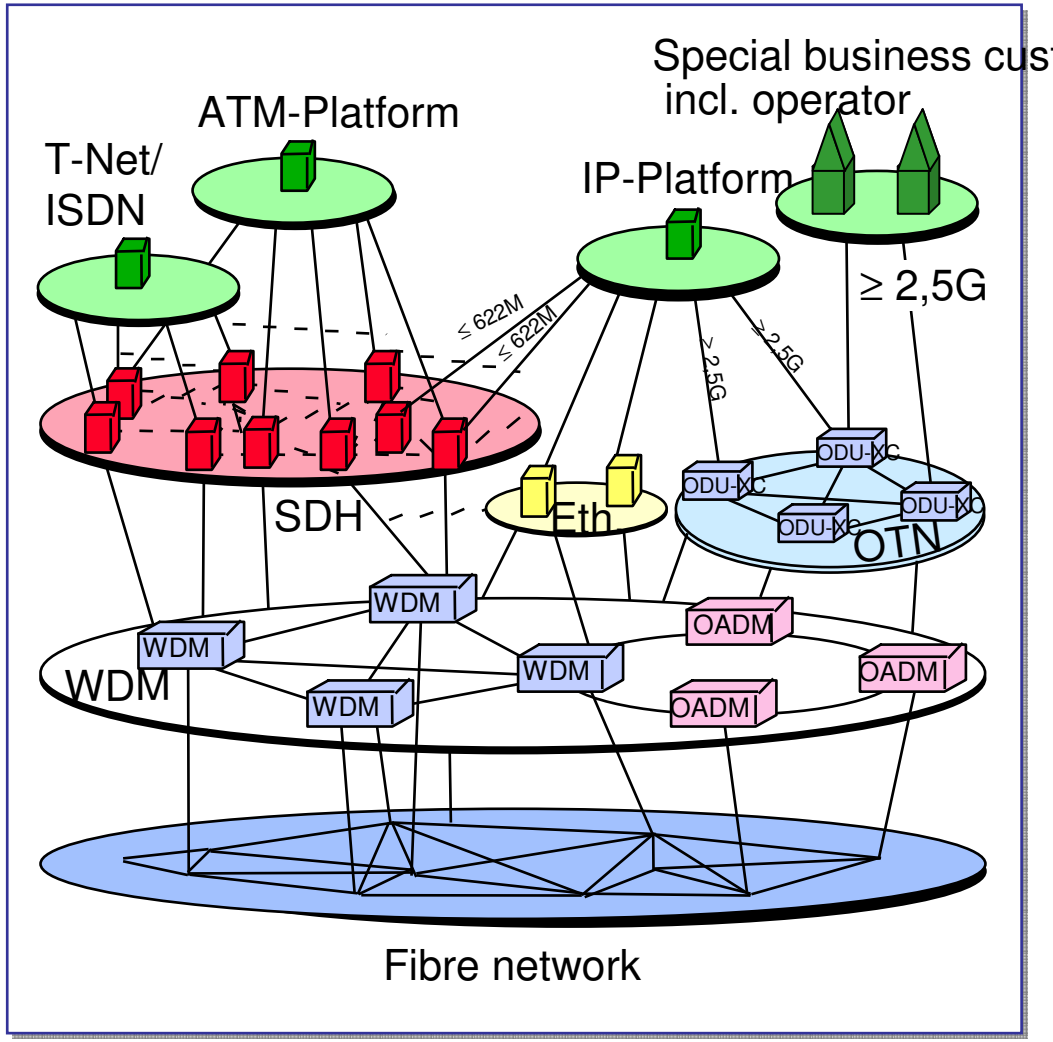
Agenda

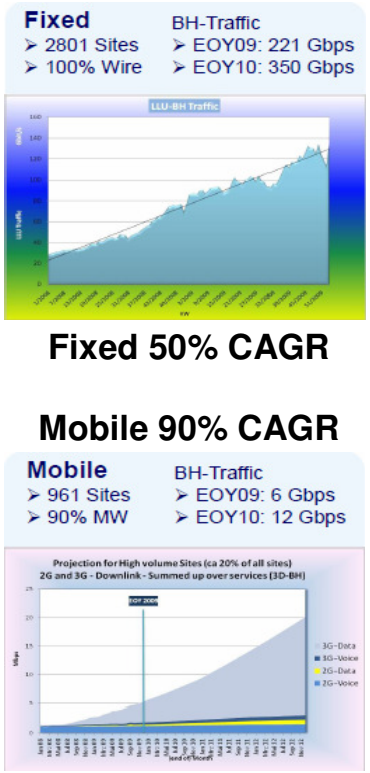
- **Current network pain points**
- **Network architecture evolution**
- **Opportunity to realize new architecture**

