Enabling Connected Homes with Indoor Fibre Solutions

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Abstract

With online video streaming, video conferencing, gaming, education, telehealth and the advent of the Internet of Things (IoT) creating a surge in application usage, real-estate developers and property owners are looking at emerging technologies to make their properties smart ready for the future. The lifestyle and Internet experience of residential tenants is constantly improving with an incredible amount of technology making its foray into their daily lives. The communications infrastructure is at the heart of such change, which is now accelerating the adoption of fibre optics both to and inside residences. This future proof technology with almost unlimited capacity, operating at the speed of light, allows telecom providers to service the insatiable demand for bandwidth by these high touch applications. This white paper will discuss the drivers, techniques and benefits of installing indoor optical fibre solutions in brownfield and new construction buildings.

1. Introduction

Buildings, formally known as Multi-Dwelling Units (MDUs), have the highest density of tenants (residents, guests or employees) in residences, hospitality and commercial business offices. They have the same growing need for ultra-high-speed Internet required by a broad range of applications to download and upload data. Independent of media platforms, high definition video is still the top application due to video streaming and gaming in the residence, video conferencing in business and very high definition imaging in healthcare. While video streaming is a broad term, viewed content can be a mix of on demand content, live TV, music, radio as well as social media video sharing. On the other hand, businesses and government need to roll out services, for example smart devices, online telehealth and virtual education, as they closely engage their customer base requiring high speed gigabit networks.

Therefore, end-to-end fibre network deployment is accelerating globally with Fibre-to-the-Home (FTTH) and Fibre-to-the-Cabinet (FTTC) replacing the existing copper cabling infrastructure[1][2]. This paper will primarily discuss end user connectivity with indoor fibre cabling solutions in buildings after it has been passed by the outside plant fibre network. With an all fibre network, broadband speeds are dramatically increased for applications available today and launched in the future.

2. Challenges and Drivers

Building owners and tenants exercise control since they are very opinionated on any cabling or wiring installed indoors. With today's unsightly large copper cabling and conduits commonly seen in building hallways, inside the tenant unit or office, there is a growing desire for new indoor fibre cabling solutions to exceed their expectations.

In addition to network capacity and ultra-high-speed broadband, fibre cables have several advantages over copper cabling including but not limited to size, weight, strength and flexibility. This combination of features has enabled manufacturers to develop fibre cabling products that overcome the following pain points when proposing new infrastructure inside the building:

- Discrete or almost invisible cabling,
- Non-disruptive to interior décor installations,
- Simple without need for training,
- Fast service turnup,
- Short installation time for crews inside building,
- Flexibility circumventing any deployment challenges

Based on the above, any indoor fibre cabling solution must also be designed with cabling installed inside risers, distributed along hallways and inside the tenant unit supported by fibre distribution cabinets, terminals and splitters.

3. Deployment Scenarios

Once buildings are passed by an outside plant fibre network, the next logical step is to connect end users when they start requesting broadband service. Indoor solution design varies considerably based upon the following factors requiring a custom engineered design:

- Type of building architecture,
- Greenfield or brownfield,
- Availability of conduits,
- Building distribution topology,
- Cabling solutions

3.1. Type of Building Architecture

Every building has a unique footprint requiring customized end-to-end solutions. Building architectures vary by height or number of floors, which we can generally categorize as garden style

apartments (up to three floors), low-rise (up to five floors), mid-rise (five to ten floors) or high-rise[3]. Therefore, prior to any solution design, it is imperative for an installation team to survey building schematics as well as perform an on-site inspection to engineer solution design.

3.2. Greenfield or Brownfield

For new or greenfield construction, it is much easier and cost effective for fibre cabling to be installed during the construction phase to get the entire building connected. On the other hand, existing or brownfield buildings require much more planning on determining the routing of fibre cables from the basement to each floor, passing each tenant in hallways and then connecting to customer premise electronics inside. Therefore, the choice of indoor cabling depends upon the type of building stage[6].

3.3. Availability of Conduits

Availability of conduit or duct is another determining factor for an indoor fibre cabling solution. In some cases, buildings already have conduit installed for existing copper wiring. It may be possible to simply leverage these conduits with ruggedized fibre cabling.

However, sometimes conduits can get congested requiring new conduits to be installed, which can be expensive. In this case or when conduit is not available, alternative cabling solutions for the hallways are required since conduit installation is prohibitively expensive. Furthermore, in rare cases, it may not be possible at all to install fibre cabling indoors (example converted heritage buildings or warehouses), thus requiring an alternative indoor solution or a façade installation.

