**broadband forum**

# MR-419
## Utilizing Existing Copper Infrastructure for Deployment of Fiber-grade Services

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**Executive Summary**

This Marketing Report answers five key questions for the recently published Technical Report TR-419[1] Fiber Access Extension over Existing Copper Infrastructure.

Fiber To The extension point (FTTep) provides service providers an architecture to deploy fiber services cost effectively.

This architecture consists of a network where the fiber is extended by using a copper medium without causing significant degradation in Quality Of Experience (QoE) compared to the Fiber To The Home (FTTH) topology.

This is a more economical way of deploying than possible with fiber networks only, by integrating complementary copper technologies such as Gfast, MoCA Access, or G.hn Access, and reusing the existing phoneline and coaxial cable infrastructure, minimizing construction work.

FTTep can also be referred to as Fiber To The most economical point.

The Broadband Forum has published TR-419 [1], which describes the main features and principals of the Fiber To The extension point architecture and the various deployment and migration options.

# 1  Why there is a need for FTTep?

**What is the problem to be solved?**

Given the ever increasing demand for high speed services that are promised with fiber network technology, there is a need for alternative and/or complementary architectures using metallic cables such as phoneline and coaxial cable in a more economical way than possible with fiber networks only.

In many cases, the time to market for deploying gigabit-capable broadband access is restricted more by cost and logistical issues versus the technology itself. This is especially true with "the last drop" to the building and with access to the inside of 'brownfield' buildings such as MDUs, dormitories, and campus environments.

Installing fiber to every living-unit is expensive in terms of labor costs, disruptive to customers, and often delayed due to slow process of getting permissions from building and living-unit owners or local authorities. To reduce the cost and complexities of deploying FTTx networks, the industry players are considering options of leveraging existing cable infrastructure and reusing existing network operators' assets, while still providing FTTH-like broadband connectivity.

This can be achieved by extending the fiber network with the copper-based point-to-point (P2P) or point-to-multipoint (P2MP) infrastructure to provide Multi-Gigabit access into the home.

The cost and complexities of deploying FTTx networks may be lower with the introduction of the Fiber To The extension point - FTTep architecture.

This architecture consists of a network where the fiber is extended by using a copper medium without causing significant degradation in Quality Of Experience (QoE) compared to the Fiber To The Home (FTTH) topology.

The location of the extension point is service provider dependent, taking into account a choice of copper technologies. FTTep can also be referred to as Fiber To The most economical point. The main objective of FTTep is to re-use existing copper or coax infrastructure to extend fiber gigabit services with minimal construction work, hence limiting deployment cost.

The Broadband Forum has published TR-419 [1] that describes the main features and principals of the Fiber To The extension point architecture and the various deployment and migration options.

# 2  What are the benefits of deploying a FTTep?

**How is FTTep different from the FTTH?**

FTTep enables next-generation access networks that deliver multi-gigabit broadband services, helping service providers to deploy broadband networks at a fraction of the cost of traditional FTTH deployments. It is especially important for areas where optical fiber cannot be deployed due to limitations on construction, lack of ducts, apartment or building accessibility, technical or historical preservations reasons.

The main objective of FTTep is to re-use **any** existing copper or coax infrastructure to extend fiber gigabit services with minimal construction work. The FTTep can be located either outside or inside the building. Locating a new, high-speed access node at the Extension Point and reusing the existing copper or coax passive networks has several advantages over FTTH, namely:

- It fits any serving area, including Multi Dwelling Units (MDU) (e.g., apartment buildings), Single Family Units (SFU), shopping malls, or office buildings.

- It avoids the need to install new infrastructure into and around the home, i.e., there is no need to install a new FTTH fiber cable or drill a hole in an external wall to take the fiber into the SFU, or install fiber within the MDU hallways all the way up, and no need to drill holes to each apartment to reach the ONU.

- It reuses the existing copper infrastructure inside or outside the building, thereby providing higher flexibility and reducing the time to fulfill a customer order.

- It provides multi-gigabit services for both residential and business customers.

- It allows customer self-install, which removes the need for a technician visit to the customer premises with its attendant cost, time, and logistical downsides.

FTTep is designed to fit any network and enables service providers to offer very fast broadband services by leveraging existing infrastructure. It allows them to minimize the installation costs and to achieve fast deployments. It also allows them to implement an optimal allocation of resources between lines given the users' real-time traffic needs.

