Fiber
Extension with
In:xtnd™ based
on MoCA
Access™ 2.5

Transform Cable Networks to Multi-Gigabit Fiber Extensions

Opportunity for HFC, Telecom and Fiber Operators

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Revision history

Date	Rev. number	Author	Version
2016-08-29	2016-01	Helge Tiainen	Version 2.0
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Document information

The purpose of this document is to describe how MoCA AccessTM 2.5 can support an increasing demand for broadband services. The main driver being the end-user demand for fast Internet access to Real-Time Entertainment services.
The MoCA AccessTM 2.5 aims to use the existing in-building coaxial infrastructure to provide 2.5 Gbps broadband access.
The development of the new MoCA Access 2.5 technology will change the mind-set how operators can offer cost efficient multi-Gigabit services over existing in-building coaxial infrastructure.

Abbreviations

Abbreviation	Description
ADSL	Asymmetric Digital Subscriber line is a type of DSL technology were bandwidth is greater toward the customer premises (Downstream) than the reverse (Upstream).
Band A-A	MoCA band 400-900MHz with a bandwidth of 500MHz us if TV band is replace with All IP implementation.
Band A-B	The Band A-B is defined between frequencies 800 MHz and 1675 MHz (875 MHz wide) used when terrestrial TV is up to 690MHz.
Band A-C	The Band A-C is defined between frequencies 1025 MHz and 1675 MHz (650 MHz wide) used when Mobile communication is using 690-862MHz or when cable-TV is up to 862MHz.
Band A-D	The Band A-D is defined between 1125 MHz and 1675 MHz (550 MHz wide) used when cable-TV is up to 1002MHz, including DOCSIS 3.0.
Band A-E	Band E is defined between frequencies 1375 MHz and 1675 MHz (300 MHz wide) used when cable-TV is up to 1218MHz, including DOCSIS 3.1.
In:xtnd Access	InCoax home modem. Separates TV and data signals. Different data services are made available through gigabit Ethernet ports and Wi-Fi.
CATV	Community Antenna Television, another word for Cable-TV.
In:xtnd Combine	InCoax Diplexer Filter– frequency multiplexer-demultiplexer filter to combine TV frequencies and data frequencies in the in-building coaxial network.
In:xtnd Control	InCoax central unit in the in-building network. Converts the incoming fiber signal to RF signal and supervises the in-building network.
In:xtnd Manage	InCoax management software system.
CLR	Coax Link Repeater – unit to amplify data signal in a coax network and bridge TV amplifiers when co-exists with Cable or Terrestrial TV.

Abbreviation	Description
CO	Central Office – a building used to house the inside plant equipment of potentially several telephone exchanges, each serving a certain geographical exchange area.
D-CMTS	Distributed Cable Modem Termination System is a piece of equipment, typically located in a cable company's headend or hub site, which is used to provide high speed data services.
DOCSIS	Data Over Cable Service Interface Specification – a standard for data communication in a cable-TV networks.
DPU	Distribution Point Unit is the G.fast Digital Subscriber Line Access Multiplexer located at within the building or very close to the building.
Downstream	Data communication direction to the subscriber.
DSL	Digital Subscriber Line.
DSLAM	Digital Subscriber Line Access Multiplexer located at Central Office.
Ethernet	A standardised serial data bus.
FTTB	Fiber To The Basement – Fiber to the basement of a building.
FTTdp	Fiber To The Distribution Point.
FTTC	Fiber To The Curb or Cabinet – Fiber to the street cabinet or pole is closer to the user's premises, typically within 300 m (1,000 feet).
FTTH	Fiber To The Home.
HFC	Hybrid Fiber-Coaxial is a telecommunications industry term for a broadband network that combines optical fiber and coaxial cable.
IPoC	IP over Coax – name of the InCoax access system.
IPTV	Broadband TV services delivered over IP protocol.
IP Video	Real-Time Entertainment as Netflix delivered over Internet.
MDU	Multi-Dwelling Unit is a classification of housing where multiple separate housing units for residential inhabitants are contained within one building or several buildings within one complex.
MoCA	Multimedia over Coax Alliance, industry standard, see: www.mocalliance.org
MoCA Access 2.5	New generation of MoCA standard supporting broadband access over coaxial networks with user capacity up to 2.5 Gbps per RF-channel and designed to co-exist with cable TV services in MDUs.
MSO	Multi-System Operator is an operator of multiple cable or direct-broadcast satellite television systems.
NOC	Network Operation Centre, is one or more locations from where network monitoring and control or network management is exercised.
Ofcom	Ofcom the communications regulator in the UK and regulate the TV and radio sectors, fixed line telecoms, mobiles, postal services, plus the airwaves over which wireless devices operate.
OFDM	Orthogonal Frequency-Division Multiplexing.
ONT	Optical Network Terminal.
OTT	Over-The-Top content refers to delivery of audio, video, and other media over the Internet without the involvement of a multiple-system operator in the control or distribution of the content.
QAM	Quadrature Amplitude Modulation.
QoS	Quality of Service - is the overall performance of a broadband network, particularly the performance seen by the users of the network.
Triple-Play	Combination of Internet, IPTV and VoIP services.
Upstream	Data communication direction from the subscriber.
VoD	Video on Demand, IPTV-based video services.
VoIP	Voice over IP, IP-telephony.

Executive Summary

Real-Time Entertainment (comprised of streaming IP Video and IP Audio) continues to be the largest traffic category on virtually every network and expect its continued growth during 2018. In North America Real-Time Entertainment accounting for 68.9% and in Europe Real-Time Entertainment is responsible for 45.6% of peak downstream traffic. Depending on the specific European country however, this percentage ranges anywhere from 25% to 68% of downstream traffic.

The Telecom and Cable/MSO industries need to fight against their legacies as much as against each other. The Telecom perhaps faced an even more fundamental challenge: The very substance that the industry is built upon, copper, and is hard pressed to operate at the great speeds necessary to support the intense traffic surging through today's networks.

That is changing. The Telecom industry long ago replaced the copper in the core of its network and in business areas with fiber. The stickier issue is the last leg approaching residential areas and how to reach the subscribers last feet within the MDU building.

The legacy of Cable DOCSIS based upon downstream data over several existing TV channels increase the complexity of the head-end and drives the investment cost as closer a DOCSIS head-end is place to the MDU building. Today the cost of a DOCSIS MDU Hub is around 5 times higher than the estimated cost of a similar MoCA Access 2.5 head-end (node controller) and with increased data throughput capacity the cost gap will continue to increase.