3.4. Building Distribution Topology

Distributing fibre cable inside buildings is corelated to the splitting topology chosen for an installation. As fibre transitions into the building, it must be terminated and distributed to the large number of tenants. A range of splitters with optical split ratios, installed inside fibre distribution terminals, help accomplish a point to point or point to multipoint network.

Following is a brief overview of the common distribution topologies:

a. Centralised splitting topology requires all the splitters to be installed in a high density fibre cabinet in the basement telecom closet. From here several high fibre count cables are taken up the riser to each floor, where they can directly pass each tenant unit.
b. Distributed splitting minimizes the number of fibre cables in the riser with splitters installed in fibre distribution terminals on every floor. Fibre cabling then passes each tenant unit on the floor.
c. Distributed cascaded splitting is used when multiple low split ratio splitters in terminals are used in the basement and floor telecom closets.

3.5. Cabling Solutions

Currently, several fibre cabling solutions are available for building connectivity. Although, comparing their specifications, features and advantages is out of the scope of this white paper, an important point of consideration is the fibre type used in these solutions. Building deployments present numerous installation challenges such as tight spaces, sharp corners, décor and impedances including fire alarms. Due to these, bend insensitive fibre (G.657.B3) has quickly become the choice for fibre cabling.

The table below provides a comparison of the various cabling solutions based on the drivers.

	Installation Technique	Riser, Hallway, Tenant	Discrete	Need Conduit	Non-Disruptive to Decor	Fast Install Time	Flexible
Air Blown Cables	Equipment air blows connectorized cable in conduit	X X X	only if conduit exists	X	only if conduit exists	only if conduit exists	-
Pushable Cables	Push and pull of connectorized cable in conduit	X X X		X			-
Assemblies and Drop Cables	Pull connectorized multifibre or single fibre cable in conduit	X X X		X			-
Track System	Raceway with multifibre or single fibre cable	- X X	X	-	X	X	X
Adhesive System	Glue invisible multifibre or single fibre cable	X X X	X	-	X	X	X
Micro Module	Pull cables in risers only for fibre breakout	X - -	X	-	X	X	X

Engineering an indoor fibre cabling solution by considering the above factors will ensure a smooth, successful installation. While each solution needs to be evaluated, this paper will discuss assemblies, drop cables and an adhesive based almost invisible fibre cabling solution for new construction and brownfield buildings.

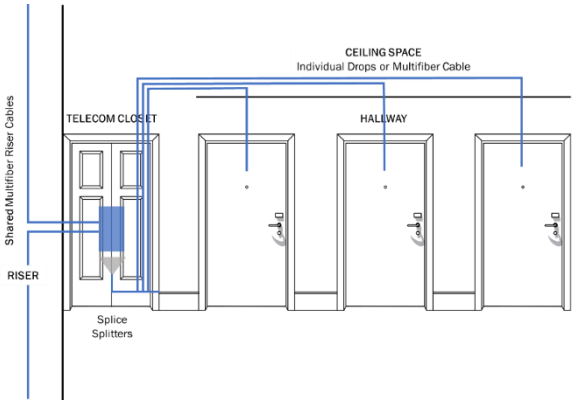
4. Assemblies or Drop Cables

Ideally, the best time to install fibre cabling is during new construction. Service providers work closely with construction companies to make end connectivity available post-construction. Since the building is fibre ready, tenants only need to order broadband service when moving in.

Fibre cable assemblies or drop cables are a very cost-effective solution to install cabling from the basement telecom closet, going up inside risers to each floor and then distributed using conduit or ceiling space to connect each tenant unit. These multifibre assemblies or single fibre drop cables can be unconnectorised, single ended or dual ended connectorised depending upon an installation preference for in field splicing or factory terminated solutions.

Usually, full pre-connectorised cables are the choice for simple plug and play reducing the need for extensive training. As needed, conduits are usually installed for drop cables to each end tenant unit. Alternatively, assemblies or drop cables may be secured in raceways above the ceiling to each tenant unit.

The figure below shows a solution concept for indoor fibre cabling using drop cables.



5. Adhesive Cabling System

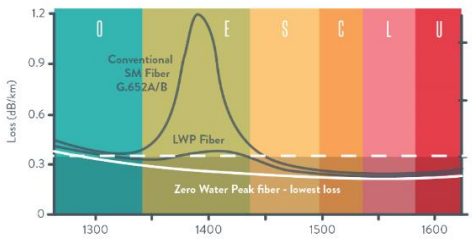
Existing or brownfield buildings present several challenges as discussed previously for indoor fibre cabling. Discreteness and blending into décor without any disruption are the key success drivers for building landlords, owners and tenants considering cabling solutions.

