How Novel Installation Solutions and Smaller Lighter Cable Deliver More Economic Deployment of Optical Fiber

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Abstract:

With the so-called "Internet of Things" emerging and 5th Generation Mobile Networks (5G) under development, the amount of data that mobile networks will soon have to handle will be multiple times greater than the volume of data backhauled today. Although wireless technologies have mostly coped so far with bandwidth demand, operators regard fiber as the truly future proof solution for backhaul of data from macrocells and small cell sites. However, the high level of investment, driven by the high cost of civil works, when installing optical cable, has hindered the growth of optical fiber in mobile backhaul networks. This paper analyses the economics behind this trend and explores innovative optical cable designs and installation techniques to demonstrate how the level of investment required for new fiber builds can be reduced and how operators can develop new revenue streams from such infrastructure.

1. Mobile Networks Evolution and the Capacity Challenge

With the emergence of the Internet of Things (numerous everyday objects – e.g. sensors - connected wirelessly to the internet), the amount of data that mobile networks will have to handle is about to increase dramatically. Analysts predict that by the end of this decade, 50 billion of those devices will be connected to mobile networks, generating 1000 times as much data as today's mobile gadgets and at rates 10 to 100 times faster than existing networks can support [1]. According to the ITU, 4G mobile networks are defined as providing at least 100 Mbps peak capacity for high mobility applications, and 1 Gbps for stationary applications [2]. Although the 5G label is premature, the successor to 4G is likely to become available by 2020 with maximum theoretical download speeds up to 1,000 faster than 4G LTE [3].

Mobile operators are facing a capacity challenge and although opening up additional spectrum for LTE could help, this is costly to undertake and in the 30 years since cellular networks were first introduced, new blocks of spectrum have been made available on only four previous occasions [4]. With limited maximum capacity per cell the only way to further increase the bandwidth available to each user is to lower the number of users per site by increasing the density of cells As most of the sites that need to increase capacity are located in urban centres, operators are adopting Wi-Fi offload and small-cell deployment strategies. However this strategy does not reduce the amount of data that ultimately needs to be backhauled when the data from the small cells is still aggregated at the nearby macrocell site [5].

Although wireless solutions using both microwave and millimetre technology are widely deployed in the backhaul (and copper also remains operational on some links), ultimately, fiber provides the best solution to address the increasing capacity demands of the mobile network.

2. Backhauling with Fiber: First Installed Costs

When considering the most important functional requirements of a mobile backhaul network, optical fiber is clearly the technology of choice. It offers near-unlimited downstream and upstream capacity. While wireless transmission is degraded by adverse atmospheric conditions, fiber remains unaffected. Also, the high capacity of fiber in combination with its low jitter and latency makes this technology suitable for future adoption of fronthauling or Cloud-RAN [6]. However, penetration of fiber in the backhaul has been relatively slow and microwave solutions continue to dominate the market, particularly in EMEA (Figure 1). This situation prevails because upfront cost is the most important factor in the operator's installation decision and fiber is still regarded as an expensive option to deploy with a long pay-back period.

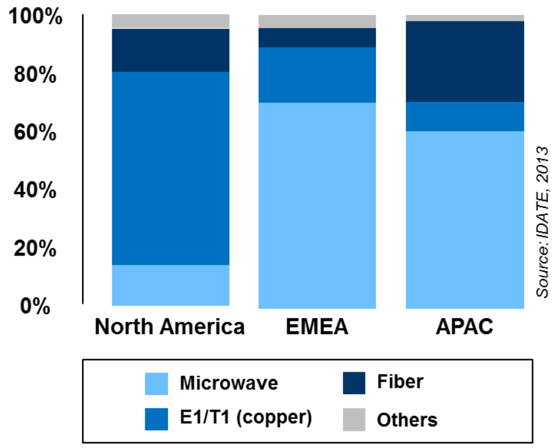

Figure 1. Backhaul technologies adoption in mobile networks

Based on available research data [7], Corning has designed an economic model to compare the cost of backhauling from a macrocell site (a tri-sectorial antenna with each sector operating at 80 Mbps) situated 3 km away from the aggregation site a using Point-to-Point (P2P) link.