HFC, Cable and MSO operators need also to answer the question when traditional Analog / Digital-TV services shall be replaced with an All-IP approach while the Telecom operators have only IP based services (TV, VoIP and Internet access) today.

When the Fiber drop point is reaching the MDU building the broadband access industry will select the in-building infrastructure which can provide symmetric Ethernet (over CAT6 or fiber) services most cost efficiently.

MoCA Access 2.5 will have the capability of providing 2,5Gbps per RF channel and with future plans of Multi-Gigabit which will be clearly more than DSL and DOCSIS based technologies can provide due to limited physical characteristics of twisted pair cables and sustained capacity limits which DOCSIS can provide.

MoCA Access 2.5 will be a revolution for the broadband access industry. Suddenly there is an access technology which can provide real gigabit Ethernet extension over existing in-building coaxial wires. The in-coming fiber capacity will be same at building point of entry as it is in the subscriber's apartment. Typically, operators provide fiber capacity of Gigabit speed to a MDU building which is shared among the subscribers in the building. Now this capacity can be extended to the apartment by using cost efficient and non-intrusive (i.e. no need to modify apartment) multi-channel MoCA Access 2.5 technology.

For Cable and MSO operators this is both a threat and opportunity because they have traditionally provided Analog/Digital

TV services and added on data services over the coaxial network. They are coming from a background of providing TV as the main service and have difficulties to leave the traditional TV distribution business model. They are also investing heavily in DOCSIS 3.1 technology to be able to provide higher sustained capacity and do not have FTTdp capabilities as the Telecom operators while MoCA Access 2.5 can be combined with DOCASIS 3.1 and a way to reduce CAPEX compared to distributed DOCSIS 3.1 solutions.

For Telecom operators is MoCA Access 2.5 an opportunity to take over the in-building coaxial network first by offering an add-on service on top of Cable and MSO services providing IPTV or Real-Time Entertainment services as Netflix. When the in-building service contract with the Cable or MSO operator is ending Telecom can be an alternative service provider by offering All-IP services over the full coaxial network RF spectrum.

Challenge broadband operators and Internet Service Providers will probably be faster than Telecom to deploy MoCA Access 2.5 technology which is already today the case. It is creating pressure on Cable and MSO operator's where they must meet price competition.

Introduction

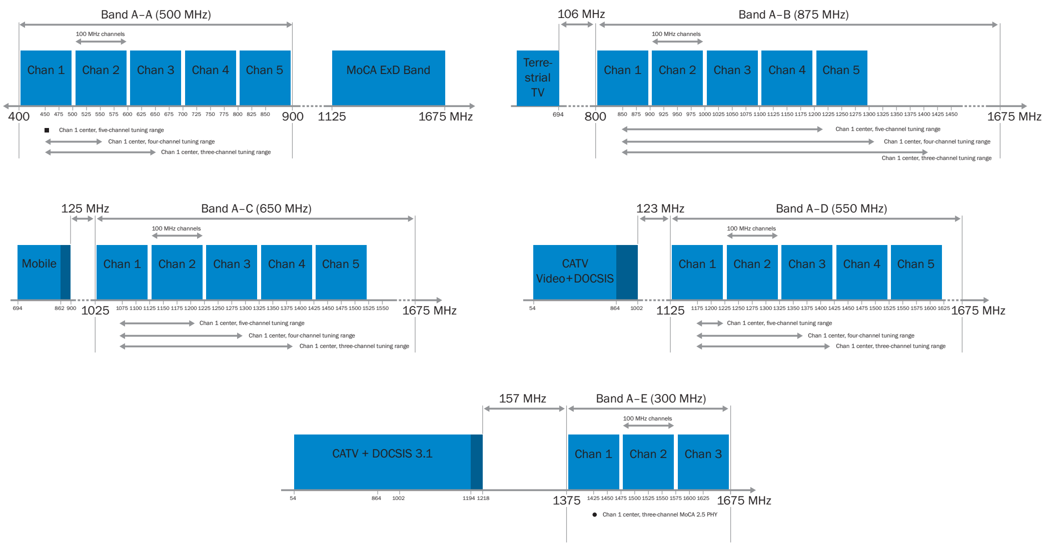
IP over Coax System overview

The central unit of the InCoax MoCA Access 2.5 system is one or several In:xtnd Control, which converts the data signal from the incoming fiber to a RF signal connected to the in-building passive coaxial cable network. The In:xtnd Control is installed at the location of the buildings TV amplifier. If existing TV services shall be kept, the In:xtnd Control RF signal is connected to the in-building coaxial network through Coax Diplexer Filters (CDF), which combines MoCA RF signal with the analogue / digital TV signal (EU frequency spectrum 5-690 MHz). In:xtnd Control communicates with In:xtnd Access connected to antenna outlets in the building. The In:xtnd Access separates the TV and data signals and converts the latter to Gigabit Ethernet. The MoCA Orthogonal Frequency-Division Multiplexing (OFDM) with Quadrature Amplitude Modulation (QAM) radio technology is the same as what is used in IEEE 802.11 Wi-fi® and 4g/LTE.

In a single coaxial cable loop with MoCA Access 2.5 one 500MHz bonded (five 100 MHz bonded channels) RF-Band A-A using 400–900MHz spectrum can coexist with one 500MHz RF-Band A-C using 1025–1525MHz. If the building has several coaxial cable loops, each loop can be supplied with two RF bands and the total capacity is shared between the connected modems.

