White paper

The impact of network evolution on optical distribution frames

by Kristof Vastmans

Service providers are continuously challenged to meet market demand for high-speed, high-bandwidth broadband services – at cost levels acceptable to the market. Addressing both these requirements entails upgrades to both the network and network topologies. Virtually all these upgrades involve new network elements consolidating more power and capabilities into smaller spaces. And these new elements require greater and greater amounts of fiber. However, merely deploying more fiber isn't enough.

Service providers must optimize their network cost, controlling both capital and operations expenditures (CAPEX, OPEX).

Network elements such as optical distribution frames (ODF) supporting service providers' CAPEX and OPEX model lead to cost-effective, future-proof networks. These ODFs should support (super) high fiber counts, while maintaining ease of installation, supporting strong fiber cable management and providing an open platform to accept emerging technologies, such as NG-PON2 systems using transmission wavelengths up to 1625 nm.

Introduction

Whether wishing to enjoy high definition television or in order to upload and download a growing amount of data, both residential and business customers expect faster, higher bit rate network connections. Traditional copper lines cannot satisfy this need as the technology is affected by significant performance degradation that has a linear correlation with distance. This is principally why broadband service is defined generically as a connection "faster than the traditional dial-up access"[1], capable of providing a bit rate higher than 2Mbps. Broadband service can therefore be delivered only with extensive use of optical connections, and numerous industry players are investing heavily in optical technology.

Both incumbent and new network providers need ODFs to manage connection between the final user and the active equipment. These providers can either run the network to provide services (internet, HD TV, on-line gaming, etc.), and/or lease it to content providers who do not own any infrastructure in the area in which they wish to operate. This second category of companies may need ODFs to connect electronic equipment to their subscribers, or they may share it with the network owner in a collocation center.

In the telecom industry, network providers usually need an ODF when they "pass new homes." This terminology describes the fiber rollout penetration; if the cable is deployed along a street with three houses and a building with three apartments, it "passes" six homes. Even if these dwellings are not yet connected to the fibers, the other end of the cables must be connected to central offices or to a point of presence (POP). To complete this activity for a significant number of potential users, additional ODFs are required. The number of ODFs is correlated to the number of homes passed, rather than the actual number of subscribers. When new customers request service activation, the network builder establishes the "last mile" connection between the household and the fiber already in place.

The correlation proposed above between the number of households passed and the number of ODFs required is backed by a consultancy report issued by WIK[2] which confirms this relationship across different network topologies. However, even if this correlation is always present, it is strongly influenced by the type of architecture chosen by each operator.

CAPEX

- Reduce real estate cost
- Optimize usage of equipment ports
- Lower overall cost of network builds

OPEX

- Increase speed of installation
- Improve quality of service
- Minimize truck rollouts
- Decrease maintenance activities

With consumer demand steadily rising, technologies rapidly evolving, and competitive pressures increasingly applied to service providers' business model, ODFs that accept and properly manage high fiber counts, and are optimized for saving both CAPEX and OPEX are a necessity, not a luxury. The right choice of ODFs can provide a solid foundation for requirements of customers and service providers today – and well into the future.

Major trend in networks and ODF products

Viewing major activities in networks, we see a move from trunk networks towards feeder and distributions networks up to the last mile. On each interconnection point of these network rings an ODF could be placed (see Figure 1). The ODF's specifications are defined by the space available and the function it has to perform in that particular place.

Comparing characteristics in the trunk network to those of the access network (Feeder + Distribution + Last Mile) the following conclusions can be made:

- Connection points become access points for network diagnostics and network upgrade

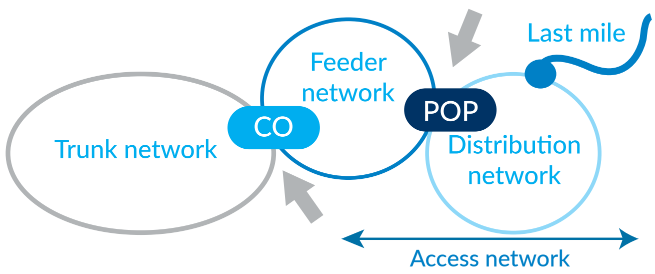
- The number of trained, skilled people (e.g. splicing technicians) is decreasing and a trend towards less-skilled people is growing
- Access to specialized tools (e.g.splicing equipment) is becoming more difficult as operators minimize CAPEX spending. Operators therefore seek solutions suited to a "plug and play" approach
- Maintenance aspects of access network are growing in importance. Operators strive to minimize OPEX. We see a strong move from "fit and forget" consolidation points towards "flex" points

Diving into greater detail on these network consolidation points, we can identify two applications with distinct needs.

