SOURIAU

White Paper November 2013

Fast and Reliable Outside Local Fiber Rollouts

Content

Esterline Connection Technologies

Introduction

When speaking about interconnectivity, most people's way of living has drastically changed over the last decade. New habits of sharing or getting information, posting our thoughts and state of mind, and watching television programs can be summarized in these words: real-time apps.
This lifestyle arises thanks to wireless PED's technology and fast Ethernet connections at home. Each time, when we refer to these worldwide access points we should now think fiber!
It is not a matter of being pro or con, it is just a tangible reality. A nice acronym has been introduced to cover all facets: Fiber To The X. X is the distance between you and the end of the fiber which localizes the technology switch from copper technology to fiber optic technology, the switch from electronic domain to photonic domain.
There is common agreement that photonics communication is becoming more dominant. We are preparing for the future and this is exactly what we see in today's deployment of connectivity network, either for fixed access while bringing fiber optics in the people's backyards, for fixed wireless access like Wi-Fi or for full mobile access while bringing the fiber to a radio antenna (LTE/4G).

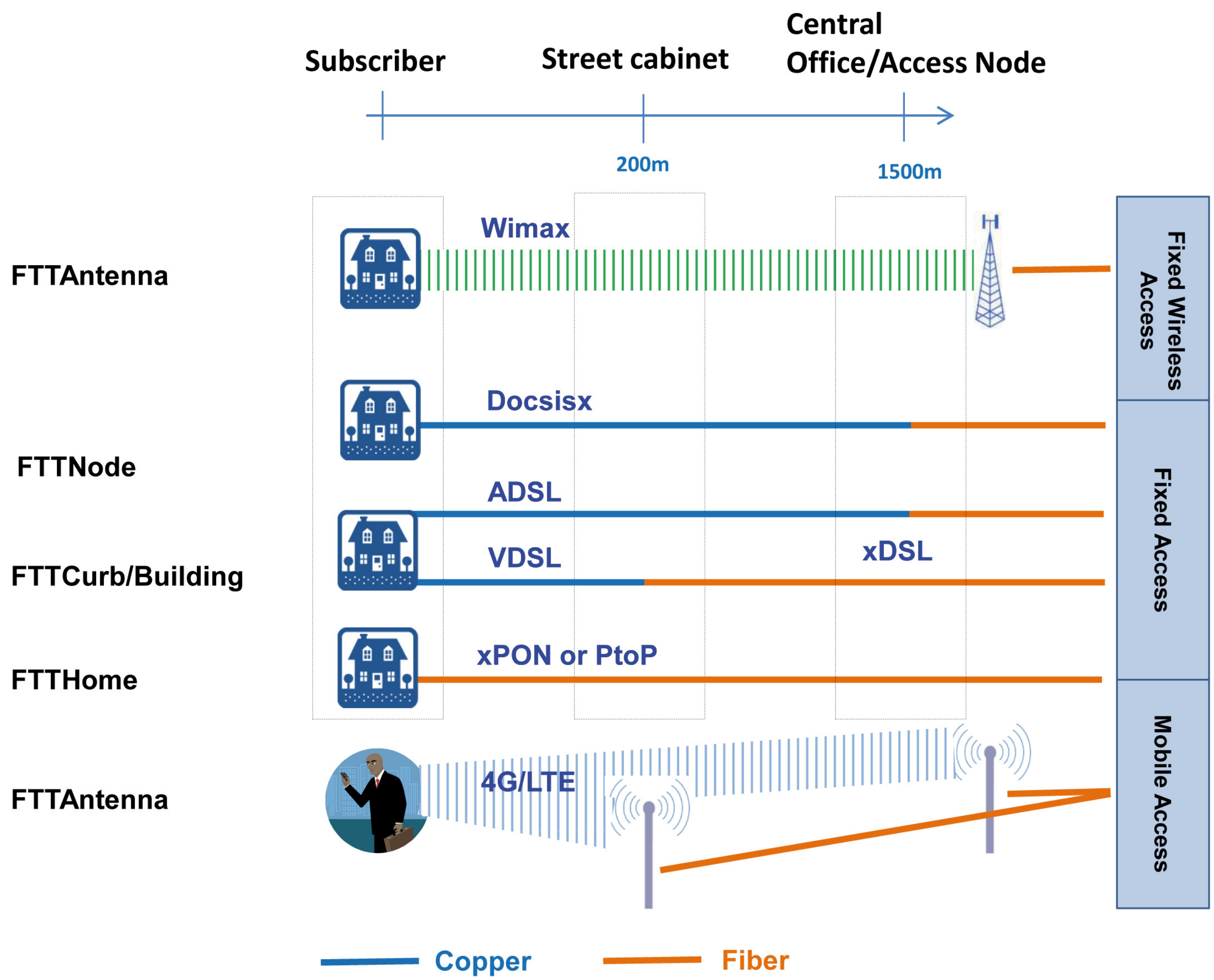


Fig. 1: Fiber expansion versus copper

Introduction (continued)

Besides the excitement of this tremendous technological revolution, the providers need to continue the rollout using different technologies (VDSL, FTTH, Wimax), in a highly competitive market, with local players and for diversified population density. In a word, the providers are always facing a difficult balance: meet the demand for greater bandwidth while keeping the network costs (CAPEX & OPEX) as low as possible because the revenues are not growing as fast as the demand.
Depending on the subscriber density in an area, different scenarios using different technology are proposed to be implemented. Each solution, motivated by a different business model, uses dedicated equipment to reach its cost-efficiency goal. The equipment manufacturers, after several years of FTTH or FTTA deployment, are now able to propose cost effective solutions for rapid and reliable deployment.