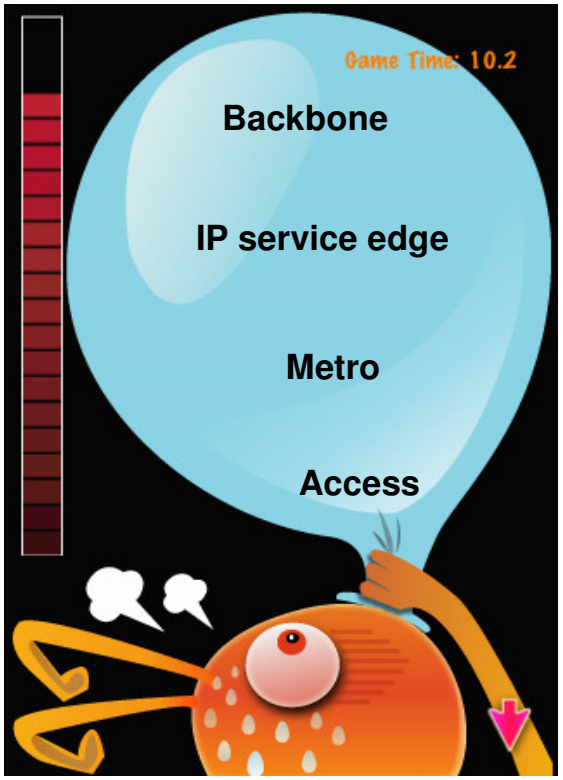
Pain Point #1: Too Many Parallel Networks

- **Multiple metro networks for similar purpose**
  - ME for triple play
  - Metro ATM for broadband Internet
  - ME over SDH for enterprise Ethernet private lines (VLL)
  - SDH (or even PDH/X.25) for private lines
- **Multiple core networks for similar purpose**
  - 1 IP core for Internet, another for high value service (e.g. VoIP)



Pain Point #2: Too Much Bandwidth Demand

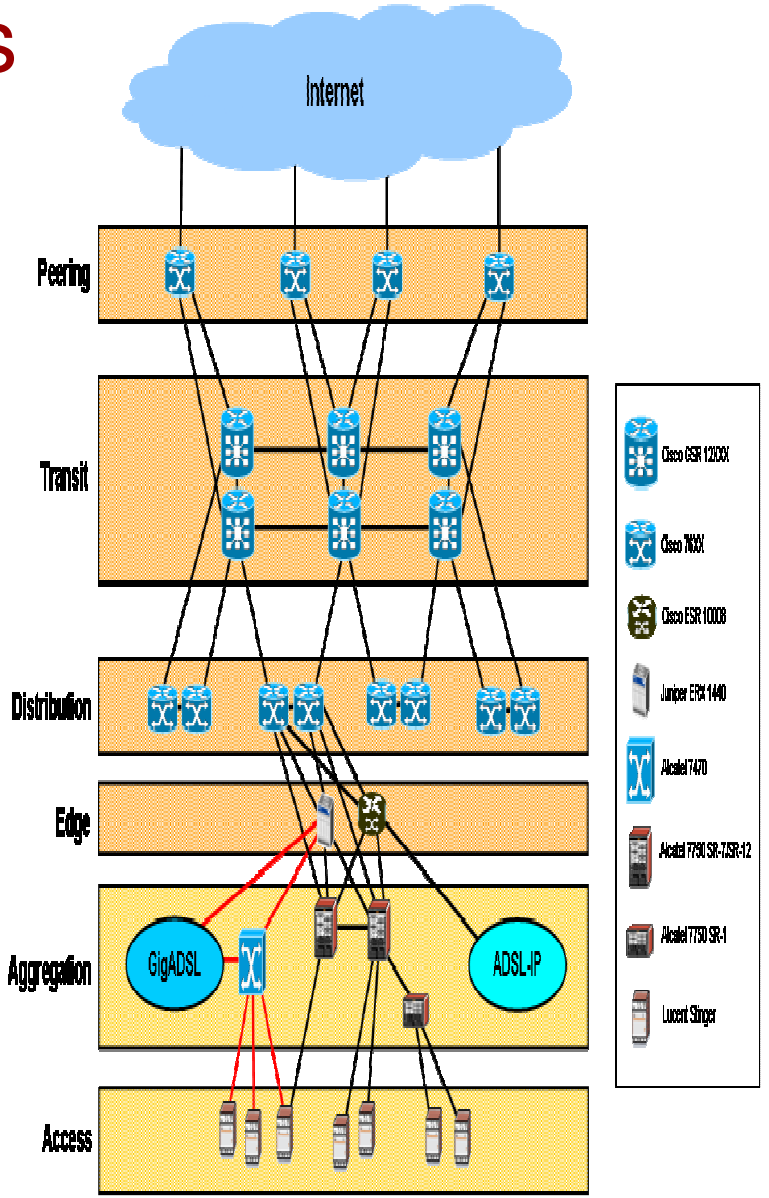




- **10x network expansion to handle 10x traffic increase is NOT an economical solution**
- **Certain architecture change can reduce cost significantly**

Pain Point #3: Too Many Layers

- **Because of historic burden, existing networks have too many layers ➔ more provisioning points, slower service turn-up, lower service reliability**
  - Metro has 2 or even 3 aggregation layers (DT: AGS1-AGS2, TI: R-feeder, Feeder, Metro)
  - Backbone has 3-4 layers (OSP: edge-distribution-transit-peering)
  - DT's testimony
    - More than 100k subscribers already signed up for IPTV, but DT can't rollout service to them quickly
    - Within 6 months, of the 80 possible issues, 60 actually happened. 3-play service's MTBA much lower (see Slide 3)



6 layers, 8 types of devices!