Since 2009, an almost invisible fibre cabling solution was developed at OFS to overcome these challenges starting with the tenant unit and on market demand rapidly followed for hallways. For both the tenant unit and hallways, this solution primarily allows for fast and easy indoor optical fibre installation using a simple process similar to caulking to attach a tiny optical fibre cable in the grooves between ceilings and walls, baseboards and walls and corners between walls.

5.1. Fibre Type

The OFS indoor cable solutions for the tenant unit and hallways both use OFS bend insensitive G.657.B3 fibre. Bend insensitive fibres can be routed around corners, inside floor terminals and small modules requiring tight bends. OFS G.657.B3 exceed the standards with a 2.5mm bending radius, retaining full spectrum performance[5]. The graph below shows OFS fibres performance along with lowest loss known in the industry as zero water peak (ZWP) loss.

Macrobend Performance (OFS G.657.B3)	
1 Turn on 5mm radius mandrel	≤ 0.10 dB at 1550nm ≤ 0.20 dB at 1625nm
1 Turn on 2.5mm radius mandrel	≤ 0.20 dB at 1550nm ≤ 0.30 dB at 1625nm



5.2. Construction Products Regulation (CPR)

CPR for indoor cables is also in effect with harmonized rules across Europe[4]. Each country defines its fire safety classification ratings for cables within this framework. The OFS single and multifibre cables surpass the indoor requirement with a superior Class Bca rating, thus meeting requirements across Europe.

5.3. Tenant Unit Cabling

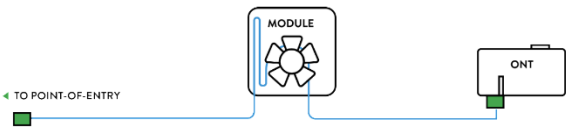
Inside the tenant unit, installers place a small module near the desired indoor Optical Network Terminal (ONT) location. Usually it is placed close to a power outlet. A small spool of factory-terminated G.6757.B3 900 micron buffered optical fibre is pressed onto an axle in this module.

This almost invisible optical fibre cable features the best available tight-bending performance (2.5 mm radius) to allow installers to wrap the fibre around dozens of corners, if needed, along the path to the ONT without incurring service-disrupting bend loss.

One of the pre-terminated connectors is then pulled to spool out enough fibre to reach another small point of entry (POE0 module in the hallway from where the fibre enters the living unit.

The installer then preinstalls a safe, water-based adhesive bead along the pathway and presses the optical fibre into the adhesive so that the fibre is fully secured and protected along its entire length by the continuous adhesive bead. The spool module is then connected into the ONT, which is usually paired with a wireless router or a set-top box. The adhesive dries clear within 30 minutes, without leaving any stains.

The figure shows the concept of the pre-connectorised spool module connecting to the ONT and POE. As seen, an advantage of the spool is to store enough slack on the spool to install fibre without measuring lengths. The extra slack not required for the installation is simply spooled back prior to connecting to the ONT.



5.4. Hallway Distribution

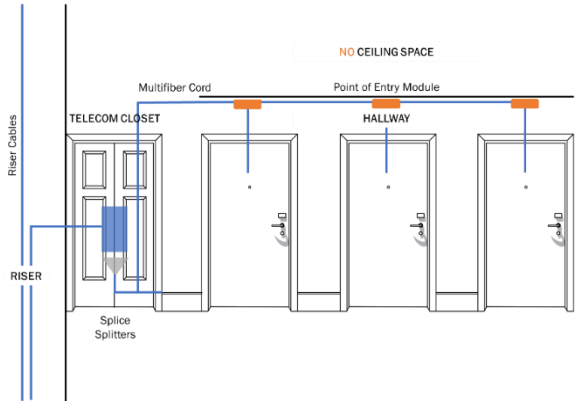
An almost invisible 2 mm to 2.3 mm diameter multifibre cable consisting of up to sixteen 250 micron G.657.B3 OFS optical fibres packaged together was designed by OFS for horizontal installation in risers and building hallways.

For risers, these cables are installed in conduits, whereas for hallways the installation process and the tools involved are identical to those used in the single fibre solution deployment process. With the same

common components, the solution helps reduce the need for retraining as well as stranding capital due to inventory management. With the same bend radius performance, this solution ensures that it can be routed around the many corners and obstacles that can exist in a building hallway installation path.