Figure 2 compares the first installed costs to backhaul a macrocell site using wireless (microwave and millimetre) versus wireline (leased bandwidth and fiber deployment) solutions. For the loose tube (LT) cable installation a 24-fiber cable blown into a 40-33 mm duct is assumed.

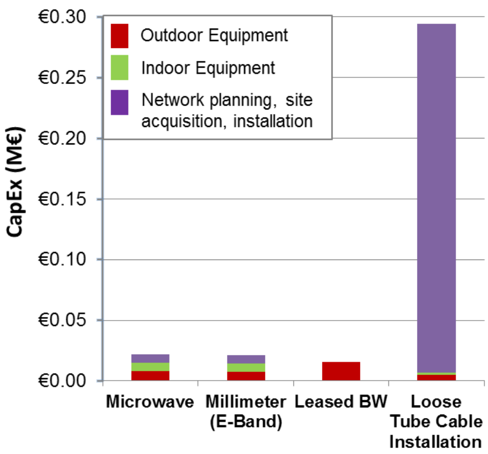

Figure 2. First installed costs to backhaul a macrocell site using wireless and wireline solutions

Compared to the other backhaul technologies considered, installing optical fiber cable using traditional open trenching is the most CapEx-intensive solution. Open trenching, although it is still the most common cable deployment technique, is an expensive, disruptive and slow process, particularly in urban areas with prices varying from £75-125 per metre (94-160 euros per metre) and installation speeds of only 30 to 50m a day [8]. Digging trenches in busy roads requires permits, traffic management and, once the ducts have been laid, reconstruction of the road by backfilling the hole and reinstating the surface.

3. Total Cost of Ownership Analysis

High installation costs and slow deployment speed of new fiber builds can explain why wireless might seem to be a more cost-effective solution. However, it should also be considered that microwave links represent a less reliable solution than fiber, having lower annual availability and requiring more site visits for maintenance and antenna realignment. Outdoor equipment costs are also significantly higher for wireless systems because of the rental fees charged by the owners of the towers on which the microwave antennas are placed. Spectrum leasing fees are also a considerable expense for wireless solutions, particularly in urban areas where some of the most common frequency bands currently used are becoming congested and expensive. For example, the U.K spectrum regulator Ofcom sets a license fee for a 23 GHz link using two 56 MHz channels of 2,827 euros per year per link [9]. Millimetre bands on the other hand can offer increased bandwidth and spectrum fees as low as 64 euros per year per link [9]. However, at these frequencies the equipment is more expensive and the maximum link distance is more limited, negatively impacting both deployment and maintenance costs.

Once installed, the on-going costs of running optical fiber links are much lower than wireless, however, due to the initial cost of traditional cable installation, the breakeven point for the technologies is somewhere between 18 and 20 years (Figure 3), too long to provide an acceptable business case for the operator.

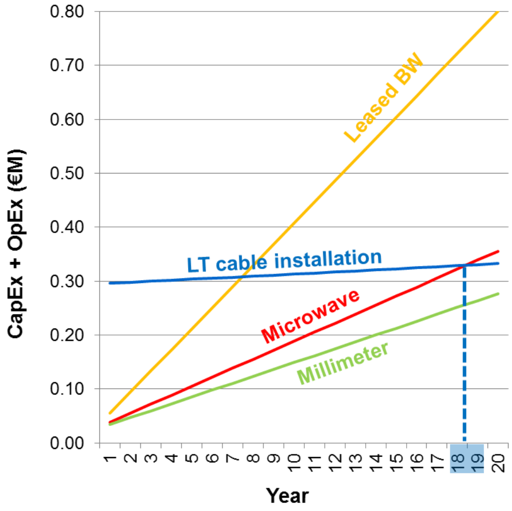

Figure 3. TCO comparison of backhaul solutions

Although leasing fiber bandwidth could be seen as a way of securing high capacity without incurring the capital cost of installing cable, high leasing fees, with prices varying from $50K to $140K per year (40K to 110K euros per year) [7] for a macrocell site like the one considered in this analysis, make this option a short-term rather than a long-term solution.

