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MoCA Access™

Reliable Gigabit Fiber Extension Over in-building Coaxial Networks

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Introduction

This paper is intended to define the bandwidth requirements for Real Time Entertainment (RTE) and compare and contrast the various network access technologies in providing sustainable bandwidth.

Impact of Real-Time Entertainment Bandwidth Consumption

Real-time entertainment*, 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 2017.

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 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.

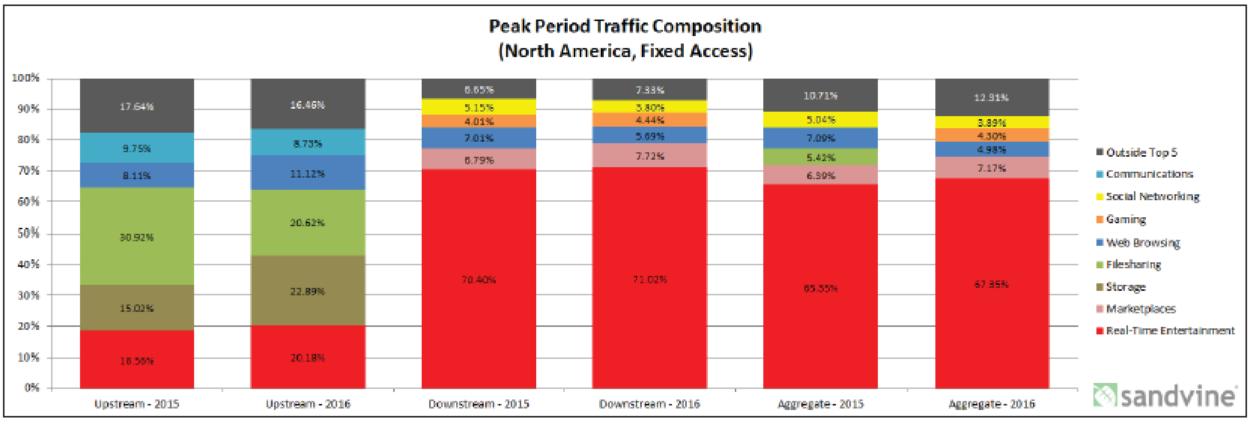

Figure 1 Peak Period Traffic Composition 2016 - North America, Fixed Access

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 RTE 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 performance offered by operators. Countries where paid streaming services are popular and high performance options are available, tend to exhibit a higher share of real-time entertainment traffic on their network.

*Sandvine Global Internet Phenomena report 2016

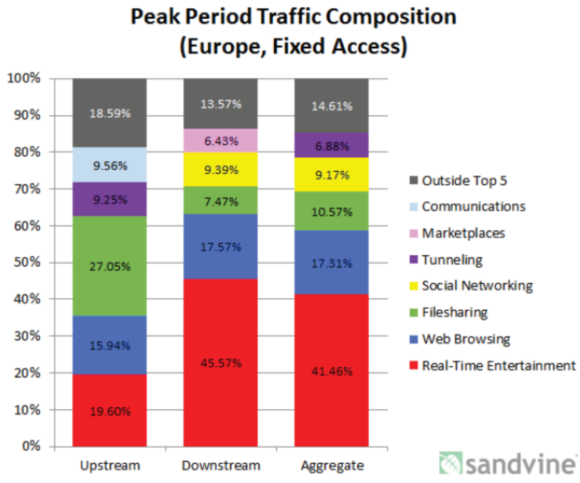

Figure 2 Peak Period Traffic Composition 2015 - Europe, Fixed Access

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 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.