Pain Point #4: High Complexity for IPTV

- **IPTV brought higher network requirements, complicated operations, and made problems more visible to end users**
  - TV has higher delay, jitter, packet Loss ratio requirements than VoIP and HSI
  - Higher complexity makes networks more difficult to operate
  - TV makes network problems more visible
- Because of BTV's real time nature, although it may be just 30% of total traffic, it may cause 70% associated complexity.
  - **In contrast, Internet can rely on TCP, VoD can rely on buffering, VoIP can rely on jitter buffer and PLC. Therefore they have low requirements on network QoS.**

Consequence of the Pain Points – DT as an Example

- **Slow service provisioning → lower competitiveness**
- **3-play service reliability 3 times lower than pure DSL → higher OPEX**

T-Home Products	MTBA E2008 in years	Customer E2008 in mill.
"Entertain" (Ethernet based triple play w. IPTV & FE; Voice mostly ongoing PSTN)	1.3	0.38
T-DSL	4.1	10.6 (plus 2.5 resale)
T-ISDN	6.6	8.3
T-Net (POTS)	12.2	20.3

MTBA - Mean Time Between Assists
The average time the equipment performed its intended function between assists; productive time divided by the number of assists during that time. Only productive time is included in this calculation.

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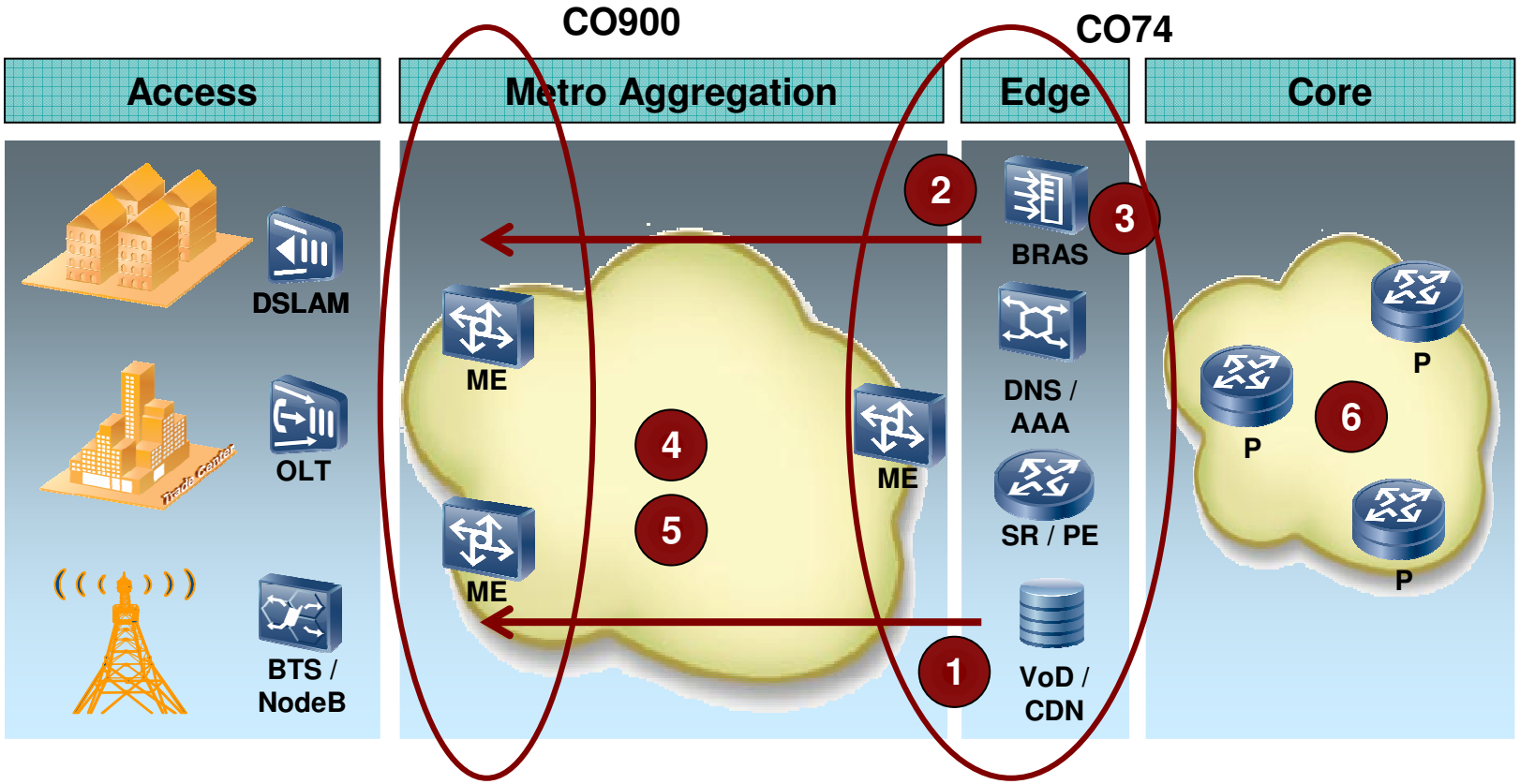
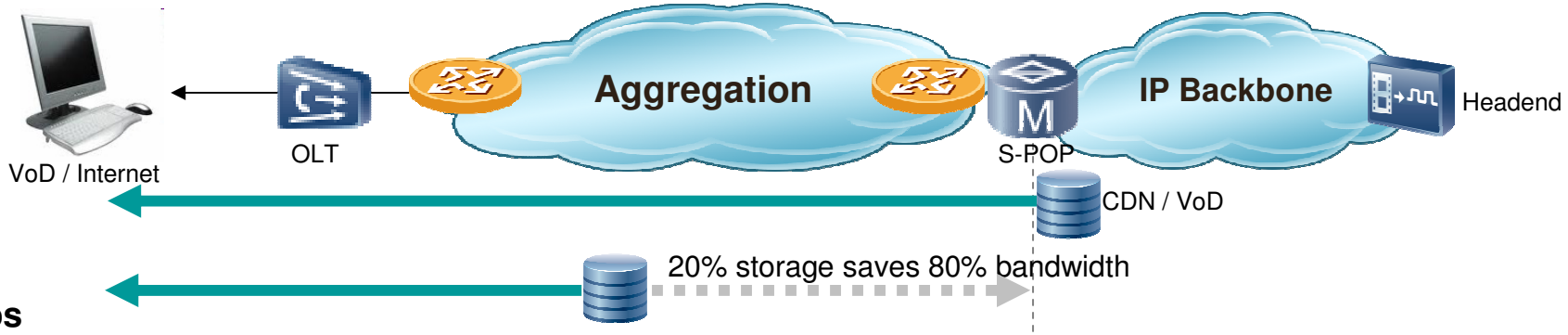
Possible Architecture Changes for Consideration