1. Application points (e.g. central office backbone) with a strong requirement for "high-flexibility" and "configurability" characterized by:
    - OPEX minimization
    - High-density vs. ease of installation
2. Application points (e.g. last mile, points of presence) where "medium flexibility" and "low reconfigurability" are accepted. These points in a network are typically characterized by:
    - CAPEX minimization due to governmental regulations (e.g. rent of public space)
    - Acceptance of very low skilled labor
    - Tolerance of ultra-high density to optimize on brownfield buildings

In spite of the different needs of the two applications, operators seek network elements that meet the same "form, fit, function" requirements in order to optimize overall OPEX. Optimization can be established by standardization of working procedures on the different network elements. Products preferred by network operators typically balance carrier challenges and needs by possessing specific attributes.

A preferred ODF system would include a system enabling high-density, manageable, future-ready deployments in less space using a plug-and-play philosophy.



CO: Central Office,
POP: Point of Presence

Figure 1: Network segments & consolidation points

Service provider challenges

Shortage of skill working with fiber

The emphasis on fast, easy installations is not only related to the total cost of the equipment in terms of purchase price, installation time and maintenance. Another factor affecting Europe, the Middle East and Africa is the lack of skill in working with fiber. A skilled workforce is required to sustain the large deployments targeted by governments and telecom operators alike. Many operators and installation service providers are struggling with this shortage.

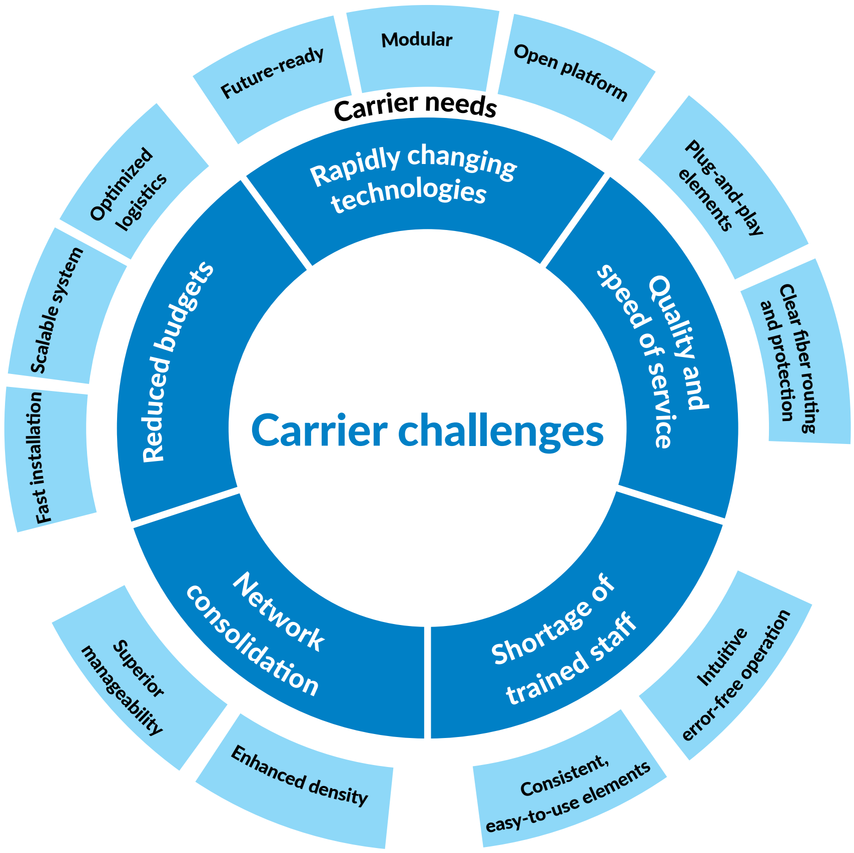
Copper technology is still adequate to deliver the national broadband requirements specified across Europe, so many incumbents feel no urgency to replace the network. The copper legacy means that some entity has the challenge of transforming a workforce that understands how to work with copper-based equipment to a fundamentally different technology. This task is generally left to the employer, and has likely contributed to the reliance on outsourcing this part of the business.