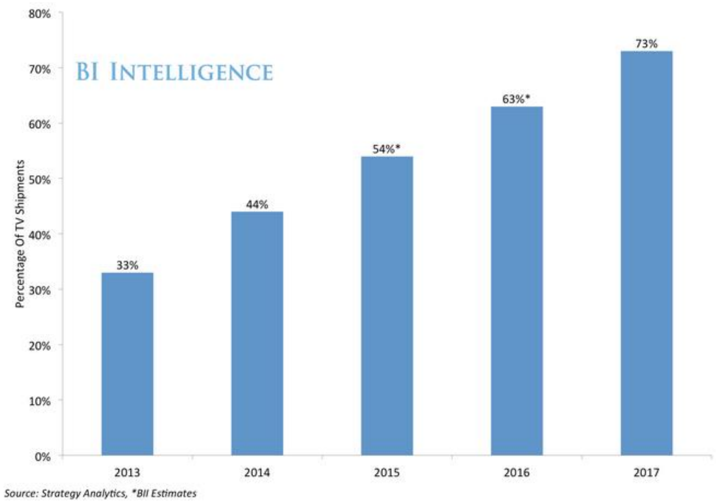

Figure 3 Global Smart-TV share of TV shipments (Source: BI Intelligence)

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.

Consumer Broadband Experience

There are many factors affecting 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 allows consumers to quickly download/upload files, delays of which are frustrating for end users. An example is downloading media using a home network for later consumption on a portable device outside the house, 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).
- Ensuring reliable performance to and between all devices regardless of the time of day or the number of devices attached to the network is paramount. This is particularly important for services that have high QoS requirements (such as IP/UHD video), and for services which require the distribution of large amounts of data over en extended period such as real-time entertainment.

Because DOCSIS is a shared bandwidth technology, it tends to suffer from a much larger drop between peak speeds and sustained bandwidth due to network congestion than VDSL/FTTC. As an example, see figure 4 regarding traffic patterns in the United Kingdom. This is even more significant when comparing services from different operators. Virgin Media offers up to 60 Mbps and BT offers up to 76 Mbps. The proportion of Ofcom testers who receive more than 80 percent of their maximum speed at peak times was 79 percent for Virgin Media as being able to provide peak speeds that are closer to or actually exceed the advertised speed.

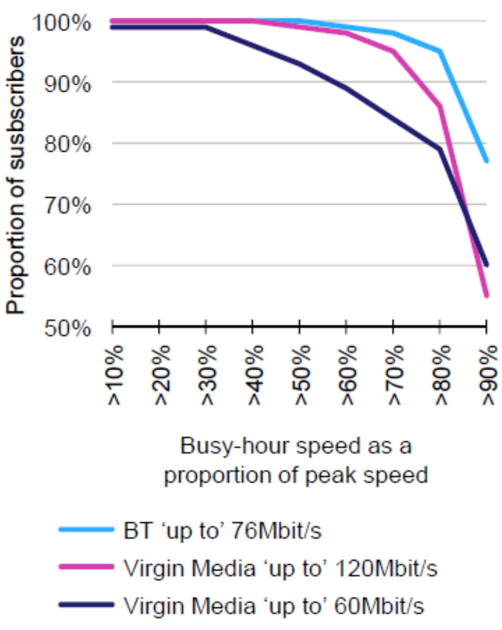

Figure 4 Distribution of busy-hour actual speed as a proportion of peak actual speed for selected BT and Virgin Media packages (Source: Ofcom, 2013)

When the real-time entertainment traffic increases in a DOCSIS-based network, where many subscribers share a link, the sustained capacity falls faster than in a DSL-based network (see figure 4). To maintain performance, and customer satisfaction, operators need to either increase the number of TV-channels used for data download, or adopt DOCSIS 3.1 which increases capacity by using a wider frequency spectrum.

Another alternative is to move the DOCSIS-based headend closer to the customer premises, sometimes referred to as CCAP and Remote-PHY, with the option of placing the DOCSIS headend in the building (MDU). This is similar to a G.fast implementation where the DSLAM (DPU in G.fast) will be installed in the MDU building to be able to provide gigabit speeds.