1. Content (e.g. D-servers, CDN) moving down?
2. BRAS moving down?
3. PPPoE replaced with IPoE/DHCP?
4. Single metro for multiple services (e.g. mobile backhaul, ATM offload)
5. Metro WDM?
6. Core optical shortcut?

Content Moving Down (1): Unicast (VoD, CDN)?

- **What**
  - Move VoD / D-servers down; introduce CND



- **Pros**
  - Move content closer to end users will reduce bandwidth cost significantly (5-hop path need 10 ports, 1-hop only 2 ports)
  - 80% users viewing 20% hot content → local storage of 20% hot content saving 80% bandwidth
  - Content closer to end users → better performance & QoE
- **Cons**
  - Extra content storage cost
  - Distributed content storage and its management (e.g. what content to store) will increase OPEX
  - Require BRAS moving down as a condition, dictating architecture change
- **Huawei opinion: possible, if bandwidth saving is greater than multiple Gbps***
- **Industry opinion: BT, FT evaluating**

* 2 thing that may delay/prevent SP from moving down content (1) metro WDM, which reduces backhaul cost from users to content → content can afford to stay in current SPOPs (2) Internet becomes a major TV distribution platform, causing 3rd party CDN (e.g. Akamai) to prevail

A Major European SP's Opinion on CDN

- **Fixed**
  - CDN for top web sites in 12 COs (outer core PoPs)
  - BRAS in 74 CoS
- **Mobile**
  - Specific content caching just for Microsoft Windows Update
  - Highly centralized in a few locations

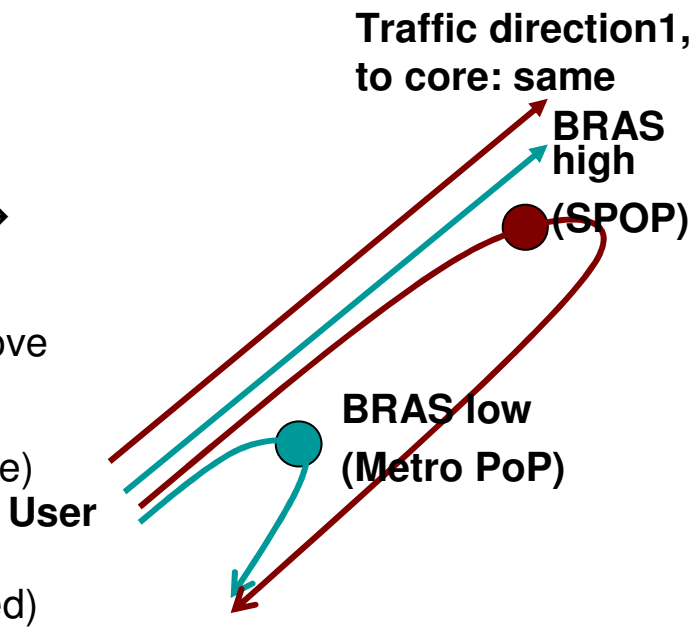
Content Moving Down (2): Multicast?