Fixed Broadband connection and local access case

As discussed, the race for data rate and bandwidth has already started. There are several technologies to provide broadband connection with different degrees of maturity. The choice and the mix technology solutions can be weighed according to the following criteria: scalability & upgrade, latency, open platform for competition, cost of total coverage, rollout speed.
The result for a few existing technologies can be found in Table 1.

Criteria	Technology					
	FTTH	Coax cable	4G	Wi-Fi	ADSL	Satellite
Scalability & upgrade	++	+	-	-	-	-
Latency	++	+	+	+	+	-
Open for competition	++	+	-	-	-	-
Total cost of coverage	-	+	+	+	+	++
Rollout speed	-	-	-	+	-	++

Table 1 Broadband technologies comparison

The FTTH rollout clearly meets the need of sustainability, availability and evolvability; certainly complemented by local FTTA solutions. To that extend, FTTH remains the most appealing as long as the total cost of coverage and the rollout speed drawbacks are properly addressed.
For long distance telecommunication, the piece of cake has already been shared between major providers and in high density populated areas the business case is generally tight, but under control. In lower population density areas, the simulation outcomes are less clear. Providers are reluctant to start a fiber rollout because of staggering investments and long payback time.

Fixed Broadband connection and local access case (continued)

*cost (€) per house/subscriber	"black area": high density, existing network	"grey and white area": lower population density, poor existing network
Active equipment	147	147
Passive equipment	491	1589
Total	638	1736

Table 2 FTTH rollout cost per house depending on population density (*Source: 2012 Finance report/ www.ftthcouncil.eu)

If we look into details (see example in Table 2), the cost of active optical equipment per subscriber is the same either for a high density area or a less populated area. The cost of passive equipment grows rapidly in the lower population density area up to two or three time the total cost of a rollout in a high population density area. This is mainly due to civil infrastructure work cost for drilling, digging, routing; the cost of the qualified labor force for field fusion splicing for instance and the installation time.