FTTep is typically deployed near the end-user either outside or inside the building depending of available copper or coaxial infrastructure. That infrastructure then in turn determines the appropriate technology to use. This can be a selection of Gfast, MoCA Access, or G.hn Access.

Some possible positioning of the Extension Points (ep) in a Multi Dwelling Unit FTTep deployment scenarios are shown in Figure 2-1.

**FTTep$_{O3}$** is typically located at distance $\alpha$ (up to 200 m) from the premises in a cabinet, manhole, pole, pedestal, or splice location where only phoneline infrastructure is available. Similarly to this, **FTTep$_{O2}$** is typically located at distance $\beta$ (up to 100m) from the premises in a cabinet or manhole where phoneline or coax infrastructure is available. **FTTep$_{O1}$** is typically located on the outdoor wall of the premises in a cabinet where phoneline or coax infrastructure is available.

In the indoor FTTep deployments, a distinction is made between three options:

- **FTTep$_{IB}$** typically located in the basement of the SFU or MDU building with phoneline or coax infrastructure available,

- **FTTep$_{IF}$** typically located on a floor level in the MDU building with phoneline or coax infrastructure available, and

- **FTTep$_{IL}$** typically located in a loft of the MDU building with only coax infrastructure available.
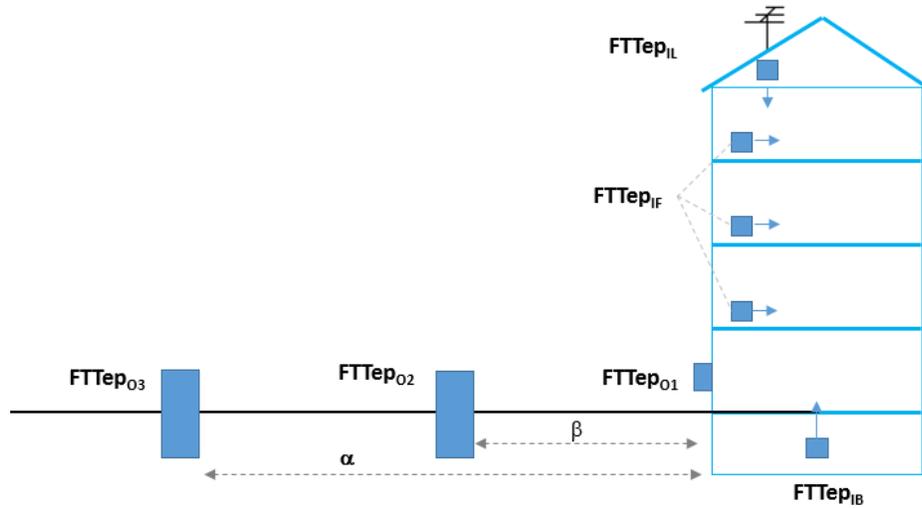


**Figure 2-1: Typical Multi Dwelling Unit FTTep deployment scenarios**

# 3  Which PON fiber deployments/use cases are covered in the FTTep architecture?

The general architecture of a network with fiber extension is shown in Figure 3-1 .
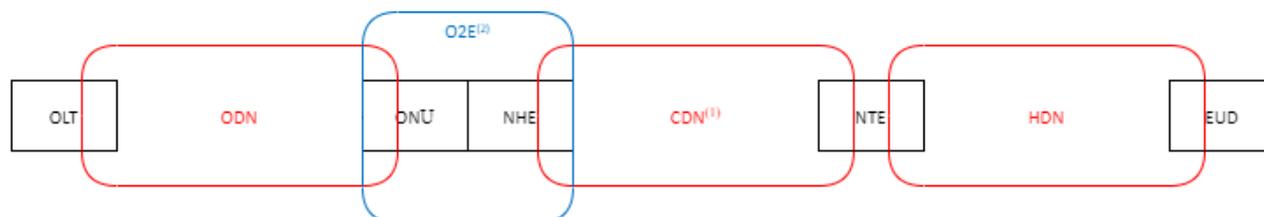


(1) CDN can also be a concatenation of CDNs
(2) Extension Point demarkates a point where the optical fiber is terminated, and the optical signal is converted into an electrical signal
(O2E) for transmission over copper infrstructure to the NTE

**Figure 3-1: General architecture of a network with fiber extension**

The overall network between the Optical Line Termination (OLT) and End User Device (EUD) is composed of three sub-networks:

- **Optical Distribution Network (ODN):** This sub-network is composed of an optical distribution system (e.g., PON) and connects the **Optical Network Unit (ONU)** to the core network through the OLT.
- **Copper Distribution Network (CDN):** This sub-network is built using a copper-based technology for the physical layer (e.g., Gfast, MoCA Access, G.hn Access) and is used to deliver the signal from the optical sub-network, and **Network Head End (NHE)**, to the premises. The length and type of this CDN depends on the use case.
- **Home Distribution Network (HDN):** This sub-network delivers the signal received from the CDN at **Network Termination Entity (NTE)** through the premises using the appropriate technology (e.g., Wi-Fi or a mix of in-home technologies).

Typical Use Cases in the FTTep deployments for extending fiber access services over existing copper infrastructure are described in TR-419 [1] and briefly summarized in the Table 3-1 below. A distinction is made based on the location of the Extension Point (Environment) and type of existing copper infrastructure.

**Table 3-1: FTTep Use Cases**

| Service area | Type of infrastructure | Use Cases |
|---|---|---|
| **MDU Shared copper network outside the living unit** | Twisted Pair | Point-to-Point data-grade twisted pair for HSIA |
| | | Point-to-Point telco-grade twisted pair for HSIA (Note 1) |
| | Coax | Coax Cabling co-existing with Analog TV service |
| | | Coax Cabling co-existing with Cable TV and DOCSIS (Note 3) |
| | | Coax Cabling Using full coax spectrum |
| | Twisted Pair | Multiline Point-to-Multi Point over Existing telco-grade twisted pair |
| | Twisted Pair (FTTdp) | FTTdp service: Classic No-RPF-Technician or self-install |

| | | FTTdp service: RPF with VoIP re-injection, Self-Install |
| --- | --- | --- |
| | | FTTdp service: RPF with VoIP, Single Port |
| | | FTTdp service: Point-to-Multi Point, Self-Install |
| | Twisted Pair (CCDN) | Concatenating copper distribution networks – O2E using multiple sections of bonded copper lines |
| | | Concatenating copper distribution networks – legacy access and bonding per pair |
| | | Copper to Fiber Backhaul migration |
| **MDU Individual copper cable outside the living unit** | Coax | Point-to-Point Coax with frequency diplexers for HSIA and satellite TV |
| | | Point-to-Point Coax  for HSIA  in MDU |
| **SFU Individual copper cable** | Twisted Pair<br>Coax | Single Point-to-Point data-grade twisted pair or coax |
| | | Multiple Point-to-Point data-grade twisted pair or coax (Note 2) |
| Note 1: Example 1, Section 3.1<br>Note 2: Example 2, Section 3.2<br>Note 3: Example 3, Section 3.3 | | |

This Section provides more details about three typical FTTep deployment cases in which Gfast, G,hn Access, and MoCA Access  are used to extend fiber services over the copper access infrastructure.

## 3.1  FTTep utilizing Gfast

The mapping of Gfast to the architecture of this use case is shown in Figure 3-2.

In this FTTep deployment model, the ODN feeds an Optical to Electrical (O2E) element that converts the optical signal into electrical signals and feeds them through a multi-pair telephone cable (also known as telco-grade twisted pair) to the customers. A single O2E installed in the extension point location may have typically from 4 to 32 ports.
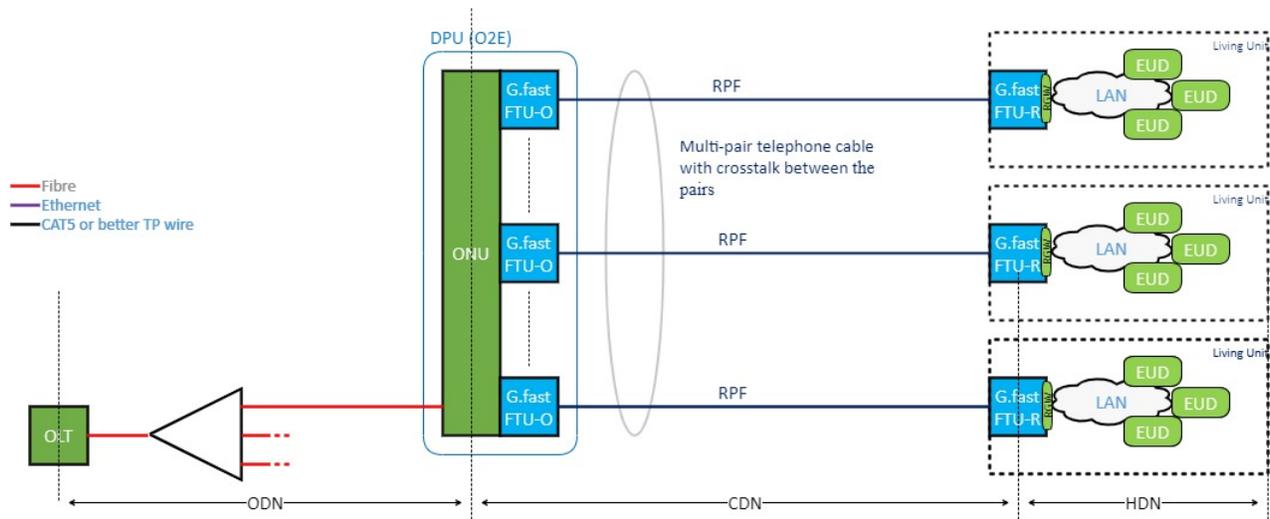
**Figure 3-2: Use Case "FTTep utilizing shared outside cable with point-to-point telco-grade twisted pair for HSIA in MDU"**