- **What**
  - Push multicast content (e.g. all TV channels) to UPEs (or even DSLAMs)

- **Pros**
  - Better QoE
  - Multicast routing become very static (to all UPEs, virtually no change over time) ➔ higher reliability, easier troubleshooting
- **Cons**
  - Extra bandwidth for not viewed channels (generally not much, and the bandwidth has been planned in the network)
  - Requires PIM support on metro UPEs
- **Huawei opinion: yes**
- **Industry opinion: Telefonica did; DT evaluating**

BRAS Moving Down?
(Assuming same # BRAS, distributed vs. centralized)

- **What**
  - Put BRAS next to DSLAM (possibly with just LAN switch in middle)
- **Pros**
  - Metro (behind BRAS) becomes L3, uniform with backbone → easier service provisioning across the network
  - Lower BRAS position enables CDN or content caching to move down as well
  - Lower BRAS position more flexible for traffic (see right picture)
- **Cons**
  - Distributed BRAS may increase OPEX slightly (vs. centralized)
  - Change existing metro architecture from L2 to L3
- **Huawei opinion: yes only if there is other reason to change metro architecture**
- **Industry opinion: CT did, FT, BT, DT evaluating**



BRAS / GGSN Convergence?

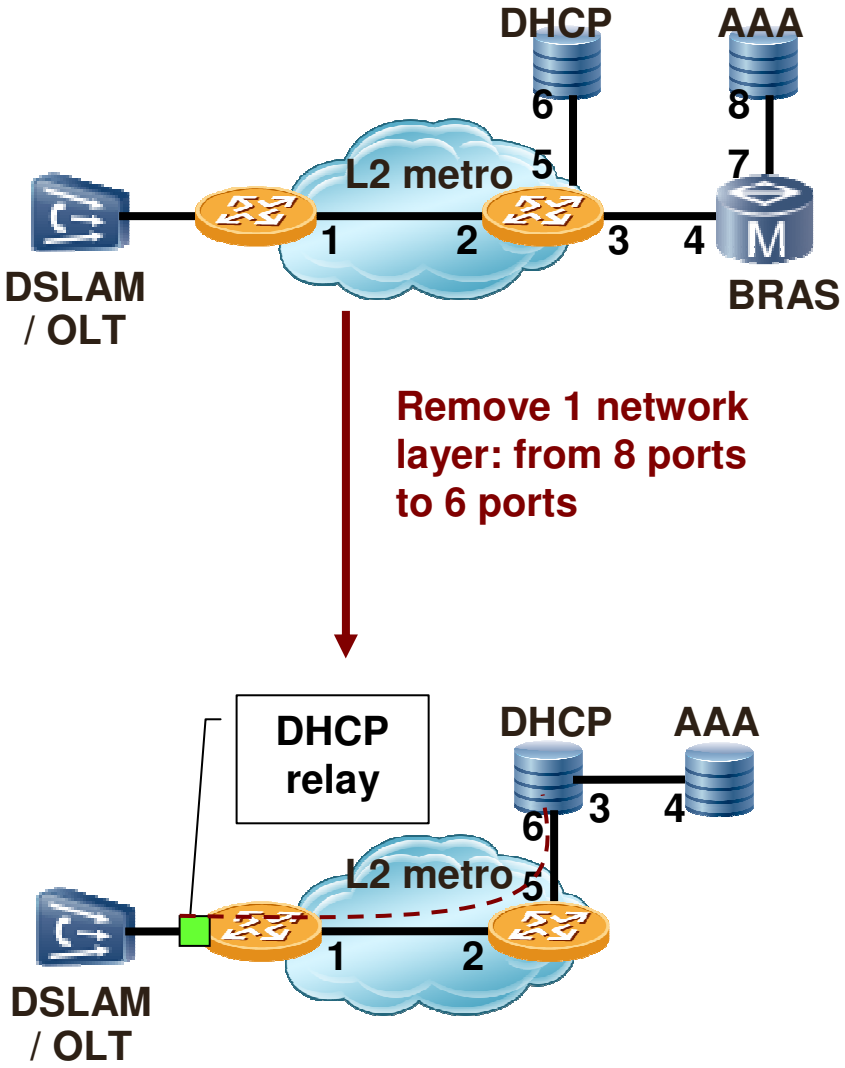
- **Pros**
  - Fewer devices
- **Con**
  - Significantly different functions in a box
  - Different user scale, not necessarily in the same CO
  - Vague organization border (fixed vs. mobile)
- **Huawei opinion: more political reason than technical reason**
- **Industry opinion: O2, Telia exploring**

Comparison between BRAS and GGSN

	BRAS	GGSN
Users scale	high bandwidth, 8K-16K users	low bandwidth,1000K users
Forwarding	heavy users traffic, high forwarding performance	light users traffic, low forwarding performance
Signaling	low requirement for signal processing	high requirement for signal processing
Packet Processing	low requirements for datagram fragmentation and reassembly; low processing performance for IPSEC	high requirements for datagram fragmentation and reassembly; IP/PPP fragmentation/reassembly; tunnel/MIP encapsulation /reassembly; high processing performance for IPSEC
Billing Requirements	Billing based on duration and traffic	Content-based billing, DPI, service awareness from L3 to L7
Access Mode	L2 access	L3 access---GTP/GRE tunnel access

