Versatile Access to Homes using Microduct-Cabling

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Abstract

Microduct-cabling is commonly used in long-haul and city-ring fiber-optic networks. The driving forces are "pay as you grow", "versatile branching" and the ease to upgrade old ducts (also with resident cables). Microduct-cabling is also used for FttH. It is derived that larger amounts of microducts per duct are most economical here, resulting in further miniaturization of the microducts (OD 4 mm). A bundle of 24 microducts is split into 4 sub-bundles of 6. They are jetted into a 40 mm OD duct (for direct burial), still with free space in the duct, guaranteeing mechanical protection and easy branching.

Jetting of microducts (also supplied prefab) can be done over about 1000 meters. The FttH microduct-cables (up to 4 fibers) can also be jetted over about 1000 m, not depending on weather conditions. The microduct-cabling FttH solution comes with a broad range of accessories, including distribution cabinets, spliceboxes and small home-connection boxes.

Introduction

Microduct-cabling (μduct-cabling) is commonly used now in long-haul and city-ring fiber-optic networks [1]. For the long-haul the main driving force is "pay as you grow". When building a link only the amount of fibers is installed that generates revenue. This is illustrated by an example where fiber optic cable has to be installed in a 50/40 mm (1.5") duct. One can install a high fiber-count cable immediately, but also a bundle of 7 low-cost 10 mm μducts can be installed, of which in only one a μduct-cable, with e.g. 72 fibers, is installed (see Figure 1). When expansion is demanded in the future simply new μduct cables are jetted in. Jetting of 2500 m per blow and any length in cascade is even better than for traditional cables.

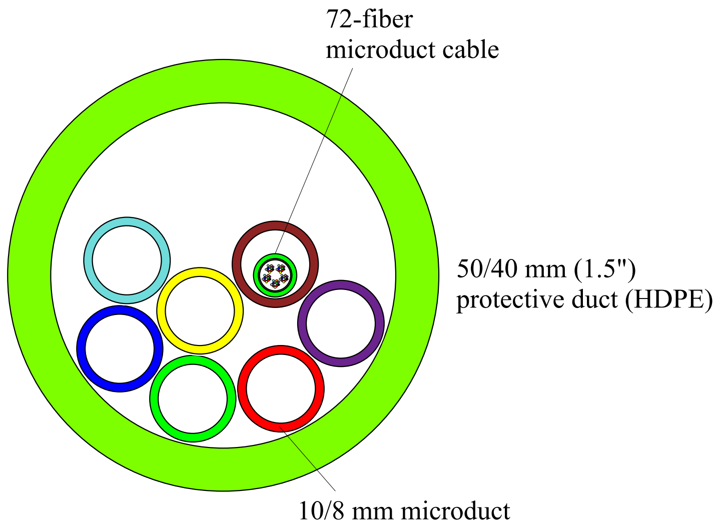

Figure 1 50/40 mm (1.5") duct filled with 7 μducts of 10 mm, one filled with a 72-fiber μduct cable

For city rings the driving force is, next to "pay as you grow", the "versatile branching". A branch can be made at any time and any place, without the need to splice the fiber. The duct and μduct of choice are simply cut, the branch duct connected, using a clip-on separable Y-connector (see Figure 2), and the μduct cable will follow the chosen path when jetted in. This avoids pre-installed cable-overlength and the belonging hand-holes or parallel ducts from splice-points to branch-points [2]. A typical configuration for a city ring is given in Figure 3, with a little more μducts of smaller size (7 mm) and, hence μduct cables with smaller fiber counts (up to 24 fibers). Also here high-performance jetting of 2500 m per blow is achieved.

Figure 2 Clip-on separable Y-connector for branching any time and any place, without splicing

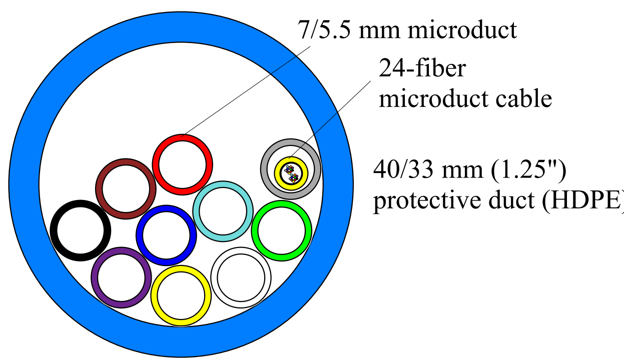

Figure 3 40/33 mm (1.25") duct filled with 10 μducts of 7 mm, one filled with a 24 fiber μduct cable

In the current difficult economic situation another important driving force is the ease to upgrade old ducts, also with resident cables, saving a lot of digging costs [1]. An example is given in Figure 4, where an additional bundle of 3 μducts of 10 mm and in one of them a 72-fiber μduct cable are jetted in a 40/33 mm (1.25") protective duct with resident 96-fiber cable. Compared to additional jetting of cable the following advantages exist:

- Longer jetting length of the μducts (less weight, even less wedging).
- μducts easily coupled to long length routes for spliceless cables.
- Jetting length of μduct cable still 2500 m per blow, usually not achieved in old ducts, even when they are empty.

