

DOCSIS® 3.1 Development and its Influence on Business

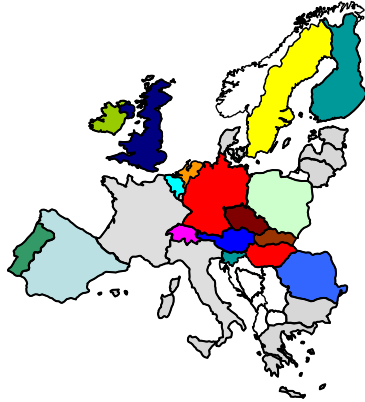
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Who is Cable Europe Labs?

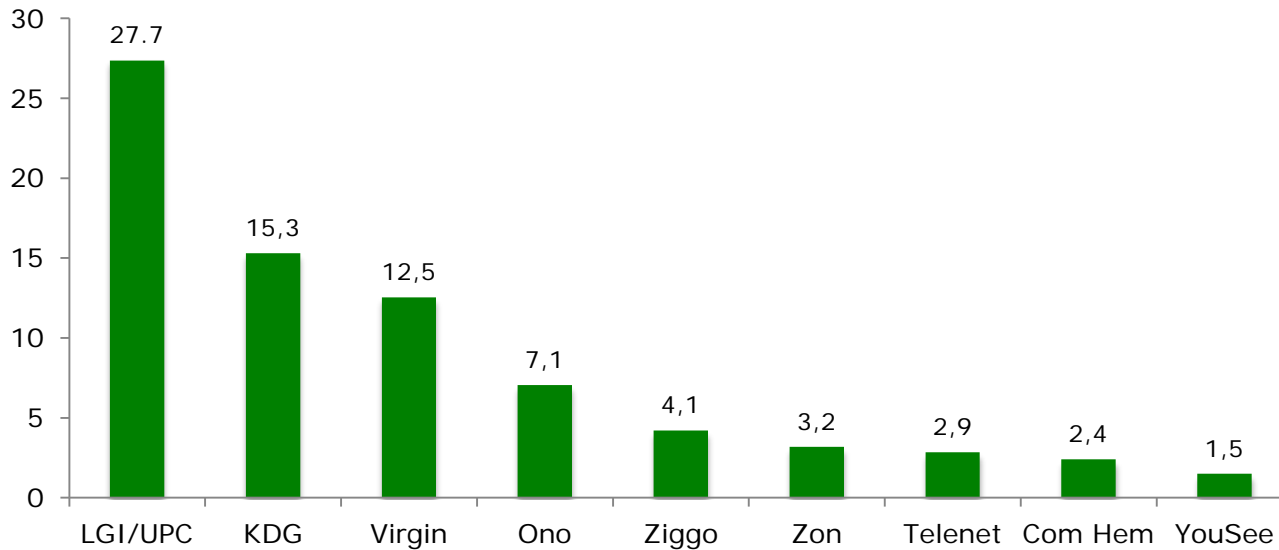


Cable Europe Labs by the Numbers



Europe – total (EU27)

Population:	503 mill
Households:	211 mill
Homes Passed:	110 mill
Customers:	65 mill
Service Subscribers:	76 mill



Source: Cable Europe Labs, Company Reports, Eurostat

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Mission and Goals of Cable Europe Labs

- **Focus on technologies with 18 to 24 month time horizon**
- **Span end-to-end network from core infrastructure to home connectivity**
- **Cover complete development process**
 - Technology assessment
 - Specification and standardization
 - Equipment certification
- **Leverage collective scale to influence cable technology development and to attract attention from important and/or innovative vendors**
- **Involve relevant stakeholders to identify important technology trends and to link them to business and commercial requirements of members**
- **Strong cooperation with partners such as CableLabs® and coordination of related standardization efforts**
- **Represent members interests in technology regulation matters together with Cable Europe**