MoCA Access 2.5 frequency bands

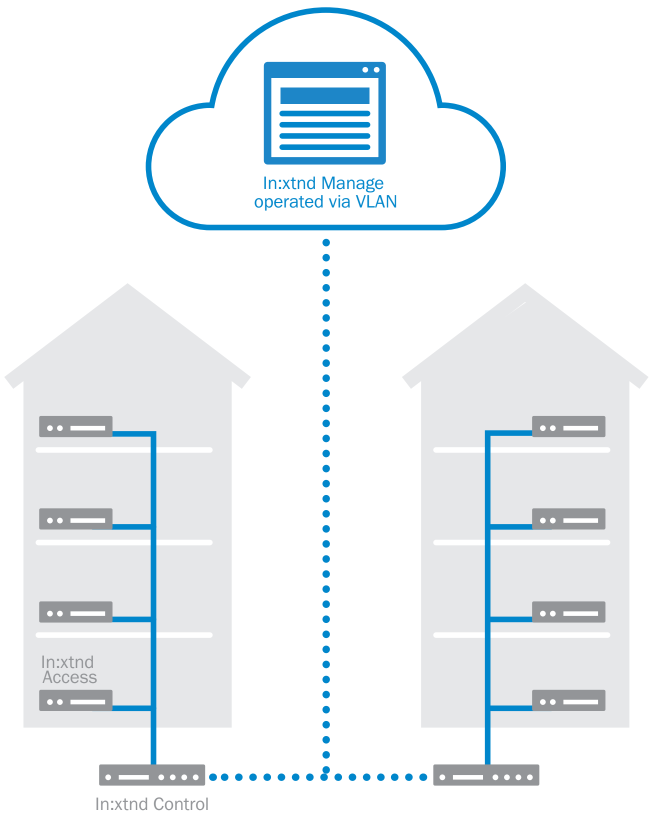
FIGURE 1



IP over Coax system overview

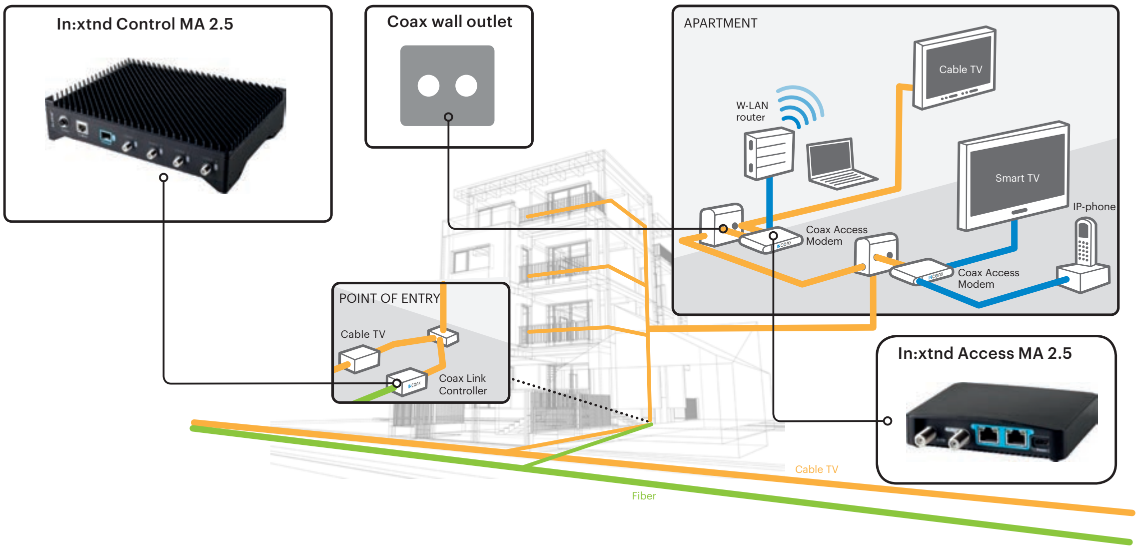
FIGURE 2

The system is configured, controlled and monitored by the In:xtnd Manage, usually installed at the operator’s Network Operational Centre (NOC).



Installation of IP over Coax in a building when coexist with cable-TV services

FIGURE 3-4



InCoax Product information

Based on the MoCA Access 2.5 standard from the Multimedia over Coax Alliance, InCoax aims to deliver the company's next generation of coaxial broadband access network solutions that can leverage the existing coaxial TV networks. The current network access technology platform, i.e. the 19XX-series, is extended with to support up to 10 Gbps throughput in the 25XX-series next generation platform.

This document contains the following next generation InCoax products:

- In:xtnd Control, with 1,0/2,5 /10Gbps fiber uplink and several RFport alternatives
- In:xtnd Access, with GbE Ethernet ports and IEEE 802.11 Wi-Fi® alternatives
- In:xtnd Manage, service/network/element management software of network elements
- In:xtnd Combine, filter and combiner of different RF-bands

Access Network Evolution

Impact of Real-Time Entertainment bandwidth consumption

Real-time entertainment [2], comprised of streaming IP video and audio, continues to be the largest traffic category on virtually every network and its continued growth is expected through 2018.

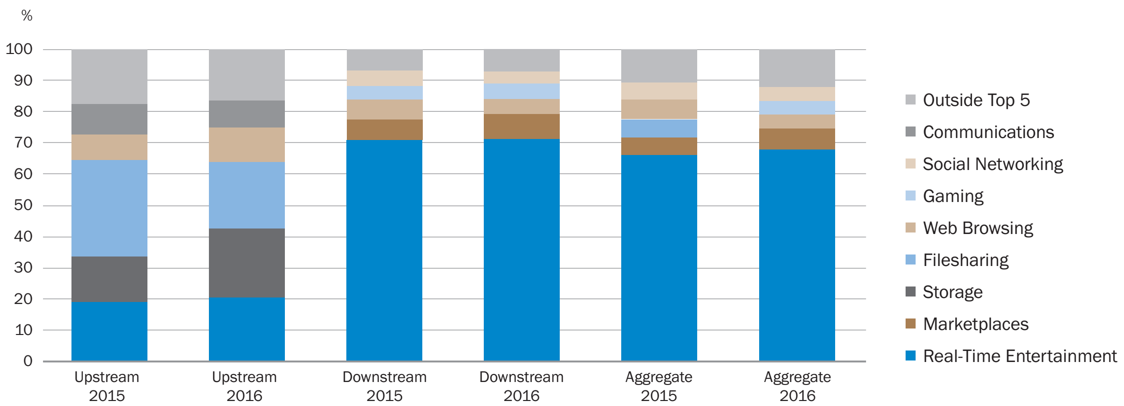
In North America, the dominance of real-time entertainment is due in large part to the continued market leadership of Netflix accounting for 35.2% of network traffic, according to numerous press and analyst reports. Amazon Instant Video is gaining in popularity and 12 consumes almost two percent of peak downstream traffic. Amazon is considered one of the leading OTT alternative video service in North America.

Parks Associates notes that many consumers in the U.S. for instance, subscribe to at least two paid service, sometimes in addition to their traditional pay TV service provider. As direct-to-consumer (or OTT) paid services continue to come to market, subscribers will now have a variety of options which will only accelerate the need for fast and reliable access networks.