So, to allow operators to realize their preferred option of using fiber to address mobile backhaul capacity challenges, improvements to cable installation technology are necessary.

4. Minicables and Microtrenching Technologies

Amongst alternatives for deploying new optical fiber cable that can help reduce installation costs, one in particular has become popular in recent years. Microtrenching (Figure 4) is an innovative deployment technique that replaces traditional open trenches with a narrow slit that is sliced or sawn in the surface of the road and into which microducts (Figure 5) are placed.

Figure 4. Example of microtrenching deployments in urban areas

This technology can dramatically reduce the costs of the civil works by up to 76% [10]. It is also less disruptive and quicker than conventional digging techniques with installation speeds of between 150 to 200m per day [8].

Microducts are small pipes which are designed to host smaller, lighter cable designs called minicables. Microducts can be procured and installed individually or in specially-designed bundles (Figure 5) according to operator capacity and upgradeability requirements.

Figure 5. Example of microduct bundles

Through a reduction in buffer tube diameter, from ~2.25 mm to 1.4 mm, (Figure 6) minicables can provide a ~50% cross-sectional area reduction relative to standard LT cables while still retaining the same functionality and capacity.

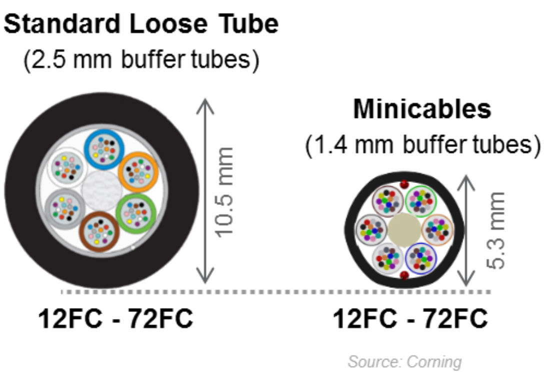

Figure 6. Corning minicables offer 50% reduction of outer cable diameter relative to standard loose tube cable

By replacing the traditional 24-fiber LT cable with 24-fiber minicable in a single microduct large savings in deployment costs can be obtained through use of microtrenching instead of traditional open trenching (Figure 7).

Use of these technologies can reduce the breakeven point between deployed fiber and wireless solutions in the backhaul down to 6-8 years.

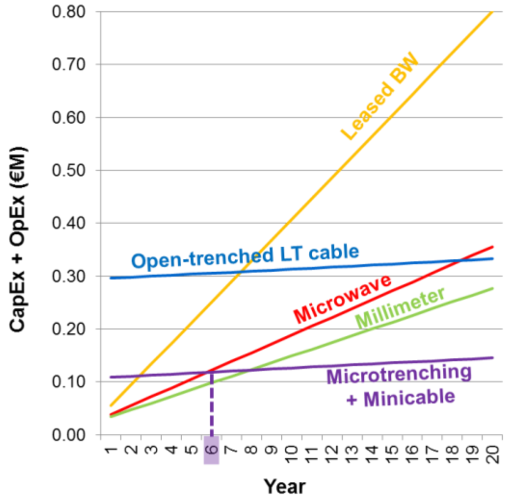

Figure 7. TCO comparison of backhaul solutions using microtrenching and minicable

5. Further Benefits of Using Minicable Technology in Backhaul Deployments

5.1 Duct Space Reutilization

Once a standard loose tube cable is deployed in a large duct, installing new cables in the same duct is not recommended as it could damage both existing and new cables. However, by overlying microducts in the large duct, minicables can be air-blown in later at no risk, allowing carriers to reutilize crowded ducts that would otherwise have been considered full. This approach allows operators the opportunity to increase network capacity at relatively low cost (Figure 8).