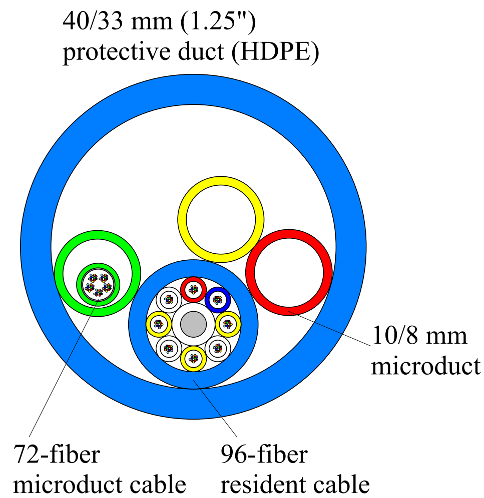

Figure 4 40/33 mm (1.25") duct filled with resident 96-fiber cable. Later 3 µducts of 10 mm and in one a 72 fiber µduct cable are jetted in

µduct cabling for FttH

µduct-cabling is also used for FttH. It is derived that larger amounts of µducts per duct are most economical here (see Appendix), resulting in further miniaturization of the µducts (OD 4 mm). With his size an economic number of 24 µducts in a 40/33 mm (1.25") protective duct (for direct burial) can be reached. In order to obtain sufficient handleability they are split into 4 reinforced sub-bundles of 6. There is still sufficient free space in the duct, guaranteeing mechanical protection and easy branching [3].

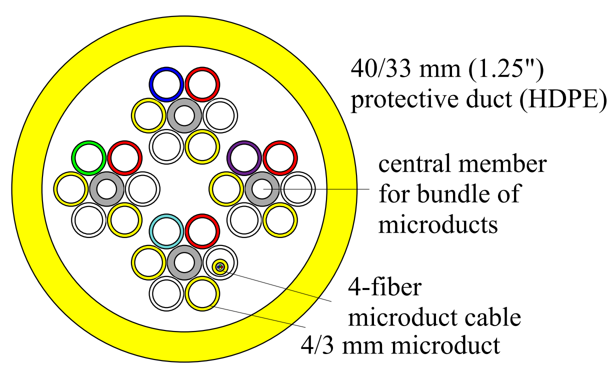

Figure 4 40/33 mm (1.25") duct filled with 24 µducts of 4 mm, one filled with a 4-fiber µduct cable

Jetting of µducts (also supplied prefab) can be done over about 1000 meters (see Figure 5). The µduct-cables (up to 4 fibers) can also be jetted over about 1000 m, not depending on weather conditions (see Figure 6). The µduct-cabling FttH solution comes with a broad range of accessories, including distribution cabinets, spliceboxes and small home-connection boxes.

Figure 5 Jetting 4 sub-bundles, each 6 μducts of 4 mm around strength member, for FttH

Figure 6 Jetting FttH μduct cable

Conclusions

μduct cabling technology is advantageous over traditional fiber-optic cabling in all layers of the network, from long-haul to Fiber to the Home. For the latter case it has been derived that a larger number of μducts is most economic. For this reason smaller 4 mm μducts have been developed, combined to handleable sub-bundles of 6 μducts each.

References

1. W. Griffioen, W. Greven, T. Pothof, "A new fiber optic life for old ducts", *Proc. 51st IWCS* (2002).
2. W. Griffioen, A. van Wingerden, C. van 't Hul, "Versatile outside plant solution for optical access networks", *Proc. 48th IWCS* (1999), 152-156.
3. US Patent no 6,572,081, June 3, 2003.

Appendix: Calculation Economic Number of μducts

The most economic number of μducts will be calculated using the simple model in Figure 7. Here *n* homes in a "street" are spaced equally with intermediate distance *h*. They are connected to a distribution point in the middle (a lot of other topologies are possible, not changing the conclusions below significantly).

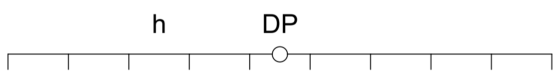

Figure 7 Schematic representation of homes in street (distance *h*) and distribution point (DP)

The relevant costs are given in the table below. Here costs that cancel out in the calculation for the optimum *n* have not been taken into account. Examples of such canceling costs are e.g. variable costs that add the same for each home, like splice and Y-branch.