Overview

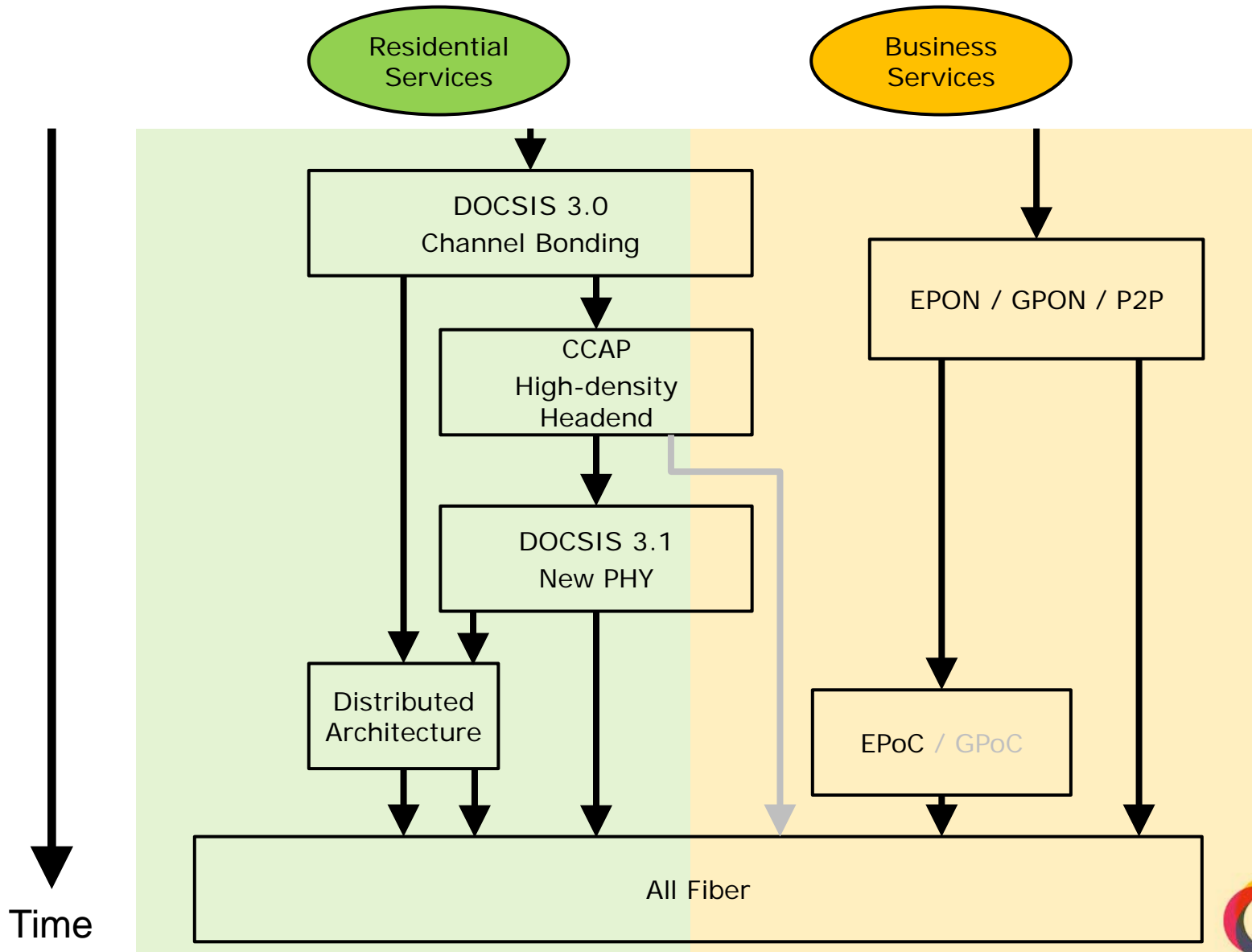
- **Drivers for change**
- **Platform optimization**
- **DOCSIS 3.1 – technology highlights**
- **Network evolution**