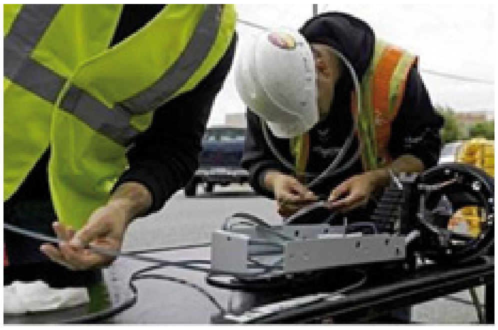


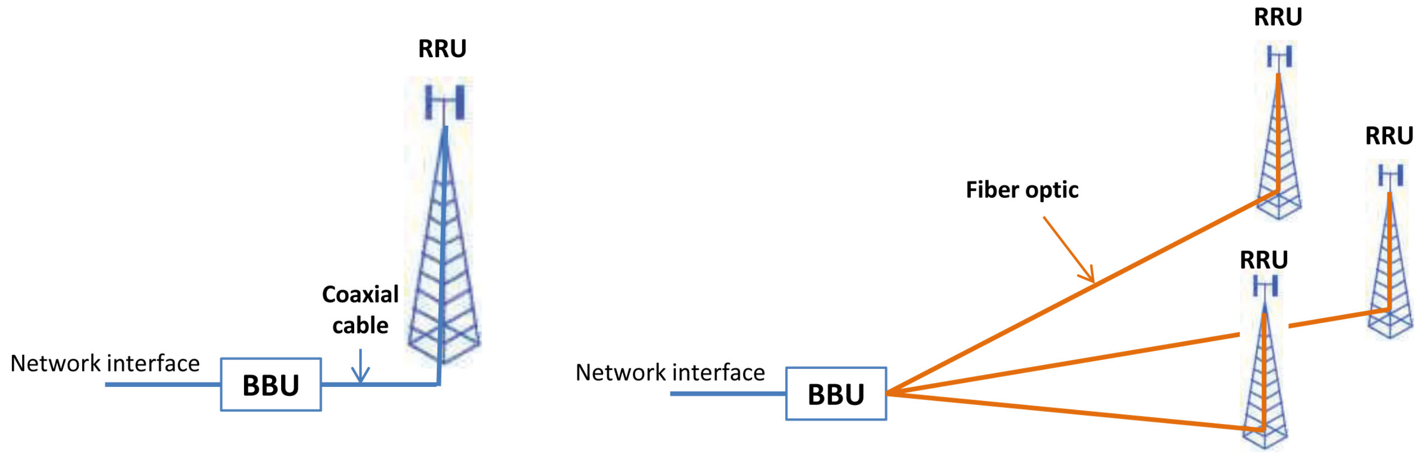
Figure 2 Field fiber splicing

The only way to make this rollout more appealing for providers in lower density areas is to reduce the passive costs. Reducing the time of installation connecting the server and the subscriber is a key factor of success to establish a rapid revenue stream.
This can be achieved with improved digging techniques, such as using a GPS located excavator. The machine is able to dig a trench at constant speed and in a highly time-predictable way. The trench can also be made more narrow and more shallow.
The rollout strategy should also be reinvented. The traditional access network approach starts linearly from the point of presence (POP) to the optical line termination, the subscriber. The connection of the last branch of the network to the subscriber is highly time consuming and unpredictable. The subscriber needs to be at home in order to implement the last connection which will generate the revenue stream for the provider but the extensive trenching to connect to the local access has been in process for several weeks. Faster models mix rollouts in parallel, starting from the subscriber and the POP at the same time.
The reduction of installation time can also be improved by using factory-terminated fiber solutions such as a drop cable from the subscriber's house or fast connection on the home junction box. A connector solution at the end of a cable is faster than any other technique for fiber field connection and also avoids requiring highly qualified technician(s) for fiber fusion splicing.

To meet the future needs of providers for FTTH in lower population density area, the installers need to find out creative rollout strategies combining new digging techniques, bi-directional deployments and innovative connectivity solutions.

Mobile broadband communication case

Mobile communication is the traditional domain for radio frequency communication and coaxial cable. With radio frequency over fiber technology, the Fiber to the Antenna concept arises with a lot of key points comparable to a FTTH roll-out.
Traditional base station architecture consists of a base band unit (BBU) that controls the radio equipment and the radio equipment itself, the Radio Remote Unit (RRU) on top of the tower. Both of these are located close together and linked with a coaxial cable. This traditional equipment footprint is large and the cables are heavy and lossy (50% of the signal is lost along the way). This leads to high deployment cost and high power consumption.



Traditional base station architecture- Backhaul

Modern distributed Architecture - Fronthaul

Thanks to digital interfacing, a fiber is now used between the BBU and the RRU. This allows a completely different architecture. The RF amplifier is now located directly in the RRU closer to the emitter and is cooled by ambient air thus saving a lot of energy.
The distance between the BBU and the RRU, previously in hundreds of meters now reaches up to 40km. The RRU goes closer to the subscriber for enhanced service whereas the more compact BBU can now be more conveniently located inside buildings.