Costs	**Basis**	**Per home**	**Per meter**
Distribution Point	DP		
μDuct			μD
Bundle Jetting	BJ_b		BJ_m
μCable			μC
μCable Jetting	μCJ_b	μCJ_c	μCJ_m

The total of the (relevant) costs per home is:

$$\frac{Costs}{n} = \frac{DP + \frac{1}{2}n(n-1)h \cdot \mu D + BJ_b + (n-1)h \cdot BJ_m + \frac{1}{4}n^2 h(\mu C + \mu CJ_m) + \mu CJ_b + n \cdot \mu CJ_c}{n}$$

Differentiating these costs with respect to *n* will result in the optimum value for *n*:

$$n = 2\sqrt{\frac{DP + BJ_b - h \cdot BJ_m + \mu CJ_b}{h \cdot (2 \cdot \mu D + \mu C + \mu CJ_m)}}$$

In Figure 8 the optimum number of homes per distribution point is given as a function of the intermediate distance between the homes. For a distance of 6 m the optimum number of homes is 43. This number increases rapidly for smaller distances and only decreases slowly for larger distances. Also the costs increase rapidly for a too small number of homes per customer, while they increase only slowly for too high numbers, see Figure 9. For this reason it is safer to choose the number of homes per distribution point a little higher than the optimum. Moreover, in the case that the homes will (first) be only partly connected a shift to an optimum with more (potential) homes per distribution point takes place (empty μducts cost only a little). A choice of 48 homes per distribution point, i.e. 24 μducts in the street, turns out to be a good choice.

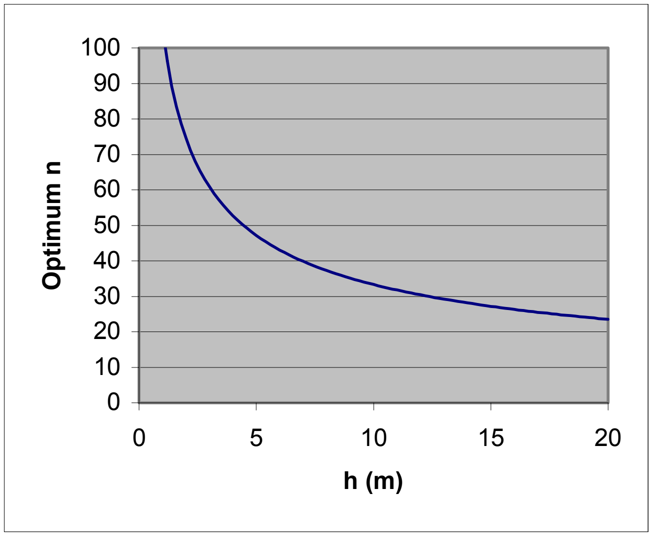

Figure 8 Optimum number *n* of homes per distribution point as a function of intermediate distance *h* between the homes

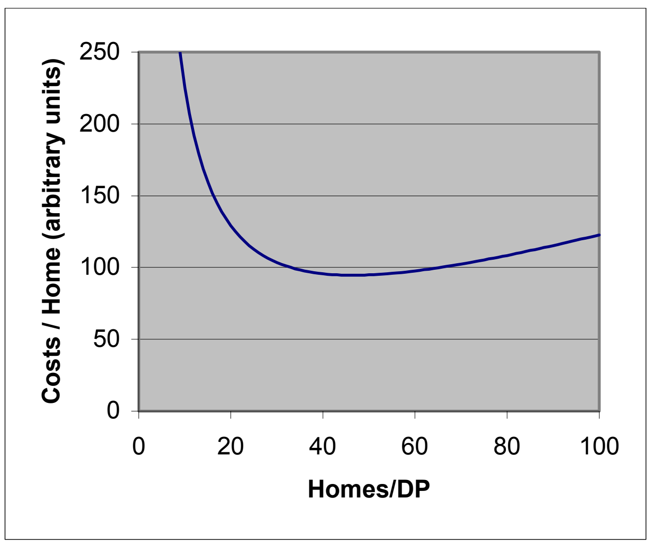

Figure 9 Costs per home as a function of number *n* of homes per distribution point for intermediate distance *h* between the homes of 6 m

For much longer intermediate distances between the homes a smaller number of microducts per protective duct may be more economic. In this case a modular system, e.g. where 24 microducts are split in 4 sub-bundles of each 6, is a good choice. Now any number of sub-bundles can be installed to find the best match. For even longer distances, e.g. exceeding 1 km without a splice, the larger microducts (offering 2.5 km per blow) can be a better choice.