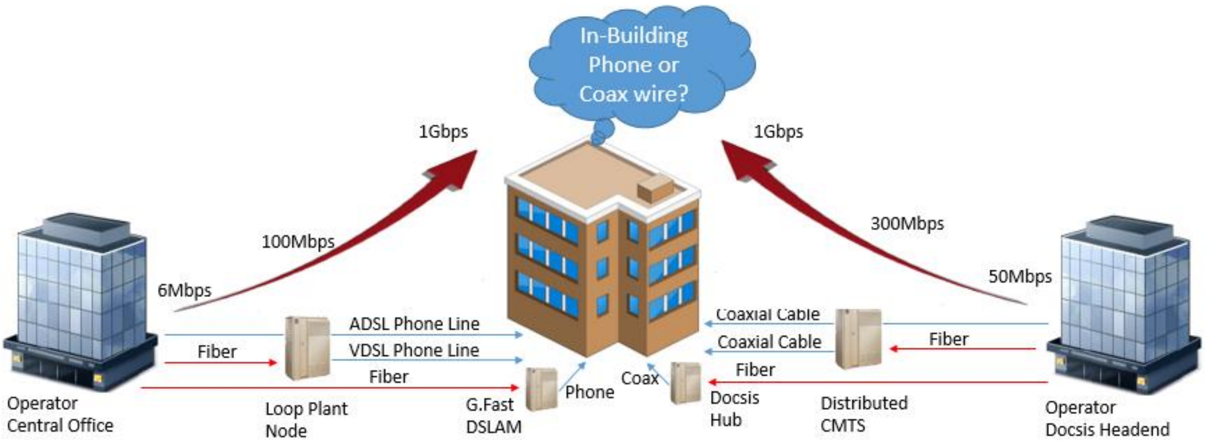

Figure 5 Increasing sustained data speed requirement push DSL and DOCSIS operators to deploy fiber drop point within the MDU building to be able to provide Gigabit services

DOCSIS operator's needs to come closer to the MDU building so fewer consumers 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.

Digital Subscriber Line (DSL)

A DSL-based access network requires that the last-mile channel (or 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 (PoP) and the subscriber.

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

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, achievable rates on the longest loops of a carrier serving area (3600 meter) are approximately 6 Mbps for download and 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 meters 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/s upstream), using the frequency band from 25kHz to 12MHz. These rates mean that VDSL is capable of supporting applications such as high-definition television, VoIP and general Internet access over a single connection.

Second-generation 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 headsets passengers use on airplanes 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.

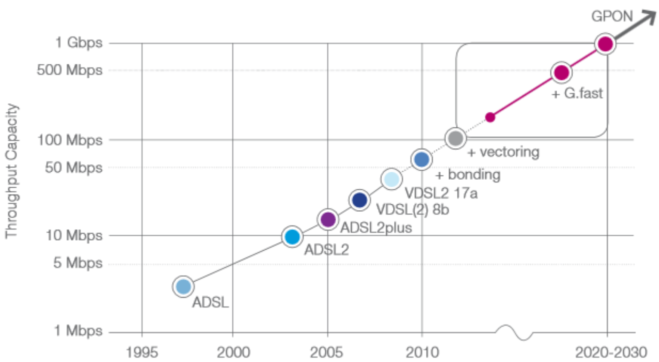

Figure 6 Evolution from ADSL to G.Fast offered by Telecom operators (Source: Alcatel-Lucent)

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 less than 100 meters.