When using the Gfast technology, the O2E is referred to as a G.fast distribution point unit (DPU) that is composed of:

- An Optical Network Unit (ONU) that terminates a leaf of an ODN and provides a User Network Interface (UNI) to a G.fast port on a DPU, and

- A G.fast FTU-O transceiver.

The G.fast ports of the DPU (O2E) are connected through multiple twisted-pairs to multiple G.fast transceivers (one per line) at the customer's premises, which are termed G.fast FTU-Rs. The G.fast DPU may use Reverse Power Feed (RPF) from the customer's premises.

The copper access infrastructure, i.e., the wires running from the extension point, may exhibit substantial crosstalk between them, which reduces subscriber bandwidth. To cope with this situation, a crosstalk cancellation mechanism, also known as vectoring, may be used by the operator to mitigate the adverse effects of crosstalk to improve performance. G.fast vectoring is an effective technology to handle crosstalk; it maximizes the data throughput of all connected customers all of the time.

Ownership of the access infrastructure depends on the region and location of the access wiring: outside twisted pairs may be owned by an infrastructure provider or service provider, while in-building wiring may be owned by the building owner. In-home wiring is usually owned by the premises owner.

## 3.2 FTTep utilizing G.hn Access

This FTTep deployment model is typical for the use case of extending fiber services over twisted-pair or coaxial lines to several SFUs that are served in the immediate vicinity and where crosstalk between the lines may exist. In case of a single SFU, there is no need to implement a crosstalk avoidance algorithm that controls the access to transmission resources, but other than that the architectural and topological aspects of using G.hn Access are the same.

**Figure** 3-3 shows an example of mapping G.hn Access technology to this use case.
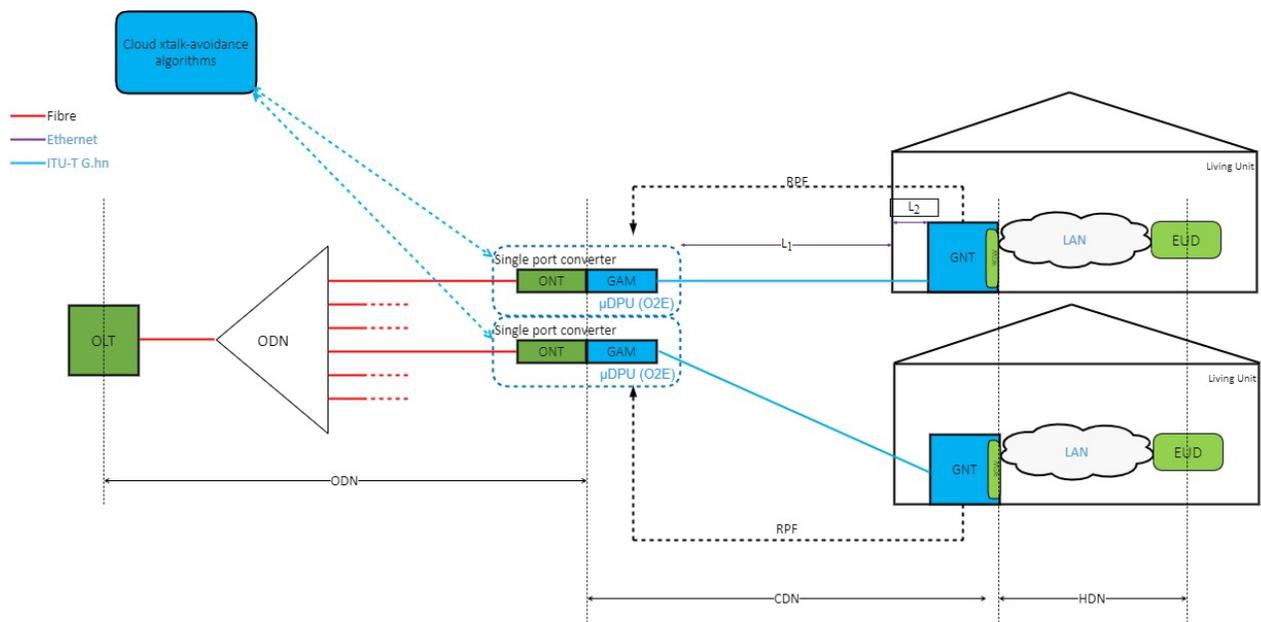
**Figure 3-3: Use Case "FTTep to multiple point-to-point Single Family Units (SFU's) over twisted-pair/coax"**