In Europe, Real-Time Entertainment is also the top traffic category, responsible for 45.6 percent of peak downstream traffic, and growing every year. It should be noted that Real-Time Entertainment traffic does vary by country with OTT as a percentage of downstream traffic ranging between 25 to 68 percent. This variance is partly explained by the availability of a number of streaming video services available in each particular country as well as the variations in Internet broadband service performance offered by operators. Countries where paid streaming services are popular and high performance broadband network options are available, tend to exhibit a higher share of real-time entertainment traffic on their network.

Peak Period Traffic Composition 2016 – North America, Fixed Access

FIGURE 5



Below are the Internet download speed recommendations per stream for playing movies and TV shows through Netflix (Source: Netflix):

- 3.0 Megabits per second - Recommended for SD quality
- 5.0 Megabits per second - Recommended for HD quality
- 25 Megabits per second - Recommended for Ultra HD quality

Every IP video service represents a separate unicast stream so there is no benefit to joining a multicast stream as in IPTV. As the adoption of HD/UHD TVs continues, RTE's share of total Internet traffic will also continue to increase.

Streaming services have gained in popularity which increases consumers need for sustained broadband capacity and when streaming services starts to support Ultra HD the sustained broadband capacity will continue to increase.

DSL evolution to support Real-Time Entertainment

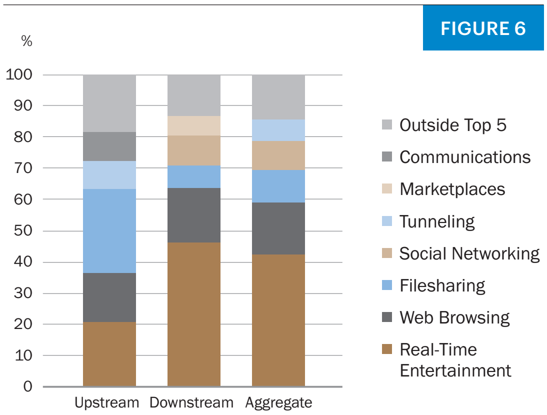
A DSL access network is an access architecture where the last-mile channel (in this case, the DSL link) is dedicated to a single subscriber. The DSL access architecture comprises two or more stages between the Internet Service Provider's (ISP) point of presence and the subscriber. They are:

1. The network between the ISP and the DSL Access Multiplexer (DSLAM), located either in the central office or in the loop plant. Where the DSLAM is located in the Central Office (CO), the up bound network-facing connection of today's DSLAMs is generally a high speed data network operated by the Internet Service Provider, with data rates at or above the Gigabit per second range.
2. The subscriber loop. The loop provides a dedicated connection to each subscriber from the DSLAM.

A typical CO-based DSLAM is a modular unit that may be populated with different types of access cards. Connections to the data network usually include multiple Gigabit or higher rate links. On the subscriber side, the DSLAM may support 500 or more DSL links, either directly or through subtended DSLAMs as described below.

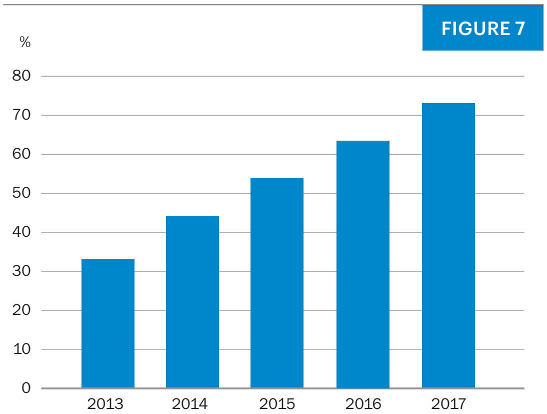
Peak Period Traffic Composition 2015 – Europe, Fixed Access

FIGURE 6



Global Smart-TV share of TV shipments (Source: BI Intelligence)

FIGURE 7



In many DSL networks, remote DSLAMs are deployed in the loop plant. This decreases the length of the loop between the subscriber and the DSLAM, which in turn enables higher data rates. These DSLAMs usually serve from 24 to 384 subscribers in a distribution area.

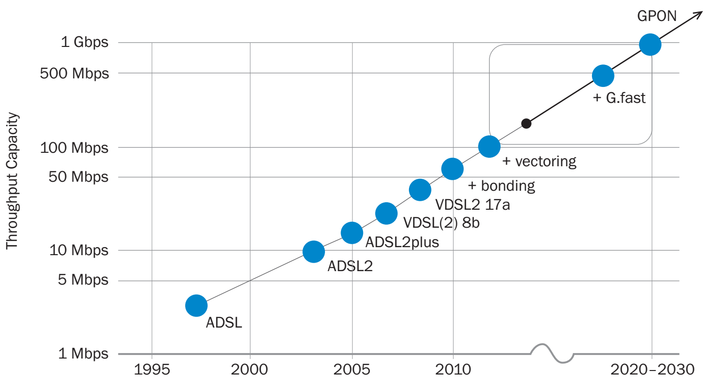
If the subscriber is served by a subtended DSLAM, there will be a connection between the CO-based DSLAM and the subtended DSLAM. Many subtended DSLAMs are fed over fiber links at Gigabit rates.

The up bound network-facing DSLAM connections described above are shared resources, over which data from multiple subscribers share bandwidth. These are typically high speed resources, operating in the Gigabit per second and above range.

Each subscriber loop connection is a point-to-point link between the DSLAM and a single subscriber. All traffic transmitted across that loop is dedicated to the subscriber served by the loop. With currently-deployed commercial ADSL technology,

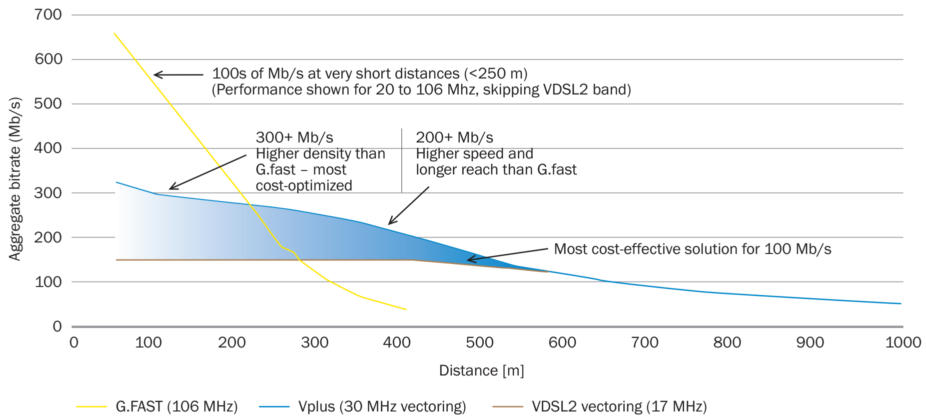
Evolution from ADSL to G.Fast offered by Telecom operators

FIGURE 8



To reach Gbps speed G.fast DPU needs to be deployed within the MDU building

FIGURE 9



achievable rates on the longest loops of a carrier serving area (3600 meter) are approximately 6 Mbps for download and approximately 1 Mbps for upload, with much higher rates attainable on shorter loops. When loops are served by a remote DSLAM dedicated to a single distribution area, the maximum loop length is typically less than 1800 meter, supporting download data rates of 15-25 Mbps per subscriber.