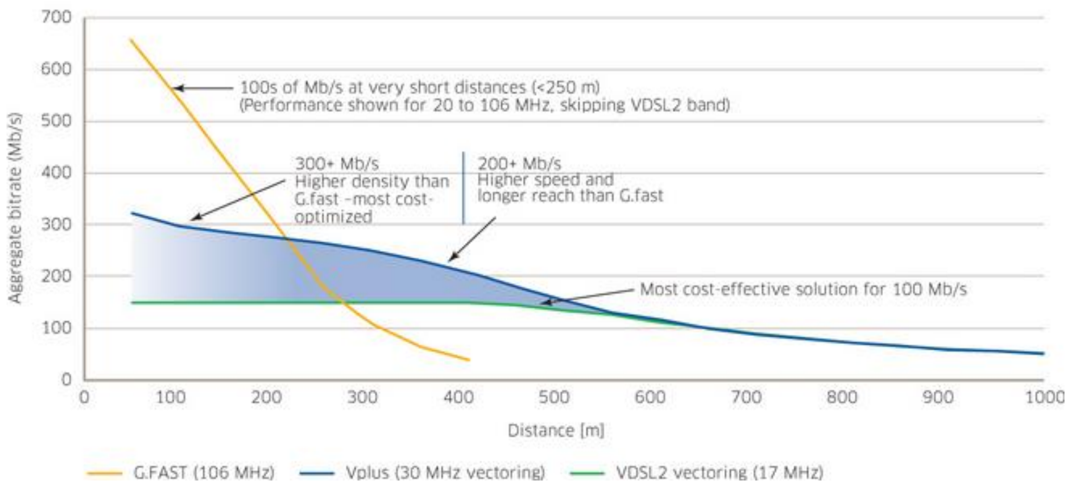

Figure 7 To reach Gbps speed G.Fast DSLM (called DPU) need to be deployed within the MDU building**.** (Source: Alcatel-Lucent)

Cable operators have a clear benefit of offering higher bandwidth peak rates compared to telecom operators and will continue with DOCSIS 3.1 rollouts.

Coax vs. Phoneline Performance

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. (See figure 8.) 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 if disturbed by radiation from the coaxial cabling.

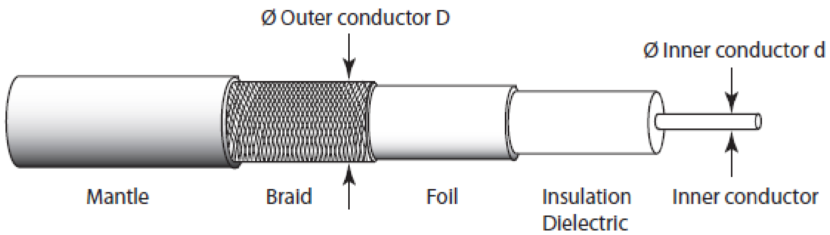

Figure 8 The construction of a coaxial cable

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; electromagnetic radiation from unshielded twisted pair (UTP) cables, and crosstalk between neighbouring pairs for instance.

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.

Figure 9 Typical twisted pair cable

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 telecommunication 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.

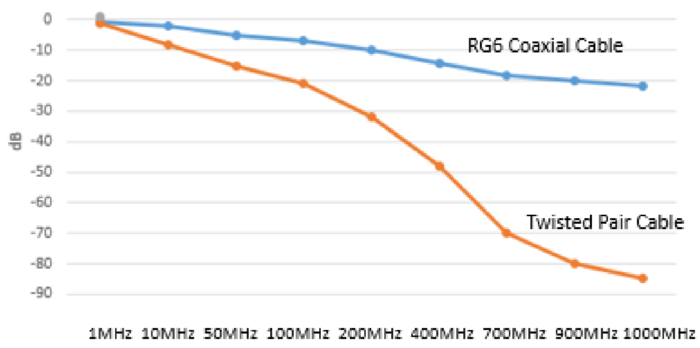

Figure 10 Attenuation comparison 100 meter distance between RG6 coaxial cable and twisted phone line on different frequencies

Increasing data speed requires support for increasing frequency spectrum as twisted pair cables require much higher attenuation to support higher frequencies than in-building RG6 coaxial cables. This means that coaxial cables are more suitable for high frequency signals than twisted pair. This is why DOCSIS offers much higher peak speeds that DSL.

Cable Attribute	Coaxial Cable Network	Twisted Pair Network
Age of 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

Coaxial cables have been upgraded due to the analogue-to-digital switch-off so most MDUs have newer coaxial cabling than phone lines. Coax supports frequency ranges typically up to 2.4GHz and data speeds of 10Gbps. Coaxial cables can match the speed of future fiber while twisted pair cannot.