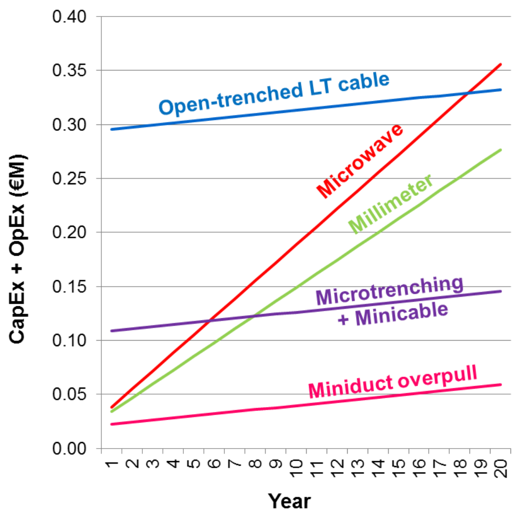

Figure 8. TCO comparison of backhaul solutions to microduct overpull

5.2 Infrastructure Sharing

Interest is growing among operators in sharing backhaul infrastructure as a means of lowering overall network costs. Sharing masts for hosting microwave antennas is the most common arrangement, for example, Telefónica, O2 and Vodafone's ten-year network sharing agreement for selected European markets [11]. Also, in 2009, Tele2 and Telenor announced an agreement to build a joint 4G network in Sweden that included the formation of a joint venture to share mobile spectrum and network construction costs [12].

Because microducts sub-divide the internal duct into smaller compartments this technology is particularly well suited to allowing the efficient sharing of duct-space amongst several operators along a route. Extending our installation model to two operators working in a consortium, the costs of deploying a microduct bundle using microtrenching technology can now be shared. This makes the business case for fiber even more positive and moves the pay-back period relative to wireless solutions down to 2-3 years (Figure 9).

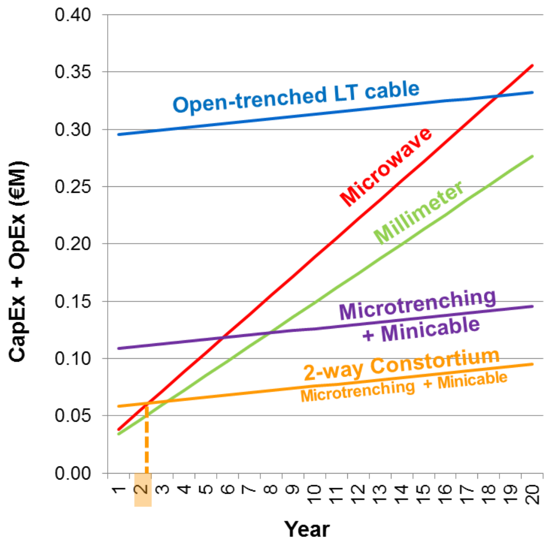

Figure 9. TCO comparison of backhaul solutions to consortium of 2 operators

Willingness to share infrastructure varies enormously depending on the market: whereas US operators seem very reluctance to share, European carriers are keener to the idea. In a recent survey of 20 operators, 20% reported that they are already sharing network infrastructure whilst a further 35% were evaluating the option [5].

5.3 Duct and Dark Fiber Leasing

Leasing bandwidth, dark fiber or duct access is a common practice in Europe. In September 2010, the European Commission (EC) issued a Recommendation with the aim of regulating wholesale products in Next Generation Access Networks (NGA) [13]. For example, the cost of renting duct space in Telecom Portugal's network in Lisbon is (€10.60/month/km/cm2) [14] and options to lease dark fiber and bandwidth are also commercially available.

An operator who deploys cable using microduct technology can open new revenue streams by leasing either some of the microducts, or the fiber contained therein.

6. Summary.

Mobile operators need to install backhaul networks that are capable of supporting the expected growth in data carrying capacity. Although more limited in terms of data carrying capacity, microwave has generally been regarded as the low-cost alternative and still leads the market whereas fiber has been perceived as a long-term investment and has often been discarded due to its high cost of deployment. However, the use of advanced installation techniques and cable technologies can greatly reduce the initial level of investment of new fiber builds, particularly if operators form consortia to share costs. Operators may also open new revenue streams by leasing infrastructure to competitors making the business case for fiber even more attractive.

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Ian Davis received a B.Sc (Hons) in Physics from the University of Nottingham in 1987 and joined Corning as a Product Engineer in 1989.

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