In this mapping, the ODN feeds an Optical-to-Electrical (O2E) element that converts the optical signal into electrical signal in a one-to-one relationship. When using G.hn Access, this element is called a µDPU and is composed of:

- Optical Network Terminal (ONT) termination
- G.hn Aggregation Multiplexer (GAM) element with a single output that acts as Domain Master of a domain composed of 2 nodes, the GAM itself, and the G.hn Network Termination (GNT).
- A switching unit that redirects the signal to the appropriate GAM.

The southbound port of the µDPU is connected through coaxial or phone lines to the GNTs. Also called End Points (EPs), they may be integrated in the Residential Gateway (RGW) or connected to it through an Ethernet cable.

Multiple µDPUs can be co-located in the same physical device or located in close vicinity. In this scenario, interference between lines may occur in phoneline deployments. To cope with this situation, a local or cloud-based crosstalk avoidance mechanism may be operated by the service provider to control the access to the shared resources in the copper segment. If different SFUs are physically separated, and the crosstalk is limited, then no crosstalk mitigation technique is needed.

In these scenarios where the crosstalk is controlled, either by applying crosstalk avoidance mechanisms or because the crosstalk is not significant, a "pay-as-you-grow" model can be used.

The µDPU(s) including the GAM(s) and GNT(s) may be fed through reverse power feeding by each of the individual lines.

## 3.3  FTTep utilizing MoCA Access

This use case addresses the situation where it is not possible to deploy FTTH within a MDU building. Typical barriers that delay and increase cost of FTTH deployment may be building owners that are not

ready to pay for the in-building fiber deployment cost, and condominium apartment owners that don't see any reason for construction work within the apartments. In this FTTep deployment model, MoCA Access is used to extend fiber services to each living unit over existing in-building coaxial network. This technology is defined to use selectable spectrum in the range between 400 to 1675MHz, allowing coexistence with pre-existing services (e.g., cable TV or DOCSIS).