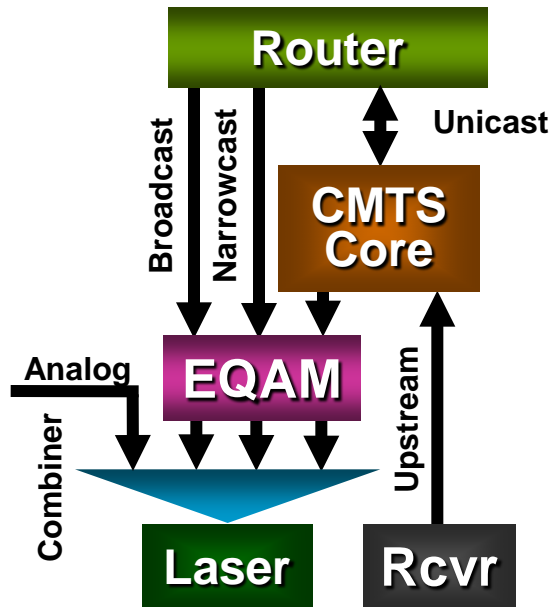
Drivers for Change

- **Increased demand on network capacity**
- **High speed data services**
 - Trendline establishes ~ 50% annual growth in downstream
 - Similar annual growth in upstream
- **Linear broadcasting services**
 - Additional TV programs (particularly HD)
- **On-demand services – “Anytime”**
 - Growing Video on Demand libraries with improved and graphically intensive user interfaces including search and recommendation engine
 - Network DVR
 - Catch-up services; personalized programming
- **More over IP – “Anywhere”**
 - Second and third screens are increasingly IP devices
 - Address individualization in user behavior

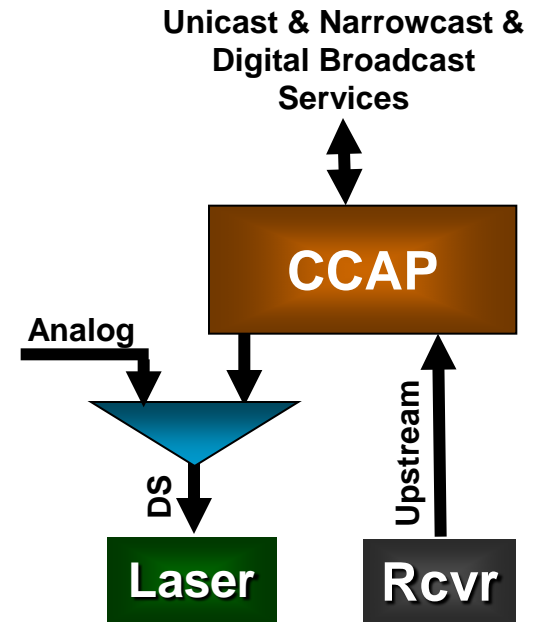
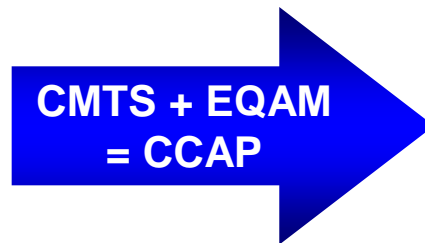
Platform Optimization



Converged Cable Access Platform - CCAP



**Today's Headend
(modular architecture)**



**Headend with CCAP
(integrated routing)**

Distributed Architecture

- **Approach: move (some) components from the headend closer to the customer (e.g. into the optical node)**
 - More efficient usage of DOCSIS capabilities in significantly improved network conditions
 - Avoid active components in coaxial network (node+0 architecture)
 - Enable migration towards digital optics
- **Mini-CMTS/CCAP**
 - Fully functional device with smaller form factor and limited performance to be deployed in the field
 - Number and location of devices results in significant concerns about reliability, robustness and management simplicity → cost driver
 - Requirements established by network operator; no interoperability issue; no specification issue
- **Remote PHY**
 - PHY layer signal processing moved to the field; most or all MAC layer functionality remains in headend
 - Requires new interfaces to enable interoperability (UEPI, Timing Protocol, etc.)
 - Likely to be addressed via CableLabs specification

DOCSIS 3.1 Project

- **New version of DOCSIS specifications (version 3.1)**
- **Development project managed by CableLabs®**
- **Active participation of cable network operators and equipment manufacturers**
 - Key factors for success: vendor contributions and alignment with operator requirements
- **Cable Europe Labs facilitating review of technical proposals by European MSOs and contribution of requirements**



DOCSIS 3.1 Objectives

- **Specification of technologies enabling**
 - Efficient support of 10+ Gbps of downstream capacity and 1+ Gbps upstream capacity
 - Significant reduction in cost per bit delivered compared to current DOCSIS technology
 - Adaptation to different amounts of available spectrum and plant conditions
 - Orderly migration strategy
 - Efficient delivery of services to both residential and business customers
 - Improved energy efficiency features such as low power standby and/or sleep modes

DOCSIS 3.1 Technology – Higher Capacity

● Main mechanisms

- New error protection algorithms and higher modulation orders
- Operation across larger bands of spectrum