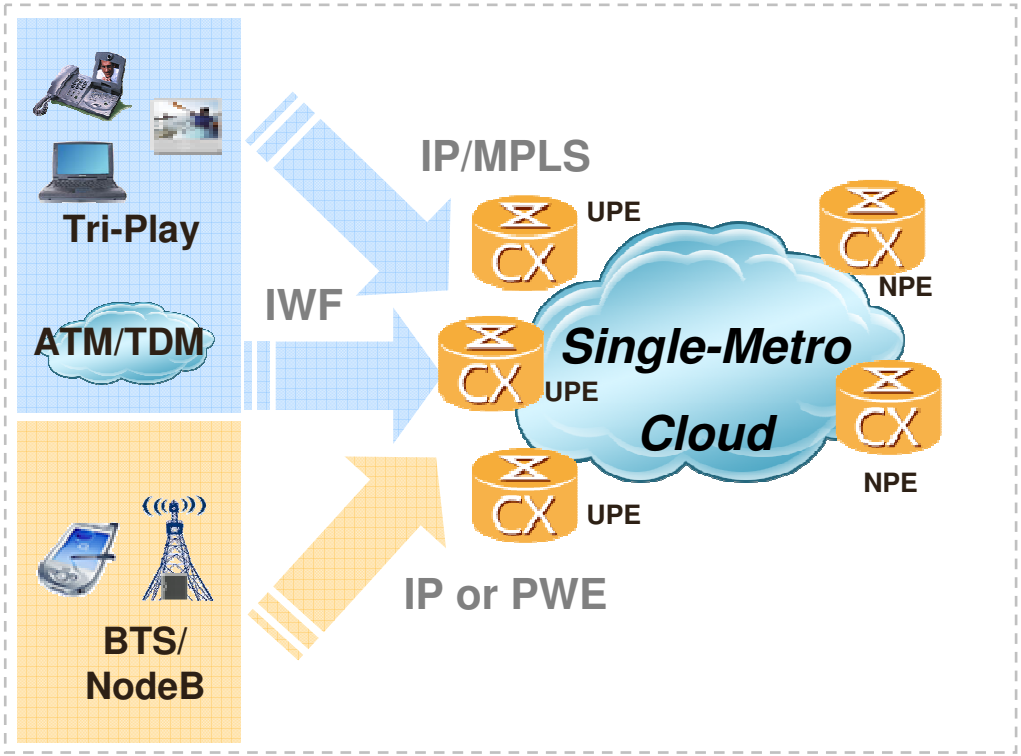
PPPoE Replaced with IPoE/DHCP?

- **What**
  - Use DHCP for HSI/VoIP rather than PPPoE
- **Pros**
  - Remove 1 network layer → lower cost, higher reliability, faster provisioning (see right picture)
  - IPTV uses DHCP → simpler mgmt if VoIP & HSI also use DHCP
  - Metro (behind BRAS) becomes L3, uniform with backbone → easier service provisioning across the network
- **Cons**
  - Less familiar operations model: can DHCP do everything PPPoE can, e.g. wholesale?
  - Change existing metro architecture from L2 to L3
- **Huawei's opinion: yes, combine with building new network for IPTV or FTTH**
- **Industry opinion: AT&T did, DT, FT evaluating, TI no**



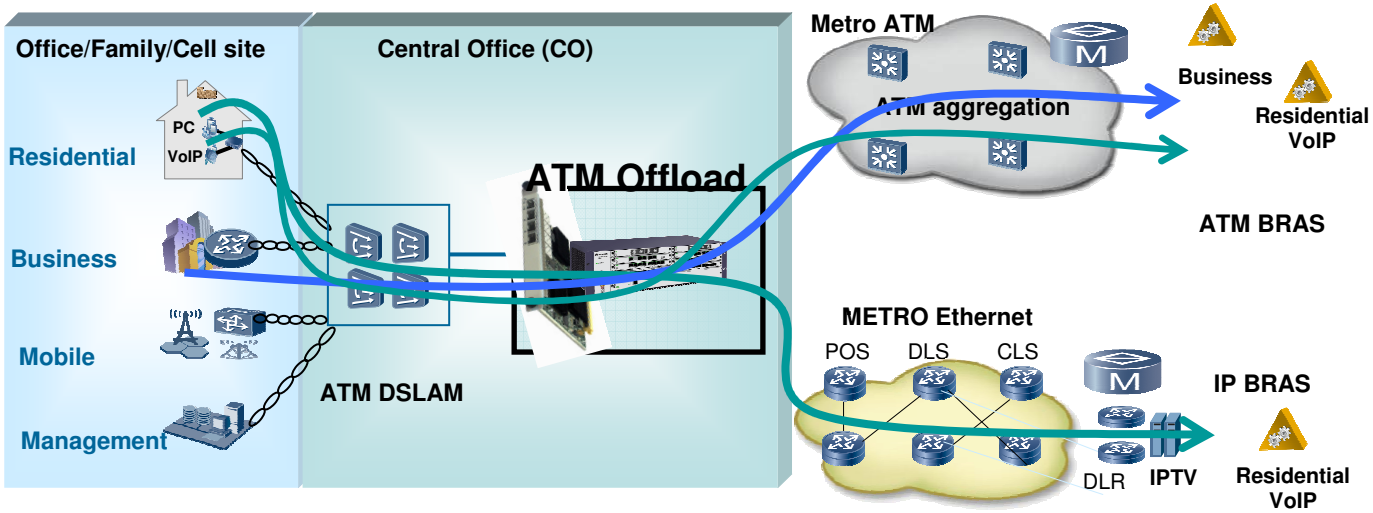
Single-Metro Multi-Play?