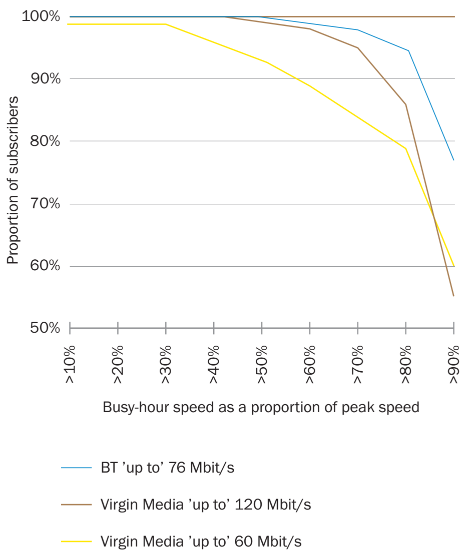
VDSL is a DSL technology providing data transmission faster than ADSL over a single flat untwisted or twisted pair of copper wires (up to 52 Mbit/s downstream and 16 Mbit/supstream), using the frequency band from 25kHz to 12MHz. These rates mean that VDSL is capable of supporting applications such as high-definition television, as well as telephone services (Voice over IP) and general Internet access, over a single connection. Secondgeneration systems VDSL2 use frequencies of up to 35 MHz to provide data rates close to 100 Mbit/s simultaneously in both the upstream and downstream directions. The maximum available bit rate is achieved at a range of about 300 meters; performance degrades as the loop attenuation increases.
Third-generation systems VDSL2 vectoring works only on twisted pair and is based on the concept of “noise cancellation”, much like the headphones people have started to use increasingly on planes, to reduce or cancel background/engine noise when listening to music or watching a movie. VDSL2 vectoring calculates the interference between all pairs in a binder, based on the actual signals, and will use this information to generate a noise cancellation signal on each pair, effectively removing all crosstalk.

G.fast is the fourth-generation DSL technology for local loops shorter than 250 meter, with performance targets between 150 Mbit/s and 1 Gbps, depending on loop length. High speeds are only achieved over very short loops which are less than 100 meter.

Cable and MSO Operators have a clear benefit of offering higher bandwidth peak rates compared to Telecom operators. This is the fact already today and it will continue with the DOCSIS evolution.

Distribution of busy-hour actual speed as a proportion of peak actual speed for selected BT and Virgin Media packages (Source: Ofcom, 2013)

FIGURE 10



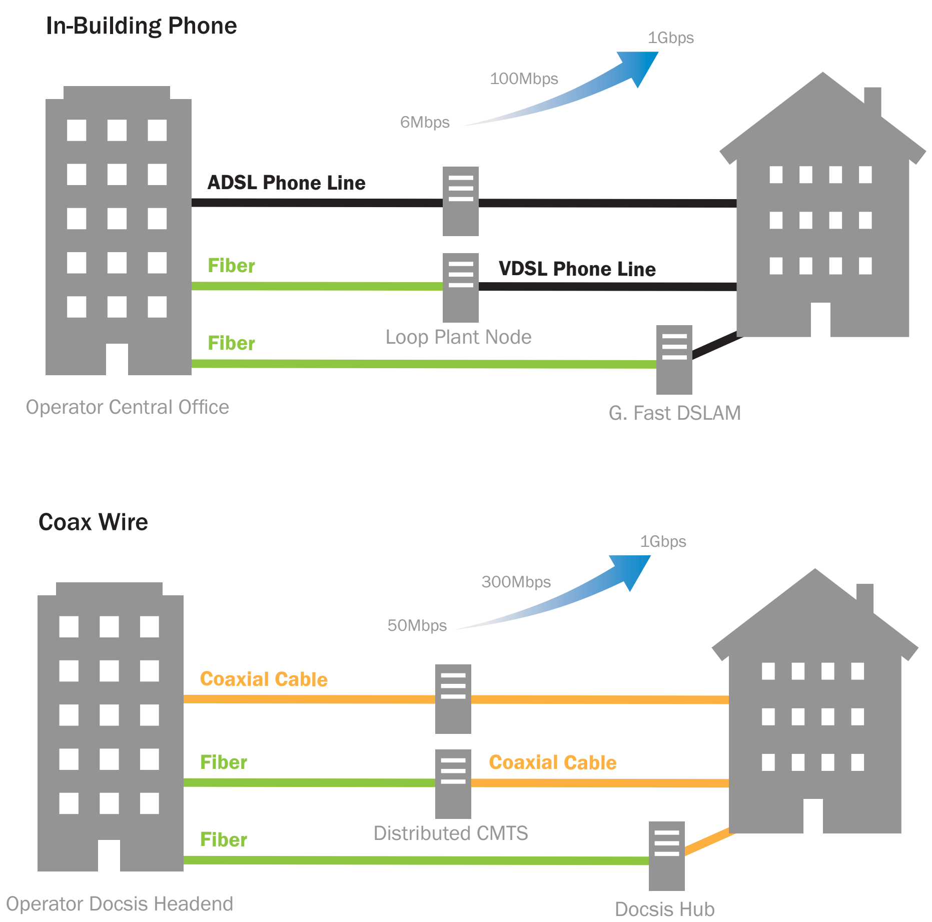
Consumer Broadband Experience

There are many factors which affects the overall consumer experience of a particular broadband delivery network. However, the two main isssues are the peak speed and the sustained bandwidth:

- Having a high peak speed can allow consumers to quickly download/upload files, for immediate consumption – and is especially important when a consumer has to wait for 16 the download to finnish before consuming. An example is downloading media using a home network for later consuption on the move, such as from a cloud storage service to an offline media player (e.g. a SkyGo movie onto a tablet, or a new ITunes album onto an IPod), prior to leaving a consumer's household.
- Having a high busy-hour sustainable speed allows subscribers to have more solid connection and to achive good performance from their connections regardless of the time of day or day of week.