Outside of Western Europe, many countries are deploying broadband services without having copper lines to rely on for the "last mile," or the copper in place is inadequate to support technologies designed to extend the life of copper networks by increasing bandwidth and speeds deliverable over this material. In this case, the skills shortage includes the people tasked with planning a network deployment, engineering the network topology and purchasing the equipment to sustain a fiber network.

As a consequence, incumbent operators in emerging markets have started to look for complete service packages. Instead of designing the network topology, planning the layout of central offices and POP houses, purchasing equipment and outsourcing the installation, some companies submit an RFQ for a particular project, and look to a 'block' of bidding companies to provide both active and passive equipment, to plan the network and to install the equipment.

Despite the outsourcing activities and turnkey supplier choice, ODF manufacturers can anticipate the trend to lower skilled workforces, by developing products with a standardized way of working across all network elements. High quality ODFs meet the following requirements:

- Standardized way of working (e.g. the same trays deployed in different network access points, using visual indications for installation and fiber management)
- Fast and intuitive access to connectors by full accessibility to trays from the front
- Tool-less installation of optical modules with a plug and play approach
- Reduction of overall weight of ODF elements in order to ease installation and protect installers (e.g. ergonomically designed elements)
- Upgradeable passive elements and optical modules for a "build-as-you grow" model
- Adaptable to new connector and fiber technologies with low investment



Easy to understand, error-proof features, as well as familiarity that comes from deploying identical elements in all parts of the network, reduces training time and more than compensates for employing lower skilled technicians. Regardless of the skill level of the local workforce, CAPEX and OPEX will be saved and the network's reliability and flexibility enhanced.

Effect of consolidation on ODF

Consolidation of central offices and points of presence, is driven mainly by the need to reduce real estate costs, as well as by energy saving programs. As they consolidate these facilities, operators must take into account many different factors:

- "Top" ducting congestion caused by the consolidation of equipment, and their related cabling, into smaller spaces
- Decrease in logistic costs by limitation of different patch cord lengths and installation of pre-cabled products
- Reduction of operational cost for customer hook-up
- Maintenance of current network reliability by avoiding installation errors and assuring proper handling, routing and storage of fibers to prevent excessive fiber bends

As an example of the impact of bad fiber management on profitability, it has been estimated that approximately 14 percent of active ports can no longer be accessed. This has a direct negative impact on both CAPEX and OPEX. A study carried out by CommScope showed that the main cause of network losses and failures is improper routing by technicians of the functional overlength of fibers and cables in an ODF. Functional overlength is defined as the extra length required for Day 2 reconfiguration activities (e.g. customer changes, renewal of active equipment). Wherever fiber is used, routing paths must be clearly defined and easy to follow – to the point that the technician has no other option except to route the cables properly. Leaving cable routing to the technician's imagination leads to an inconsistently routed, difficult-to-manage fiber network. Uncontrolled bending of fibers is often caused during handling of the fibers and negatively effects network's long-term reliability and performance.

Flexibility requirements in an ODF

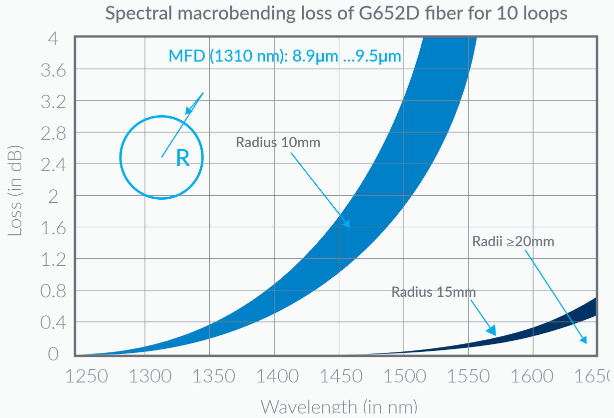
When considering flexibility we come naturally to a discussion of where and why flexibility is required in a central office.