- **What**
  - Use ME for 3-play & ATM, MBH
- **Pros**
  - Single network for multiple applications → lower CAPEX / OPEX
- **Cons**
  - ME network more complicated (but not much more as 3-play is most complicated)
- **Huawei opinion: yes**
- **Industry opinion: yes**



ATM Migration is a Big Dilemma
Walk Out the Dilemma with ATM Offload

- **ATM network works well now**
- **ATM needs expansion because of increase of ATM DSL users' Internet traffic**
- **ATM expansion investment questionable because ATM considered sun-set technology**
- **Full ATM migration with PWE attempted many times but almost no success**
  - Enterprise customers like ATM for quality & stability
  - Enterprise customers & SPs themselves not confident that IP PWE can provide same quality & stability
  - Migration will cause service disruption
  - SPs have little incentive to discard working well ATM



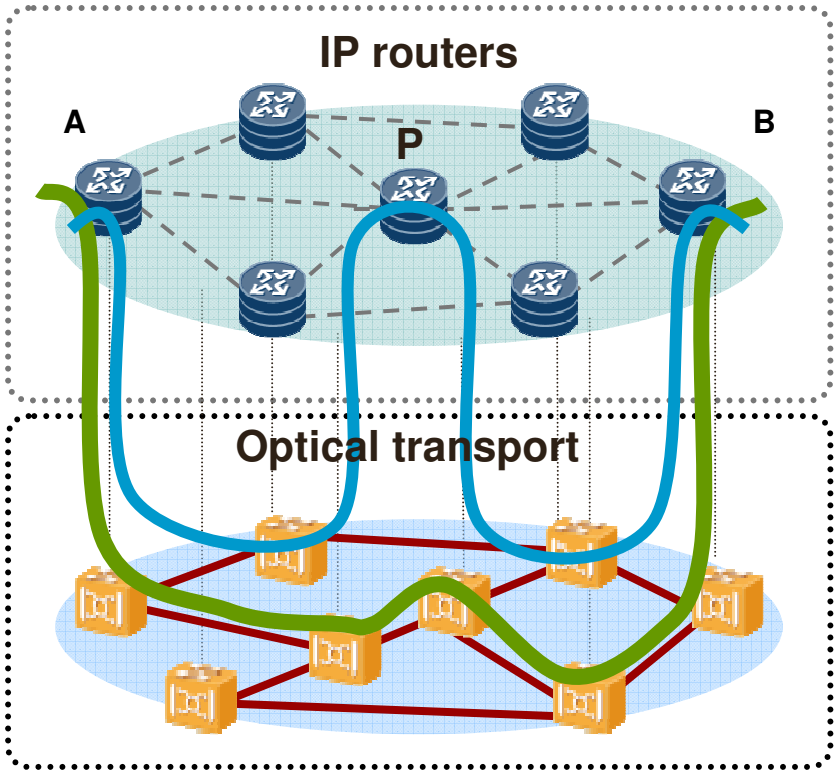
- **Proposal: terminate residential ATM DSL traffic, but keep existing ATM networks for enterprise customers**
- **Solve the expansion dilemma nicely**
  - Removed expansion pressure source → no need for expansion
  - Enterprises customers stay on ATM → no quality/stability concern
  - Simple solution, no migration, no service disruption, no need to discard ATM

Move Traffic to Lower Layer (1): Metro WDM?

- **What**
  - Replacing metro SDH with metro DWM
- **Pros**
  - Carrying traffic in metro WDM more cost effective and reliable than in metro Ethernet network
- **Cons**
  - Need to build it → additional CAPEX
- **Huawei opinion: yes**
  - It's predicted that as FTTH is rolled out, metro WDM will soon follow. Metro WDM footprint will reach the COs where OLTs locate
- **Industry opinion: yes**

Move Traffic to Lower Layer (2): Core Optical Shortcut?