Figure 3-4 shows an example of mapping MoCA Access technology to this use case.
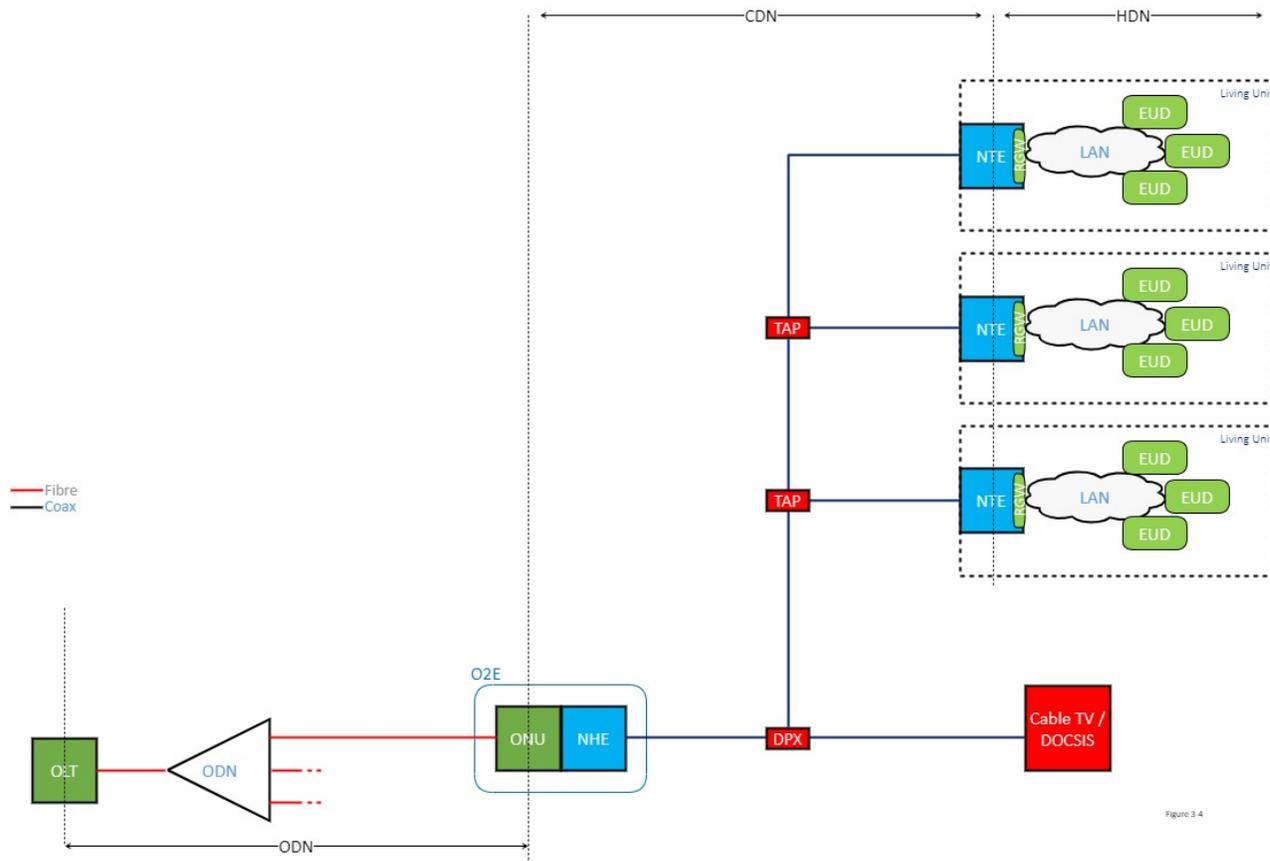


**Figure 3-4: Use Case "FTTep utilizing shared MDU Coax Cabling co-existing with Cable TV and DOCSIS"**

Typically in coaxial networks, an O2E is installed in the basement at a passive network entry point alongside the in-building TV amplifier (in a Network Head End [NHE]). The ONU is usually a SFP module which converts the optical signal to electrical and where its RF transceiver and a RGW build a transparent bridge for the delivered services.

The RGW is connected to the coaxial network by its in-built transceiver that has a passive diplexer to filter the signal to the TV set, set-top box or DOCSIS modem, and the data signal to the RGW. DPX is a diplexer filter/combiner that isolates the TV band and the RF transceiver band and combines different RF bands. TAP is a coaxial tap that divides the RF signal to each living unit.

Depending on a type of network topology (star, trunk with a tap, or splitter), a connection of each MDU's Living Unit RGW to a common multi-tenant infrastructure outside the living unit, via shared cable, cable bundle, or individual cable in a shared conduit, can be point-to-point or point-to-multipoint. The NHE may be reverse powered from the customer's premises only in case of point-to-point network topology.

# 4  Is FTTep relevant in the next generation network infrastructure?

**The short answer is: Yes**.

The Multi Dwelling Units and Multi-Tenant Units serving areas pose a challenge for FTTH deployments. The cost, complexity, accessibility to apartments, and sometimes social and legal barriers to installing new cabling in an MDU/MTU risk creating underserved areas.

A key factor in any network upgrade is time-to-market for new services.

A fiber connection to an MDU/MTU building is generally installed faster and more cost effectively than to an individual residence. The cost and complexity of placing fiber deep inside the living unit connected to an indoor ONT for each subscriber (FTTH CPE) can drastically increase time-to-market.