● Effects

- Low Density Parity Check (LDPC) enables higher order modulation even in current networks
- Increase in spectral efficiency
 - More bits/second/Hz in current plant conditions (e.g. noise, reflections)
 - Same capacity at worse plant conditions (more subscribers can be reached with higher tier services)
- Simple example
 - 8 bits /symbol with 256QAM → 12 bits/symbol with 4096QAM = 50% capacity increase
 - Currently about 50 Mbps per 8 MHz channel (or about 4.7 Gbps per 862 MHz plant) → then about 75 Mbps per 8 MHz spectrum (or about 7 Gbps total)
- Spectrum enhancement
 - ~ 500 MHz of downstream spectrum at 10 bps/Hz (net throughput) for ~ 5 Gbps capacity in DOCSIS 3.1 vs. ~ 780 MHz for 5 Gbps with DOCSIS 3.0

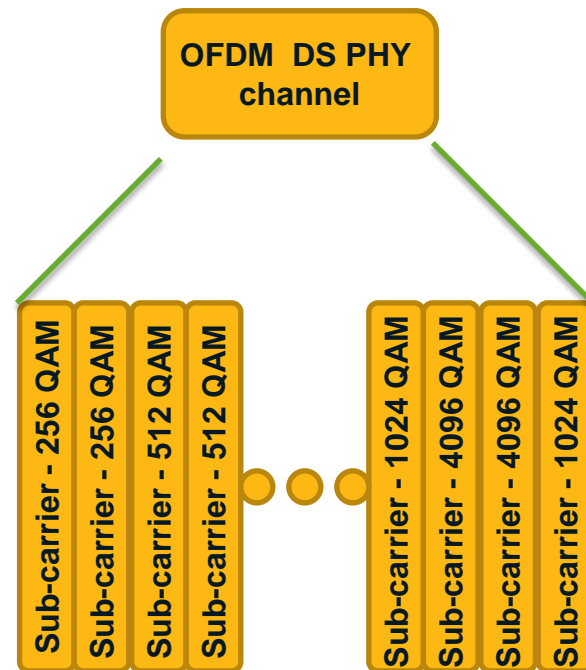
DOCSIS 3.1 Technology – Robustness, Flexibility, Cost Reduction

- **Main mechanism**

- Orthogonal Frequency Division Multiplex (OFDM) for Upstream and Downstream

- **Effects**

- Transmission of multiple narrow sub-carriers in a frequency block ('OFDM channel' or 'OFDM symbol')
- Each sub-carrier individually adjustable in modulation order and FEC to accommodate
 - Plant conditions (e.g. older network parts)
 - Disturbances (e.g. LTE interference)
 - Spectrum availability (e.g. co-existence with legacy services)
- Flexible spectrum usage not restricted to 6/8 MHz channels; incremental capacity additions
- Improved scaling to large bandwidth compared to bonding single carrier QAM channels (SC-QAMs)
- Mature technology used in many other platforms (notably mobile technologies) → Economies-of-scale and larger vendor community