In terms of costs, weight and footprint the FTTA concept is a step ahead compared to the coaxial cable previous model. This is valid as long as the deployment is fast. RF installers are accustomed to heavy cable and field termination with copper technology. With fiber, the field termination is nearly non sense, especially while sitting at the top of an antenna tower. Re-training technicians for fiber technology, finding expertise for fast installations or hiring new technicians is time consuming and leads to additional costs.

The challenge, both for FTTA installers and equipment manufacturers, is to integrate fiber optics while continuing to reduce implementation and maintenance costs in order to meet providers' ROI target. Again, innovation in fiber interconnectivity solutions is a key factor.

Challenges for factory-terminated connectivity solutions outside cabinet

Coming from an all fusion spliced solution scenario for telecom fiber over long distance, the local access network for FTTH in lower population density areas and the LTE/4G deployment require innovative connectivity solutions. For FTTA, the splicing process used in telecommunications rooms or in a controlled environment such as a shelter is practically impossible on top of a windy and wet mast.
Table 3 compares different connectivity technologies according to the required skill level, the optical performances, the logistics and some maintenance aspects. The result favors factory pre-terminated cable with connectors, as long as all the field aspects are taken into account.

	Connectivity technology				
Criteria	Mechanical splicing	Fusion splicing	Mechanical splice connector	Fusion splice connector	Factory pre-terminated cable
FO expertise	-	- -	-	- -	++
Installation time	-	-	-	-	++
Optical performance	++	++	+	+	+
Logistics	+	+	+	+	-
Sensitivity during installation	+	-	+	-	+
Mating / De-mating	-	- -	+	+	+

Table 3 Comparison of connectivity technology

FTTA and FTTH for local access tend to bring the fiber optic connection outside the traditional telecom cabinet. The motivation is the reduction of the number of junction boxes thus leading to higher expectations regarding connector features. Specifications for pre-terminated cable with connectors need to be prepared.

Reliable partnership

Since pre-terminated cable, by definition, cannot be easily reworked in the field, the physical infrastructure must be described. The installer needs to work closely with the equipment manufacturer to establish a detailed engineering description of the site that defines the exact routing in limited spaces or through conduit. New field tools like GPS tablet and dedicated CAD software can transmit the information from the infrastructure side directly to the harness shop.

To keep fast the pace of installation, a logistics partner should deliver the pre-terminated cable assembly on time according to the schedule of the work, otherwise the benefit is lost.