In general we can state that flexibility is required to provide:

- Test access
- Migration paths for future technologies (e.g. NG-PON2)
- A migration path for new active equipment or additional providers

Flexibility is obtained by using connector technology, known in the optical industry as a mating/de-mating point. Connector access points most widely used are the SC-PC and SC-APC connectors. A trend towards small-form-factor types such as LC-PC and LC-APC and the MPO connector is mainly driven by equipment manufacturers.

All unused "flexibility" has a high impact on density and operating cost of an optical distribution frame.



The attenuation caused by macrobending is wavelength dependent (see Figure 3). For the same bend, the increase in attenuation will be higher for the longer wavelengths. As specified in the standards IEC 61756-1[3] and ITU-T L.13[4] the recommended minimum permanent storage radius for the conventional single-mode fibers (ITU-T G652D) is 30 mm, however, in local cases a radius of 20 mm is allowed (for example a bend at a connector boot).

Figure 3: Wavelength dependence of macrobending loss

Within a central office typically two main types of ODF can be created:

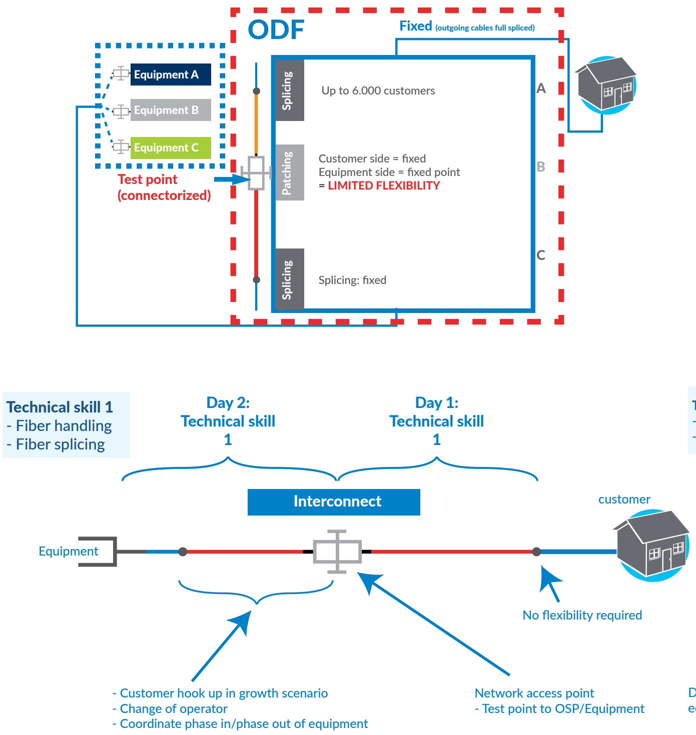


Figure 4 Central office with interconnect ODF

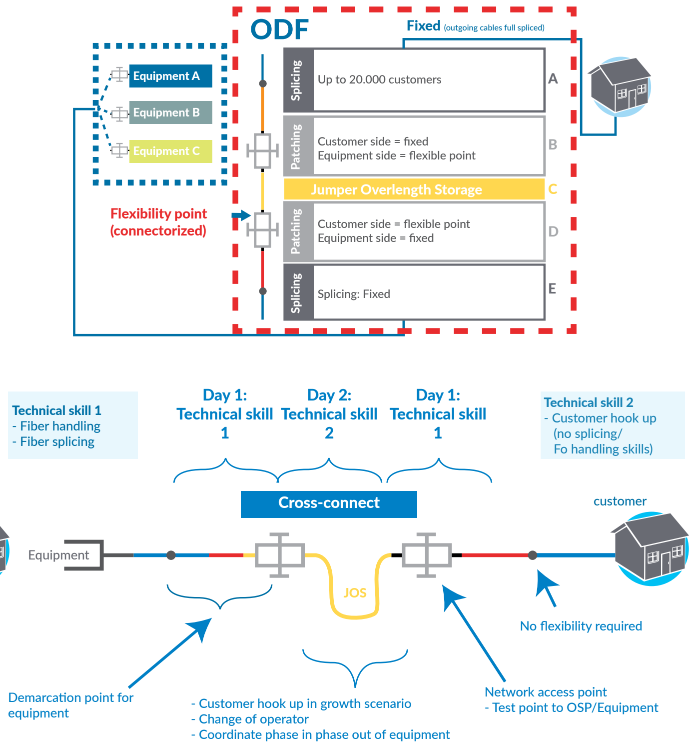


Figure 5: Central office with cross-connect ODF

Interconnect (Figure 4)

While decreasingly popular in central offices, interconnect ODFs are still used in last mile flex points such as points-of-presence.
The main characteristics of an interconnect ODF are:

- Smallest footprint density (half of cross-connect)
- One skill level required (accepted in high take rate areas)
- Limited flexibility

Cross-Connect (Figure 5)

Operators prefer cross-connect ODFs, in the following circumstances:

- High flexibility and re-configurability is required
- Future expansion is unpredictable
- In anticipation of continued scarcity of highly skilled workers
- Continued drive to conserve energy

Cross-connect frames help control an operator's energy expenses.

Energy savings are becoming increasingly important. The need to save energy costs, as well as a growing desire to be a "green" company, drives operators to a building layout that separates an active equipment "hot island" from passive equipment "cold islands". When active and passive equipment is housed together in the same room, the operator must cool the entire area. Separating them into hot and cold islands (or indeed into other rooms), allows the operator to localize air conditioning to the equipment most in need. Cross-connect frames facilitate this separation and, properly configured, improve airflow throughout the facility. Depending on the size of the central office, energy savings up to 25 percent could be obtained by following the hot –cold island plan.