DOCSIS 3.1 Technology - Migration

● **Backward compatibility**

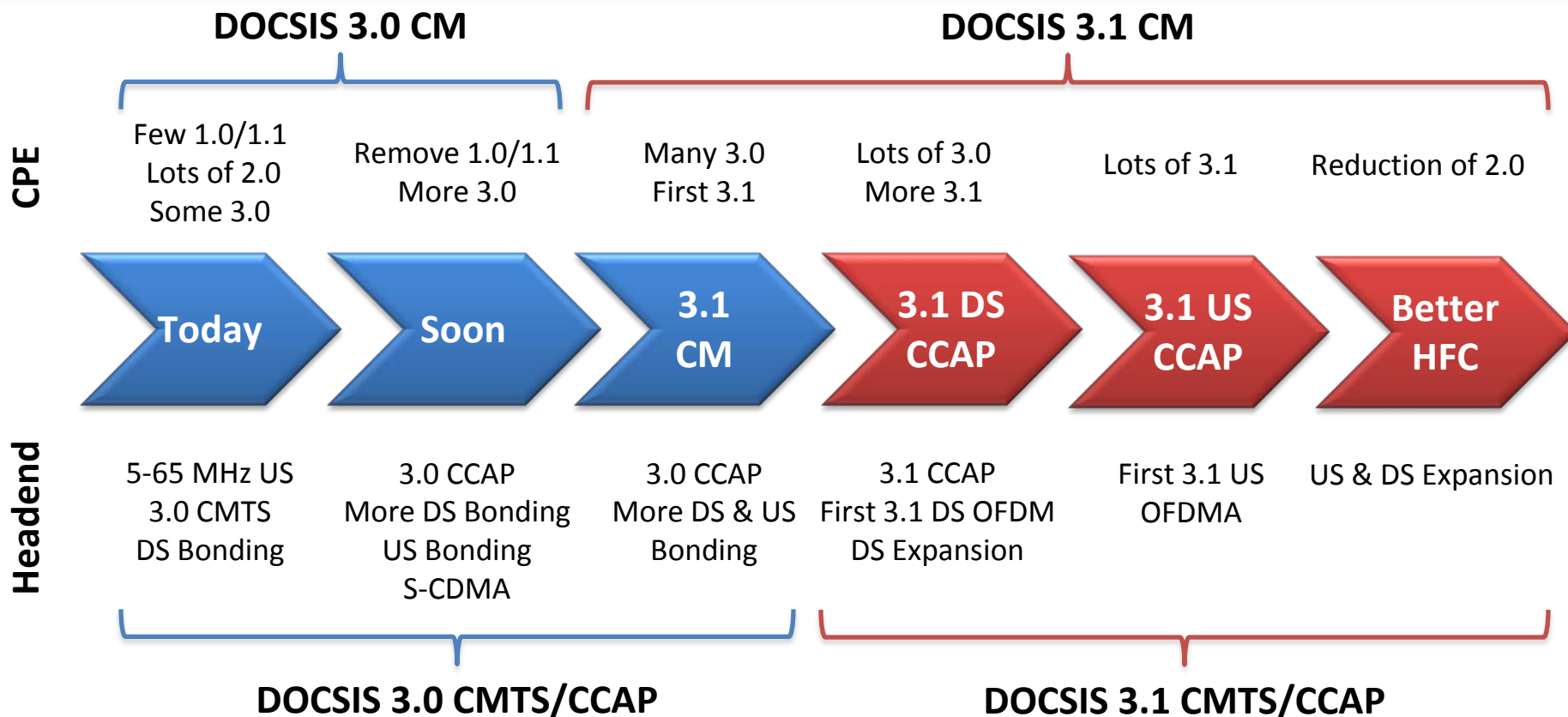
- Support of at least 24 bonded SC-QAMs in downstream and 8 in upstream
- S-CDMA in the upstream
- DOCSIS 3.1 CMs required to operate on DOCSIS 3.0 CMTSs
- DOCSIS 3.1 CMTSs required to support DOCSIS 3.0 (and 2.0) CMs
- To be implemented also with CCAP equipment

● **Operation on existing HFC networks**

- Upstream spectrum remains below downstream
- Supports operation with existing upstream splits (42/65 MHz as mostly in operation, 85 MHz as specified in DOCSIS 3.0)
- Supports spectrum enhancement in upstream (e.g. 200 MHz) and downstream (e.g. 1.2 GHz or even 1.7 GHz)
- Supports the ability to take advantage of enhanced capabilities when network, headend and CPE equipment permit



DOCSIS 3.1 Use Cases



Considerations when introducing DOCSIS 3.1

- DOCSIS 3.0 CCAP before DOCSIS 3.1 available
- First DOCSIS 3.1 CM with DOCSIS 3.0 CCAP
- Introduction of DOCSIS 3.1 DS in CCAP via Firmware Upgrade
- Introduction of DOCSIS 3.1 US in CCAP via Line Card swap
- Expansion of frequency range particularly in US very complex

(Source: CableLabs, Comcast)