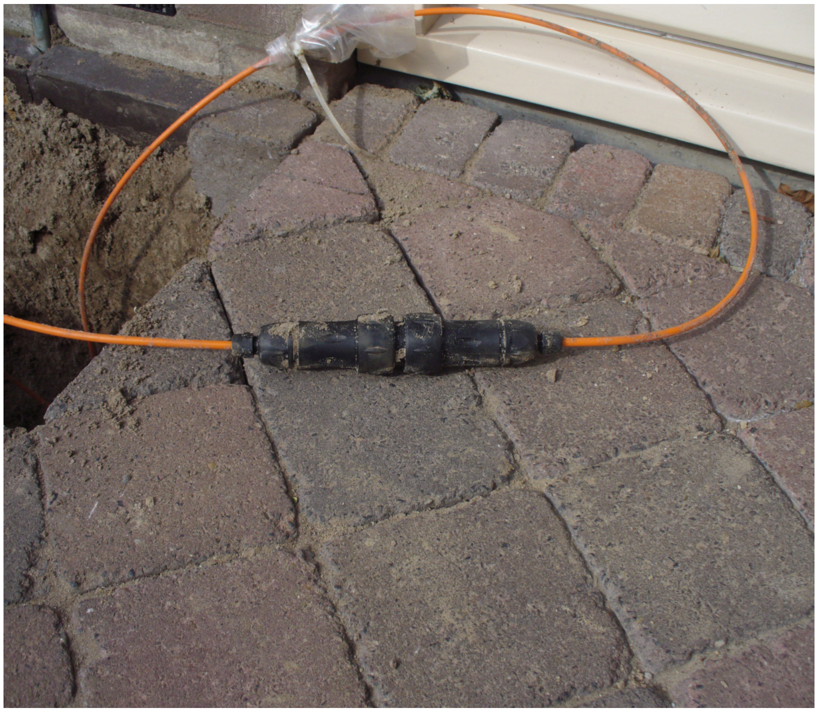


Fig. 4: Typical FTTH local access work

Fast field solution

A pre-terminated harness installed by civil infrastructure workers must exceed the standard robustness criteria. A high mechanical retention between the connector and the cable should be ensured either if the cable is pulled from a reel or hoisted, or if the cable is pushed inside a conduit. The twisting of the fiber cable should also be taken into account, especially if it is a multiple-fiber cable to prevent fiber breakage.

The installers don't want to switch the team between digging and making connections for FTTH or be required to retrain the team from coax to fiber technology for FTTA. The fiber optic connection shall be made with a user-friendly connector housing without having to deal with specialized embedded technology. The connector should also be designed to prevent any fiber optic ferrule breakage on the field and minimize the fiber contamination when the dust cap is removed.
The locking system of the connector should be fast and secure, leaving no doubt about the connection performances. Some connector features are very useful such as audible and visual controls.

Fig. 5: Fast & robust field connector

Easy maintenance

The operability and the upgrade of the network should last for decades. This means that the connection should use a standard interface, such as an ST, SC or LC optical terminus that will be available on the market for decades. Using a specialized connector design with proprietary contact design can be an advantage for installation cost and space saving purposes but not necessarily for maintenance costs. For instance, the minimum inspection tools required for an optical end face inspection are not always compatible for various connectors. Field cleaning tools should be easy to use and highly efficient in keeping fiber endfaces clean without degrading endface quality.

Pre-terminated solutions based on standard distribution cable are highly recommended. Each cable has its own specification in terms of bending, tensile strength, even color. The installer technicians are more likely to adhere to one routing system from one end to the other end of the rollout; if a change is required, it can have a negative impact on performance consistency. Using one type of standard distribution cable also lowers the cost during installation and maintenance.

Fig. 6: Optical end face cleaning

Reliability

The cost increase of using pre-terminated cable with connectors in place is balanced by the cost savings of reduced installation time. Singlemode fiber networks deployed 25 years ago are still compatible today with 400Gbit data transmission. No copper network can meet that level of future compatibility to handle significantly increased data rates. As a consequence, the connection must provide a guaranteed sustainability equivalent to connections used in telecom cabinets with the same optical performance. This means full connector environmental sealing. The minimum requirements include UV durability, a waterproof level of IP68, corrosion protection, chemical resistance, and shock and vibration compliance. The most harmful vibration for fiber application is at low frequency and high magnitude, as when close to a heavily traveled road or on top of a windy mast.
The fiber optic terminus components, including the ceramic ferrule and ceramic guide sleeve, should have long-life with continuous high optical performance. Through analog TV transmission, more and more optical power is injected into the fiber. Any misalignment can lead to unacceptable insertion losses and possible overheating/degradation of the fiber. The design of the cabling chamber or service loop in the backshell at the rear of the connector should eliminate macro-bending and micro-bending that leads to early aging of the fiber.

Summary

The FTTH rollouts over regions and the FTTA (4G/LTE) rollouts are the "data highways" of the future, improving lifestyle, creating higher data rate opportunities. Fiber optics technology is definitely a change to "going green." It limits the impact to the landscape, saves energy both in production/installation phase and in the operation phase.
States and providers are seeking solutions to offer the largest regional coverage to satisfy every citizen. The key is to be fast enough to mitigate rapid traffic growth driven by increased bandwidth services and increased network cost. In that regard, innovation of passive optical components such as factory terminated cable with connectors can bring cost-effective solutions and can also ease difficulties of switching from copper technology to full fiber usage.
The next challenge for pre-terminated cable is to offer a reliable connector for hybrid cable, mixing copper for supply and fiber for data inside the same shell, taking into account the features of both technologies.

Vincent Metzger
Fiber Optics Application Engineer
Esterline | Connection Technologies
SOURIAU