Cross-connect ODFs also provide an easier migration path to new technologies, and to additional subscribers. With proper planning, the ODFs will grow with the operator's business, limiting the need to obsolete and replace them.

A final word – plan for future

There is a clear trend towards higher fiber and connector densities. Space in a central office or telecom hotel is expensive. Because more and more fibers need to be terminated, the space reserved for an ODF must be used in the most effective way. An important vehicle to achieve this is the 'miniaturization' of connectors. Small-form-factor connectors and multifiber connectors help increase ODF densities, but can result in less flexibility or safety. Also 'off-frame splicing' can help to increase densities in certain locations. The time when the ODF was just a flat plate with connectors in a front-patching topology is gone. More complex constructions are needed to achieve the densities requested.

There is an increasing need for ODFs with a very high fiber count. Because the number of DWDM channels continues to grow along with bit-rate on one channel (currently moving to 40Gbps), one fiber pair from a backbone network can easily be demultiplexed into a few hundred fibers. All these fibers need to be managed.

With FTTH rollouts, there is definitely a need for high fiber count ODFs. In some ODFs a decision could be made to use splicing rather than connectors, for example in termination of outside plant cables. In such a situation, overall flexibility must be provided through active equipment technology (e.g., through switches, etc.). The flexibility to respond to new customers, new technologies, or to network issues, must still be planned for.

Conclusion

The upgrade of existing networks, and the rollout of new networks and services demands careful attention to all a service provider's assets – including the choice of optical distribution frame for the central office and points of presence. The best networks are built to be not only reliable, but also to be flexible, expandable, and most of all, adaptable to whatever changing technology may require.

About the author

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Kristof Vastmans is Senior Product Manager for Central Office/ Data Center Fiber for CommScope in EMEA and drives innovative ODF platforms in the distribution and access network. He joined the company in 2000 in R&D as a product development engineer and became a certified Black Belt in Lean Design in 2006. From 2007, he has lead a development team to drive innovations and new platform systems for outside plant and last mile in-building applications.

References and notes

1 Federal Communications Commission, undated

2 Hoernig, Jay et al, December 2010

3 IEC 61756-1 Fiber optic interconnecting devices and passive components - Interface standard for fiber management systems - Part 1: General and guidance

4 ITU-T L.13 Performance requirements for passive optical nodes: Sealed closures for outdoor environments

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