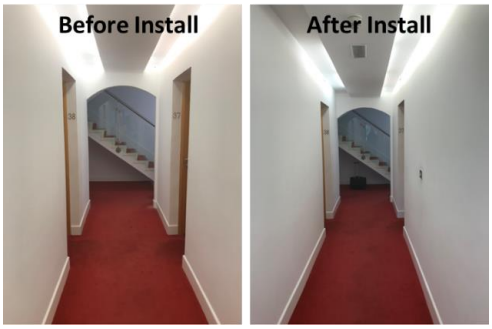
Installers first survey the building hallways before mounting a POE wall module above and on the exterior of each tenant unit or office. The multifibre cable is then unspooled and adhered to crown molding or wall-ceiling crevices horizontally in the hallway across a row of tenant units. A recommended length of slack is then stored inside each POE module after which a dedicated, color-coded strand of optical fibre for the tenant unit is extracted and fusion spliced into a connector (mechanical connectors can also be used). This method allows for simple, plug-and-play connections to the single fibre solution inside the tenant or office.

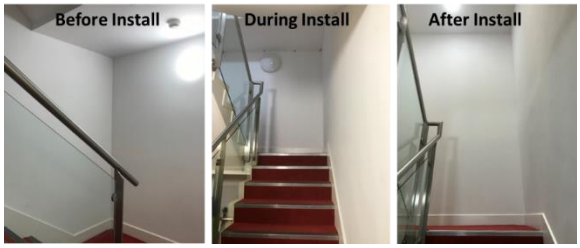
The figure below shows the concept of the indoor multifibre indoor cable that is almost invisible after an installation is complete.

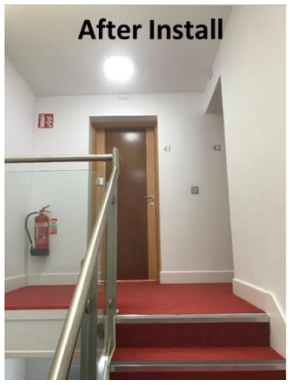


6. Installation Example

Pictures from a recent hallway installation in Ireland is shown below. In this block of buildings, the indoor multifibre cable had to be routed from the ground floor telecom closet along hallways, up stairwells to the top floor passing six apartments. When comparing the hallway before and after the installation, the OFS indoor multifibre cable is not visible.







Following is a summary of the installation in the main areas of the building:

a. *Main floor*: Here the indoor cable had to be routed along the ceiling to pass the two apartments facing each other and then being routed into the stairwell for the upper floors. Each POE had five loops or about 1m of cable stored for slack.

b. *Stairwell*: The indoor cable was routed in 4 flights of stairs along the wall and stairwell. During the install, as seen in the picture, painters tape was used temporarily to maintain cable adhesion in the corners when continuing the installation.

c. *Upper floor*: The last apartment on the top floor was installed after passing all the apartments below. The fibre was connectorised using a mechanical connector. Using a power meter and a light source, the fibre for this apartment was measured at -0.6dB loss after approximately 150 bends.

Compared to other Europe installations using splicing, we have measured -0.3dB loss when using splice on connectors or pigtails. The decision of using splice on connectors or mechanical connectors is made by the service provider team after comparing them for performance well documented in fibre optics[7].

Overall, the building tenants were quite amazed on how the service provider is getting them ultra-high speed broadband. When a tenant subscribes to broadband service, a service delivery team will connect customer premise equipment using the 900um buffered optical fibre inside the tenant unit.

7. Conclusion

As global fibre installation continues to accelerate, Internet service providers need innovative indoor cabling solutions to offer gigabit broadband speeds to their demanding end customers. This paper presented the key drivers, installation factors and types of cabling solutions. It also described a new almost invisible fibre cabling solution using an adhesive based system that is accelerating in its adoption globally.

The tiny optical fibre cables blend into the décor so that they are virtually invisible to the human eye. They can also be painted or caulked over if the end user chooses. This simple process distributes fibre along hallways and places fibre deep into a living unit quickly and without disrupting the décor or the resident. Such an indoor solution fits any building type, provides the flexibility if conduits are congested or not available and even enables installations in heritage buildings.

As mentioned previously, every building is unique requiring a customized solution that must be designed after taking all factors into consideration. The hospitality segment consists of buildings that are much more complex, requiring added solution planning. The author contributed to a hospitality architecture paper with other industry colleagues, which provided an indoor fibre solution framework for buildings in this segment[8].

This paper endeavours to help the decision making process for these custom indoor fibre cabling solutions enabling a successful installation with delighted end customers.

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