Increasing sustained data speed requirement push DSL and DOCSIS operators to deploy fiber drop point within the MDU building to be able to provide Gigabit services

FIGURE 11



Good performance is required both for services which have high QoS requirements (such as IPTV or video conferencing), and for services which require the distribution of lage amounts of data over en extended period such as Real-Time Entertainment.

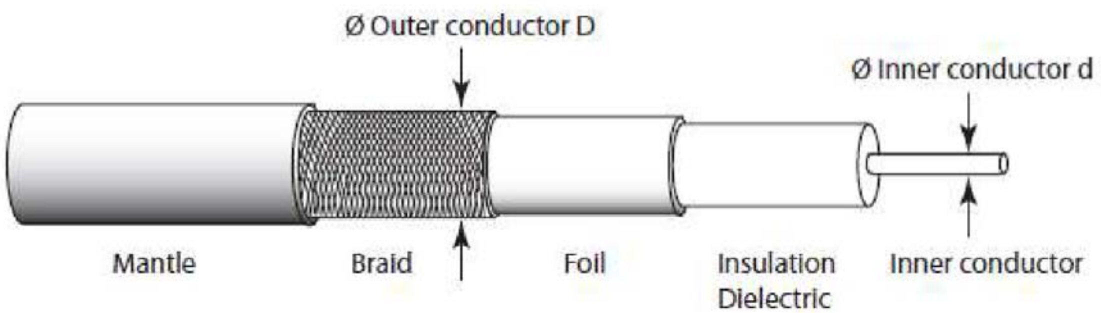
Because DOCSIS uses shared bandwidth on the access network, it tends to suffer from a much larger drop between peak speeds and sustained bandwidth due to network congestion than VDSL/FTTC does. This can be seen by considering the actual achievable speeds of DOCSIS during the busy hour (when the largest number of users are likely to be using the network at once), as shown in Figure 8 for the UK. This effect is even more significant when comparing similar packages (i.e. Virgin Media up to 60Mbps with BT's up to 76Mbps); the proportion of Ofcom testers who receive more than 80% of their maximum speed at peak times was 79% for Virgin Media being able to provide peak speeds that are closer to or actually exceed the advertised speed.

When the share of Real-Time Entertainment is increasing, as earlier described, in a DOCSIS based network were many subscriber are sharing a DOCSIS link will the sustained capacity fall faster than in a DSL based network. To keep customer satisfaction Cable and MSO operators needs either to increase the number of TV-channels used for data download or adopt 17 DOCSIS 3.1 which will increase capacity by using a wider frequency spectrum.
Other alternative is to move the DOCSIS headend closer to the customer premise or having the DOCSIS headend in the actual MDU building. Same will apply for DSL operators when G.fast will be deployed it will in principal mean that the DPU will need to be installed in the MDU building to be able to provide Gigabit speed.

DOCSIS operator's needs to come closer to the MDU building so fewer customer are sharing on the available capacity to guarantee high sustained capacity per customer while DSL operators need to come closer to the MDU building by shorten the phone line loop so a customer can have higher capacity.

The construction of a coaxial cable

FIGURE 12



In-building Coax vs. Phone line comparison

Coaxial cable, a tubular two-core cable consisting of a core and a shielding, are used in cable and terrestrial TV systems and other high-frequency applications. The construction is showed in Figure 11. A mantle covers the cable; a protective cover made of either of white PVC or black polyethylene (PE). Braid and foil acts as shielding and protects the cable from irradiation of unwanted terrestrial frequencies in order to prevent interference. Braid protects against low frequencies and the foil protects against high frequencies. Conversely, it protects the foil and braid from the environment is disturbed by radiation from coaxial cable.

The insulation, or dielectric, has the function to hold the inner conductor in place. The best insulator available is air. To obtain good attenuation characteristics the insulation also 18 contains small air bubbles that makes it feel like foam rubber. The more air in the insulation, the cable attenuates less. Most common types of plastic are polyethylene (PE) and foamed polyethylene. The inner conductor is made of copper and has a certain diameter that varies between 0, 5 mm–2, 0 mm for the cable used in-building networks.

Twisted pair cabling is a type of wiring in which two conductors of a single circuit are twisted together for the purposes of cancelling out electromagnetic interference (EMI) from external sources; for instance, electromagnetic radiation from unshielded twisted pair (UTP) cables, and crosstalk between neighbouring pairs. In balanced pair operation, the two wires carry equal and opposite signals and the destination detects the difference between the two. This is known as differential mode transmission. Noise sources introduce signals into the wires by coupling of electric or magnetic fields and tend to couple to both wires equally. The noise thus produces a common-mode signal which is cancelled at the receiver when the difference signal is taken.

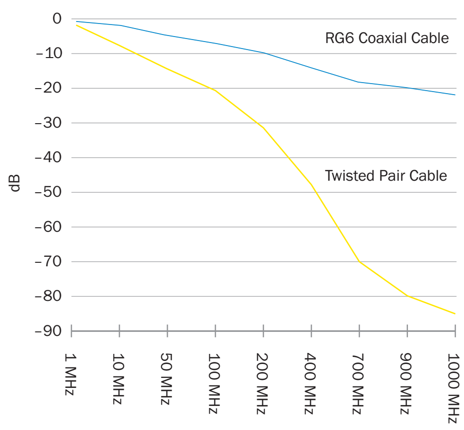
This method starts to fail when the noise source is close to the signal wires; the closer wire will couple with the noise more strongly and the common-mode rejection of the receiver will fail to eliminate it. This problem is especially apparent in telecom-

Typical twisted pair cable

FIGURE 13

Attenuation comparison of 100 meter RG6 coaxial cable and twisted phone line on different frequencies

FIGURE 14



munication cables where pairs in the same cable lie next to each other for many kilometres. One pair can induce crosstalk in another and it is additive along the length of the cable. Twisting the pairs counters this effect as on each half twist the wire nearest to the noise-source is exchanged.