FTTep provides additional options for service providers to complete a fiber rollout and be ready to offer services in their MDU/MTU deployments to any customer in a timely, cost effective, and reliable manner.

FTTep enables operators to deploy gigabit services to the most economical point to customers in MDUs without need to connect fiber to each living unit.

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# 5  What are the future prospects for FTTep?

In the future, fiber is undoubtedly moving closer and closer to all homes and businesses; however, the utopia of an all fiber broadband world is years or even decades away. The last drop, whether from an external DPU, in-building MDU or MTU, or in a campus environment, is unquestionably the most operationally difficult and CAPEX/OPEX expensive.

In the last few years, it has become evident that from a subscriber perspective, the most important factors in their broadband experience is ensuring the service can meet both their downstream and upstream data demands, and equally as essential is that the service is consistent, reliable, and fit for the purpose to meet all their user and application demands. A service fit for today's and tomorrow's need for multiscreen UHD video, virtual, and augmented reality and the multi-device connected home.

The regulatory, governmental, and broadband industry perspectives recognize the importance of continuing to invest in technologies that squeeze more bandwidth out of existing twisted pair and coax infrastructure so that we do not exacerbate the digital divide, where an all fiber world is not realistic in the short or medium term for every premise.

Gfast, MoCA Access, and G.hn Access are already in use today and have proven successful in offering a stable, proven solution in enabling a gigabit-reliable experience to millions of users. Additionally, new access technologies and standards that are under continuous development ensure that many existing and legacy copper investments in greater data rates and increased reach still have significant relevance to the broadband world, in parallel and complementary to pure fiber rollouts.

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# 6 Conclusion

Fiber to The Extension Point provides service providers an architecture to deploy fiber services cost effectively.

This architecture consists of a network where the fiber is extended by using a copper medium without causing significant degradation in Quality Of Experience compared to the Fiber To The Home topology.

This is a more economical way of deploying than possible with fiber networks only, by integrating complementary copper technologies such as Gfast, MoCA Access, or G.hn Access and reusing the existing phoneline and coaxial cable infrastructure, minimizing construction work.

FTTep can also be referred to as Fiber To The most economical point, which increases deployment speed and take-up rates for a faster return on fiber investment.

The Broadband Forum has published TR-419 [1], which describes the main features and principals of the Fiber To The extension point architecture and the various deployment and migration options.

# 7 Terminology

## 7.1 References

The following references are of relevance to this Marketing Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Marketing Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

| Document | Title | Source | Year |
|---|---|---|---|
| [1] TR-419 | Fiber access extension over existing copper infrastructure | Broadband Forum | 2020 |

## 7.2 Definitions

The following terminology is used throughout this Marketing Report.

| Term | Definition |
|---|---|
| Gfast | Broadband Forum's name for the gigabit broadband access technology G.fast specified by ITU-T Recommendations G.9700 Fast access to subscriber terminals (G.fast) – Power spectral density specification and G.9701 Fast access to subscriber terminals (G.fast) – Physical layer specification |
| MoCA Access | Access network technology defined in the *MoCA Access specification* that is designed to operate on the existing coaxial plants found in residential and commercial buildings and adapt to the associated channel characteristics |
| G.hn Access | HomeGrid Forum's name for the use case where the G.hn technology specified by ITU-T Recommendations G.996x *Operation of G.hn technology over access and in-premises phone line medium* is used for broadband access applications. |

## 7.3 Abbreviations

This Marketing Report uses the following abbreviations:

| | |
|---|---|
| CDN | Copper Distribution Network |
| EP | End Point |
| EUD | End User Device |
| FTTep | Fiber To The extension point |
| FTTH | Fiber To The Home |
| GAM | G.hn Aggregation Multiplexer |
| GNT | G.hn Network Termination |
| HDN | Home Distribution Network |
| MDU | Multi Dwelling Unit |
| MTU | Multi-Tenant Unit |
| NHE | Network Head End |

NTE             Network Termination Entity
O2E             Optical-to-Electrical Entity
ODN             Optical Distribution Network
OLT             Optical Line Termination
ONT             Optical Network Terminal
P2MP            Point-to-Multipoint
P2P             Point-to-Point
QoE             Quality of Experience
RGW             Residential Gateway
RPF             Reverse Power Feed
SFU             Single Family Unit
UNI             User Network Interface

End of Broadband Forum Marketing Report MR-419