- **What**
  - If traffic between 2 PEs can occupy a λ, set up a new λ between them. No longer transit the P router
- **Pros**
  - Move network expansion from P router to optical layer ➔ lower CAPEX, higher reliability
- **Cons**
  - Optical layer needs OTN capability (but this will happen anyway)
- **Huawei's opinion: yes**
- **Industry opinion: yes when OTN deployed**



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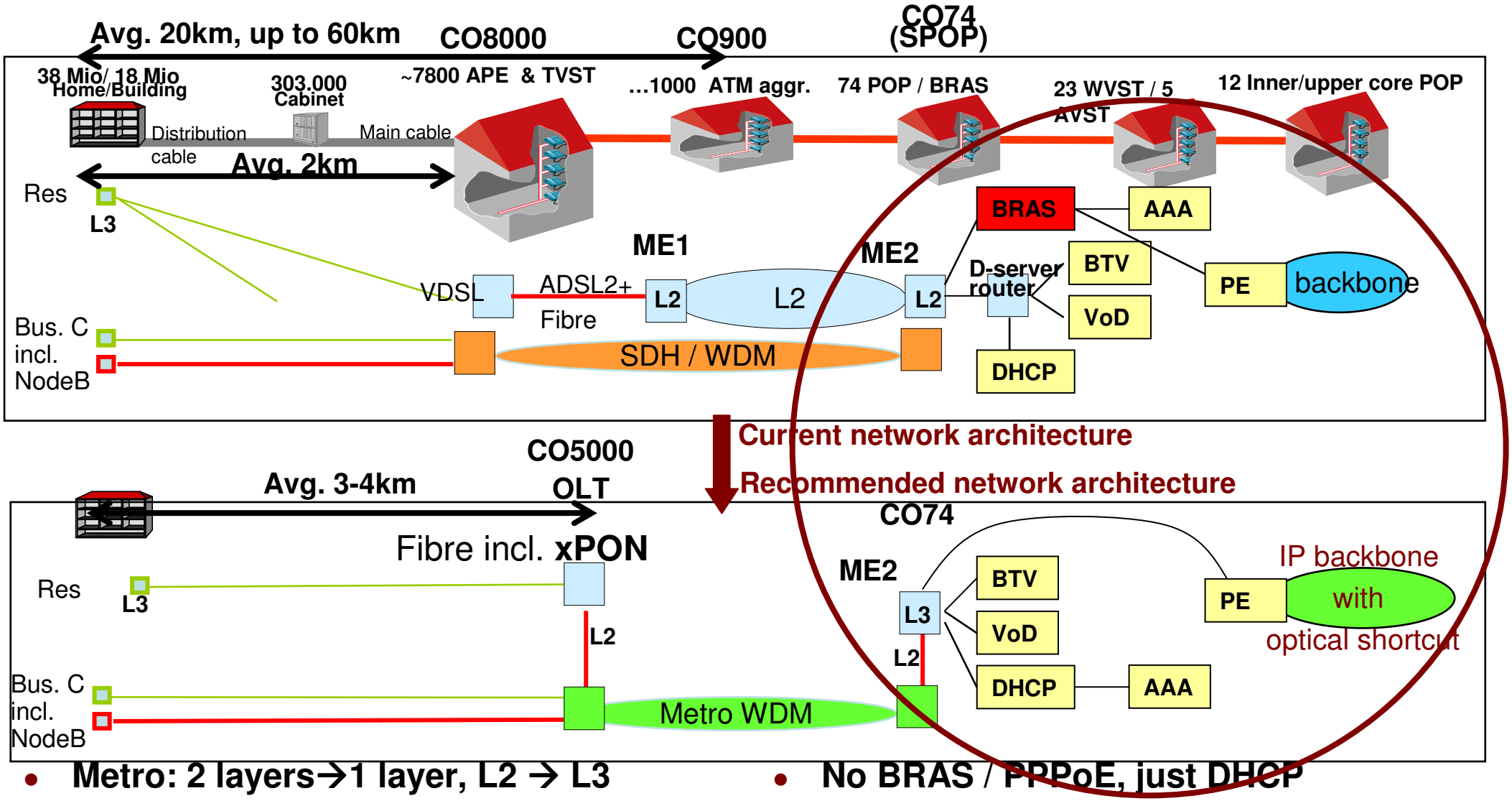
Huawei's Recommended Network Architecture Evolution



- **Metro: 2 layers→1 layer, L2 → L3**
- **BTV/VoD: 5 layers → 3 layers**
- **Internet: 5 layers → 3 layers**
- **10 electric boxes → 7**
- **No BRAS / PPPoE, just DHCP**
- **Start this architecture from CO74 (current SPOP), expand towards CO900**

Summary of Differences & Benefits

	Fields	Existing Architecture	New Architecture	Benefits
Flatten	Metro layers	2-3	1	Faster provisioning, fewer failure points, lower OPEX
	Network layers for Triple-play	5	3	Faster provisioning, fewer failure points , lower OPEX
Simpler	BRAS or DHCP	BRAS/PPPoE for HSI/VoIP, DHCP for IPTV/VoD	DHCP for all	Uniform subscriber management using DHCP Multi-Edge → Single Box
	L3 or L2 metro	Emulated L2 over L3 with MPLS	L3	Simpler: no MAC learning, withdrawal, flooding
Faster	Metro WDM	No	Yes	Economic backhaul of OLT's traffic to (extended) SPOPs
	Backbone Optical shortcut	No	Yes with OTN	Lower cost, more reliable network

New network thinner, simpler, faster in provisioning and lower in OPEX

Thank You

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