Providing the interfering source remains uniform, or nearly so, over the distance of a single twist, the induced noise will remain common-mode. Differential signalling also reduces electromagnetic radiation from the cable, along with the associated attenuation allowing for greater distance between exchanges.

Increasing data speed requires support for increasing frequency spectrum and it is obvious that in-building twisted pair phone cables have much higher attenuation performance to support higher frequencies than in-building RG6 coaxial cables. This means that coaxial cables is more suitable to carry high frequency signals than the twisted pair cables and is also a reason why DOCSIS operators can offer much higher peak speed than DSL operators.

Coaxial cables have been upgraded due to Analog to Digital-TV switchover because digital- TV broadcasting offer a wider range of channels so in most MDU buildings the coaxial network have been upgraded compared to phone lines. Coaxial cables support frequency range typically up to 2,4GHz and support data speeds above 10Gbps. Coaxial cables can match the speed of future fiber while twisted pair cables cannot.

Operator's accomplishment to change access technology

Telecom operators has by tradition tried to maximizes the existing copper infrastructure investment by adding new technologies for broadband access as ADSL, VDSL, VDSL Vectoring and now for the future G. fast supporting close to 1Gbps if the copper loop length is shorter than 100 meter.

For Greenfield deployment it is assumed that FTTH in Single Home and FTTdp in MDU will be the selected solution.

For Brownfield Single Home deployment will an alternative be FTTH if there is area penetration level of more than 50% of the subscribers otherwise it will be FTTdp which is located in a street cabinet.

For Brownfield MDU deployment will the FTTdp be in the basement of the MDU building to meet the requirement of 1 Gbps capacity if DSL operator shall be able to compete with DOCSIS operators.

G.fast is proposed by some vendors that instead of using in-building copper wires that it shall be possible also to use the coaxial infrastructure. G.fast is using a spectrum initially up to 106MHz and later up to 212MHz. If the building already have

Cable Attribute	Coaxial Cable Network	Twisted Pair Network
Age of in-Building cabling	+	–
Cable Availability at Point of Entry	+	+
Cabling reach TV- location in the home	+	–
Cable Network HF Attenuation	+	–
Future Support for Multi-Gigabit	+	–

Table 1 Coaxial and Twisted Pair cable strength (+) and weakness (–) comparison

DOCSIS services from a Cable or MSO operator the G.fast cannot co-exists on the same coaxial cable. G.fast requires also that the coax infrastructure is from distribution point over a dedicated coaxial wire to each apartment which is not the case in many MDU buildings. So G.fast over coax is not able to cover all coaxial infrastructure MDU alternatives.

By opening the G.fast coax option is obvious that Telecom operators see coax as an alternative to support Gigabit services if the FTTdp is in the building.

MSO and Cable operators has by tradition tried to maximize the existing coaxial infrastructure investment by adding new technologies for broadband access as DOCSIS1.0, DOCSIS2.0, DOCSIS3.0 and now for the future DOCSIS3.1 supporting up to 10Gbps.

The coaxial networks need to be upgraded to support frequency range up to 1218MHz when deploying DOCSIS3.1. It means that splitters and taps need to be upgraded and all TV amplifiers needs to support this higher frequency ranges and also cover return frequency range up to 200MHz. The network will still be a shared media. If a DOCSIS headend is supporting 500 subscribers, these subscribers will share provided capacity , stay in Mbps per subscriber and that will not meet future requirements of sustained capacity required by Netflix UHDTV and similar services. In average in Europe do every home have 2,4 TV-set so that will require a sustained capacity of 60Mbps and this will not DOCSIS 3.1 meet without having the DOCSIS 3.1 hub in the MDU building.

DOCSIS and DSL Capability Upgrade Options		Time frame		
		Now	Medium	Long
Options for DOCSIS Operators	Technology	Deploy DOCSIS 3.0	Deploy DOCSIS 3.1	MoCA Access for All-IP over coax
	Spectrum	5-862MHz	5-1006 MHz or 5-1218 MHZ	5–1700 MHz
	Network	Reducing homes per node	Distributed CMTS or DOCSIS Hub	FTTdp deployment within MDU building to support MoCA Access
Options for DSL Operators	Technology	VDSL	VDSL Vectoring /G.Fast/ MoCA Access 2.5	MoCA Access either co-existwith TV/DOCSIS or All-IP over coax
	Spectrum	Up to 35MHz over copper line	Up to 106 MHz over copper line	Up to 212 MHz over point-topoint coaxial line. Copper lines can only be used on very short distance less than70 meters
	Network	FTTC typically street cabinet	FTTC for VDSL Vectoring and FTTdp within the MDUfor G.Fast/MoCA Access 2.5	FTTdp for MoCA Access in the MDU

Table 2 Summary of upgrade options available to DOCSIS and DSL operators

For Greenfield deployment it is assumed that FTTH in Single Home and FTTdp in MDU will be the selected solution for Cable and MSO operators to offer both TV services and DOCSIS services over the fiber.

For Brownfield Single Home deployment DOCSIS will continue to be a strong alternative if

there is an existing coaxial network. For Brownfield MDU deployment will the FTTdp be in the basement of the MDU building to meet the requirement to serve Real-Time Entertainment services and continuing serving both traditional Digital-TV and DOCSIS services.

Is MoCA Access 2.5 changing the access game play?

The DSL and DOCSIS industries need to fight against their legacies as much as against each other. The DSLs perhaps faced an even more fundamental challenge: The very substance that the industry is built upon, copper, and is hard pressed to operate at the great speeds necessary to support the intense traffic surging through today's networks.

That is changing. The DSL industry long ago replaced the copper in the core of its network and in business areas with fiber. The stickier issue is the last leg approaching residential areas and how to reach the subscribers last feet within the building.

MoCA Access 2.5 will have the capability to provide 2,5Gbps and with future plans up to 10Gbps which will be clearly more than DSL based technologies can provide due to limited physical characteristics of twisted pair cables.

The legacy of DOCSIS based upon downstream data over several existing TV channels increase the complexity of the head-end and drives the investment cost as closer a DOCSIS head-end is place to the building. Today is the cost of a MDU DOCSIS Hub around 4-5 times higher than the cost of a similar MoCA Access 2.5 head-end and with increase data throughput capacity the cost gap will continue to increase.