Fiber to the drop point (FTTdp), FTTC and FTTB Deployments

Telecom operators have by tradition tried to maximize the existing copper infrastructure investment by adding new technologies for broadband access such as ADSL/VDSL and vectoring and now G.fast. The latter can support close to 1Gbps if the copper loop length is shorter than 100 meters.

For green field environments, it is assumed that FTTH for single homes and in MDUs will be the selected solution.

For brownfield living environments, single home deployment will be primarily FTTH if there is an area penetration level of more than 50 percent of the subscribers, otherwise it will be FTTC located in a street cabinet.

For brownfield MDU deployment the FTTB will be deployed in the basement to meet the requirement of 1 Gbps capacity in order for DSL/G.fast operators to compete with DOCSIS.

G.fast over coax

G.fast over coax also uses existing wiring but is able to achieve higher performance than traditional copper. G.fast is using a spectrum initially up to 106MHz and later up to 212MHz. G.fast cannot co-exist with DOCSIS on the same coaxial cable, thus is not likely to be considered by cable MSOs committed to DOCSIS. G.fast requires that distribution over a dedicated coaxial wire to each apartment which is not the case in many MDU buildings especially in Europe and Asia. G.fast over coax is not able to cover coaxial infrastructure which are shared by multiple apartments in a MDU building.

Telecom operators see the use of coax as a way to support gigabit services if the FTTdp is in the building.

MoCA Access

As DSL runs out of steam, Telecom operators are installing fiber closer to the subscriber. The challenge is how to get from the cabinet or basement of an MDU to each apartment.

MoCA Access is based on MoCA 2.0 Bonded and is capable of 1 Gbps actual throughputs (MAC) with migration to MoCA 2.5 which is capable of 2.5 Gbps actual data rates.

DSL Capability Upgrade Options		Time frame		
		Now	Medium	Long
Options for DSL Operators	Technology	VDSL	VDSL Vectoring / G.fast / MoCA Access 2.5 as G.fast extension	MoCA Access either co-exist with 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-to-point coaxial line or MoCA Access for Gigabit services
	Network	FTTdp typically street cabinet	FTTC for VDSL Vectoring and FTTdp within the MDU for G.fast / MoCA Access 2.5	FTTH to each apartment or FTTdp for MoCA Access in the MDU

Table 2 Summary of upgrade options available to DSL operators

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 head-end and with increase data throughput capacity the cost gap will continue to increase.

Comparing MoCA Access and G.fast

CAPEX comparisons can be difficult to make, because they are heavily dependent on supplier technology and equipment costs. Additional cost considerations include the geography and soil conditions, the existing infrastructure, availability of existing ducts, and labor.

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

MoCA Access 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 the fiber deployment cost is 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 line 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 line.

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 is a GPON and MoCA Access 2.5 a good combination because it does not require visits to each apartment.

Technology	Speed	CAPEX (€)	Availability
Vectored VDSL	50-100 Mbps	265 - 440	Today
G.fast	100 Mbps-1 Gbps	1230 per line	2016-2018
MoCA Access 2.0	1.0 Gbps	400 - 600 per line	2017
MoCA Access 2.5	2.5 Gbps	450 - 650 per line	2017
FTTH	2,5 Gbps shared over 32 or 64 lines	2200-4400 per line	Today

Table 3 Coaxial and twisted pair cable strengths and weaknesses

Conclusion

MoCA Access 2.5 is a very cost efficient solution compared to G.fast and DOCSIS 3.1. It is very scalable compared to G.fast in particular with 1 Gbps available now via MoCA 2.0 and a migration path to 2.5Gbps via MoCA 2 .5.

MoCA Access is a strong candidate to change the way Gigabit services are offered especially in MDU buildings. It can be deployed either to co-exist with traditional TV/DOCSIS services or as an All-IP over in-building coax networks providing multi-gigabit services.

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