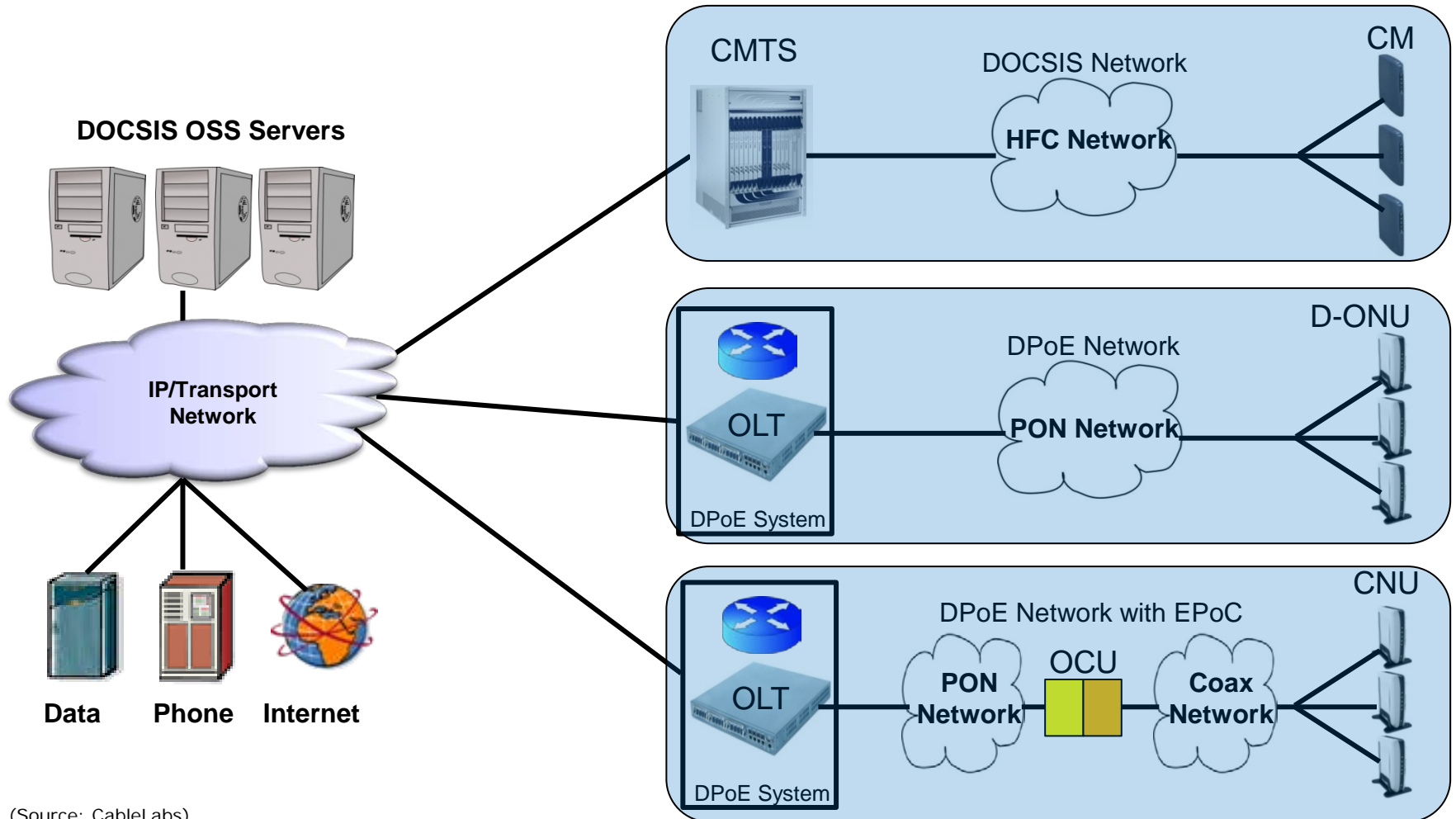




Towards FTTH ?

- **Service requirements are technology agnostic → customers require speed, QoS**
- **Technologies not necessarily mutually exclusive but complementary**
- **Advantages of DOCSIS 3.1 as a delivery platform**
 - Data rates (and supported service tiers) competitive
 - Connectivity available
 - Demand-driven network upgrades ('Fiber-to-where-it-makes-sense')
 - Protection of existing investment
- **Marketing challenge: symmetric services**

Converging HFC Platforms



(Source: CableLabs)

Summary and Timelines

- **DOCSIS 3.1 enabling Gigabit services**
 - Technical highlights
 - New FEC and higher order modulation for improved capacity
 - OFDM for flexible spectrum usage and adaptation to plant conditions enabling cost reductions
 - Backward compatibility (support of 24x8 DOCSIS 3.0 operation at a minimum)
 - Initial benefits (e.g. improved spectral efficiency and flexible spectrum usage) on existing plants without changes
 - Full benefits (e.g. capacity enhancement and spectrum expansion) without additional exchange of equipment
 - Target timelines see completion of specifications in 2013 and initial products as early as 2014
- **Significant step in evolution of HFC networks → remain competitive with alternative access technologies (on cost efficiency and capacity)**
- **Capacity enhancements and, consequently, capital investment consistent with customer demand**
- **Fiber connectivity to subscribers only where needed and/or economically feasible (e.g. business customers, green field)**
- **DOCSIS 3.1 in combination with other technologies (DPoE, EPoC) creates network agnostic IP delivery platform**

Thank you for your attention!

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