For HFC, Cable and MSO operators need also to answer the question: "When shall traditional Analog / Digital-TV services be replaced with an All-IP approach while the DSL operators have only IP based services today?". MoCA Access 2.5 is a strong candidate to change the way Gigabit services are offered especially in MDU buildings. It can be deployed either to coexist with traditional TV/DOCSIS services or as an All-IP over coax solution providing multigigabit services. This means MoCA Access 2.5 also fits the challenging broadband operators and Internet Service Providers, as well as the telecom operators.

From a technology and performance point of view is MoCA Access 2.5 a very cost efficient solution compared to G.fast and DOCSIS3.1. It do not have the legacy burden as DOCSIS and it is very scalable compared to G.fast were the 2,5Gbps and in future up to 10Gbps can be provided to a subscriber. It will correspond to the

Technology	Network Access Speed	CAPEX (€) per subscriber	Availability
Vectored VDSL	50–100 Mbps	265-440 (with DSLAM in CO)	Today–2018
G.fast	100 Mbps–1 Gbps	1230 (including FTTB)	Today–2018
FFTH	2.5 Gbps shared over 32 or 64 subscribers	2200-4400 (with ONT at subscriber)	Today–2018
MoCA Access 2.5	2.5 Gbps shared coaxial loop over 31 subscribers	450–650 (including FTTB)	Today–2018

Table 3 Access Network Technology speed, CAPEX and availability comparison, based on operator total cost of installation per subscriber from [5].

incoming fiber capacity which today is 1Gbps and in future 10Gbps over the fiber to the MDU building.

MoCA Access 2.5 and G.fast CAPEX Comparison CAPEX comparisons can be difficult to make because they are heavily dependent on supplier technology solutions and equipment costs, but also on the geography and soil conditions, on the existing infrastructure, availability of existing ducts, on the city infrastructure environment and on the labor costs. Several presentations compare CAPEX costs per subscriber for network access technologies.

The cost estimates in this comparison for vectored VDSL, G.fast and GPON are obtained from "Giga Feast or Fast", G.FAST Summit May 21, 2014. Vectored VDSL is acknowledged as the most cost-effective option, with an average cost of €265-440 per subscriber has been reported by service providers deploying Vectored VDSL with DSLAM installed in the CO.

MoCA Access 2.5 requires FTTB were the fiber drop point is typically installed in the MDU basement were also the in-building TV amplifier point is located. In this comparison is the fiber deployment cost estimated to same as a FTTH deployment cost. Cost of in-building MoCA Access is based upon costs reported by service provides deploying pre MoCA Access solutions and including fiber deployment costs is MoCA Access 2.5 acknowledged as cost effective as Vectored VDSL, with an average cost of €450-650 per subscriber and with capability of providing Gigabit services.

G.fast is estimated to a much have higher costs than Vectored VDSL. G.fast implementation require shorter distance between the Distribution Point Unit (DPU) and subscriber which in the practical life means that the DPU will be installed in the MDU to come close enough to MDU apartment unit. G.fast is estimated to be €1230 per subscriber.

GPON has the highest costs, since it requires fiber installations to the building and also within the building where it terminates in Optical Terminal Unit (ONT). An often-cited cost concern about GPON is installing fiber in the drop segment, which requires consent and coordination with the homeowner or landlord.

Therefore, GPON and MoCA Access 2.5 combination is very good because it does not require coordination, landlord consent or visits to each apartment in the MDU buildings. The solutions are completely non-intrusive and will not require any installation of new cables, new outlets or optical network terminals (ONT), neither restoration of apartment after installation.

The subscribers can install the MoCA Access 2.5 modems themselves, as with ADSL and VDSL modems.

All-IP Cable Revolution

MoCA Access 2.5 will be a revolution for broadband access industry. Suddenly there is a technology which can provide real fiber extension over existing in-building wires. The incoming fiber capacity will be same at building point of entry as it is in the subscriber's apartment. Typically, operators provide point to point fiber capacity of 1 Gbps or GPON 2.48/1.25 Gbps to a MDU building which is shared among the subscribers in the building. Now this capacity can be extended into the apartment by using cost efficient MoCA Access 2.5 technology.

For Cable and MSO operators this is a threat because they have traditionally provided Analog/Digital TV services and added on data services over the coaxial network. They are coming from a background of providing TV as the main service and have difficulties to leave the traditional TV distribution business model. They are also investing heavily in DOCSIS technologies to be able to provide higher capacity and do not have FTTdp capabilities as the Telecom operators, except for some HFC.

For Telecom operators is MoCA Access 2.5 an opportunity to take over the in-building coaxial network first by offering an additional service on top of Cable and MSO services providing IPTV or Real-Time Entertainment services as Netflix or similar. When the inbuilding service contract with the Cable or MSO operator is ending, the Telecom operator can be an alternative service provider by offering All-IP services over the coaxial network.

Challenging broadband operators and Internet Service Providers will probably be faster than Telecom to deploy MoCA Access 2.5 technology which is already today the case. It is creating pressure on Cable and MSO operator's where they must meet price competition mainly on Internet surf services.

In many countries regulatory authorities are only focused on deregulation of the phone wires. The regulated access to Next Generation Access Networks (NGA) 2010/572/EU has now become law and in many EU member states and some states have also included coaxial networks which was very unpopular among Cable and MSO operators. The MoCA Access 2.5 will support regulatory requirements of having several operators using the MoCA Access 2.5 node for unbundling services.

In addition, the EU also aims for aggressive broadband coverage in "Connectivity for a European Gigabit Society" (from [6]): "In 2010, the Digital Agenda for Europe defined objectives for connectivity by 2020: universal availability at 30 Mbps, to ensure territorial cohesion, and subscriptions at 100 Mbps by at least 50% of European households, to anticipate future competitiveness needs." The document also defines future objectives for 2025:

"...access to connectivity offering at least 100 Mbps for all European households." This clearly requires reuse of existing cable and wire infrastructures to be able to meet the goals set.

Operators who are early adopting the MoCA access opportunity will have clear benefits in the All-IP Cable revolution because they have set up the organization to perform deployments over coaxial networks before competition.

References

[1] Analysys Mason report: Future capability of cable networks for superfast broadband

[2] Sandvine: Global Internet Phenomena, 2016

[3] Broadband Forum: DSL Technology Evolution

[4] Alcatel-Lucent: Overview of G.Fast

[5] J. M. Cioffi and G. Ginis "Giga Feast or Fast", G.FAST Summit May 21, 2014

[6] Connectivity for a Competitive Digital Single Market – Towards a European Gigabit Society, COM(2016) 587

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