Versatile Optical Access Network for Business and Future Consumer Market

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Abstract. Today's technology of optical cabling is not ideally suited for use in access networks. In this paper an alternative approach is presented where individual miniaturised cables are installed in dedicated mini-tubes. The proposed concept not only equals the functionality of the current copper network, with its numerous branches. The versatile concept also allows growth of the network in a competitive market, where initial costs shall be low.

1. Introduction

Optical telecommunications networks installed today are usually based on simple point-point connections. This was sufficient in current trunk networks connecting the exchange offices. But the limits of today's technique become clear when the optical fibre starts to penetrate into the access network, from the exchange offices to the customers. At this moment the majority of access networks still consists of copper twisted-pair. When fibre takes over it will find itself in a deregulated market. In order to be successful here initial costs should be kept to a minimum, growing with acquisition of customers. Some business customers ask for optical links, but it is unknown when and where future connections must be made. Today's technology lacks versatility to follow the demands. Later, in case the optical penetration in the access network becomes larger (ultimately Fibre To The Home) a lot of branching of the optical network is necessary. Using the current technology this means: a lot of optical splices.

Splices are to be avoided in optical networks whenever possible. They are costly, they contribute significantly to the (low) signal attenuation of the fibres, they cannot be placed close to each other (because of modal noise) and, most important, fibre overlength is needed to allow splicing outside the trench. Therefore, mid-span access of an optical cable is only possible at pre-determined splice-points where the cable is stored in loops. These points, as a rule, do not match with the topological locations of branches to the customers. To avoid digging again along the previously installed cable (from splice-point to branch) extra protective ducts are laid parallel for connecting new customers, increasing the costs and consuming trench space.

When a customer asks for connection a direct link only is not a profitable solution. Because other (unknown) future customers may be passed the fibre count of the cable should be higher, increasing the costs. "Parallel upgradeability" is lacking in today's technology. But, that's not all. Also beyond the customer's connection a demand may arise. To anticipate for this one would choose to lay the feeder cable for a longer length, avoiding many

future splices in the high fibre-count cable. This means extra civil engineering and installation activities, the largest costs when building a network. The current technology also lacks "serial upgradeability".

These shortcomings of the current technology require radically new, versatile solutions. In this paper the solution to the mentioned problems is presented, the unique METRO-net® concept (®METRO-net is a registered trademark of NKF Kabel BV).

2. The METRO-net® concept

The METRO-net® concept is constructed from individual guide tubes which run through a telescopic protective tube network. A trunk tube runs through the streets and smaller tubes branch to the subscribers. Simple splittable branching connections are used which can be placed at any place and any time. Guide-tubes are simply "click-fitted" at these locations. Small, but outside plant resistant (handling and environment), optical cables (2-48 fibres) can be installed spliceless in the now created dedicated guide-tube links, e.g. using compressed air. The concept is based upon JETNET® [1,2,3] (®JETNET is a registered trademark of KPN Koninklijke PTT Nederland) which was developed to migrate the copper network to an optical network at future need. For the all-optical METRO-net® the fibre density of the cables and the maximum installation lengths have been enlarged. The concept offers the required versatility for optical access networks.

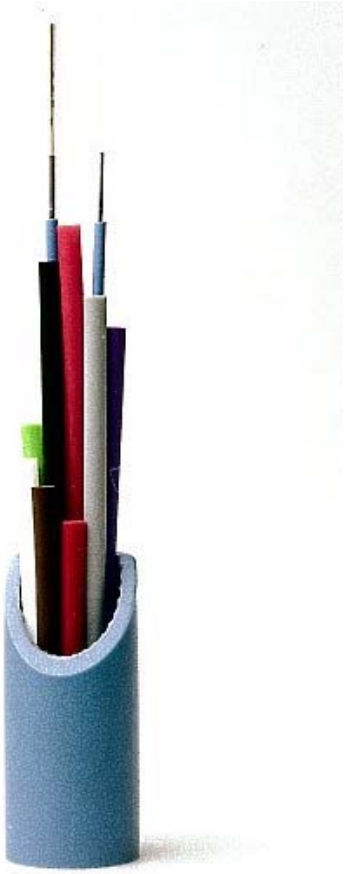

Figure 1 Protective 40 mm HDPE duct with guide-tubes and cables.

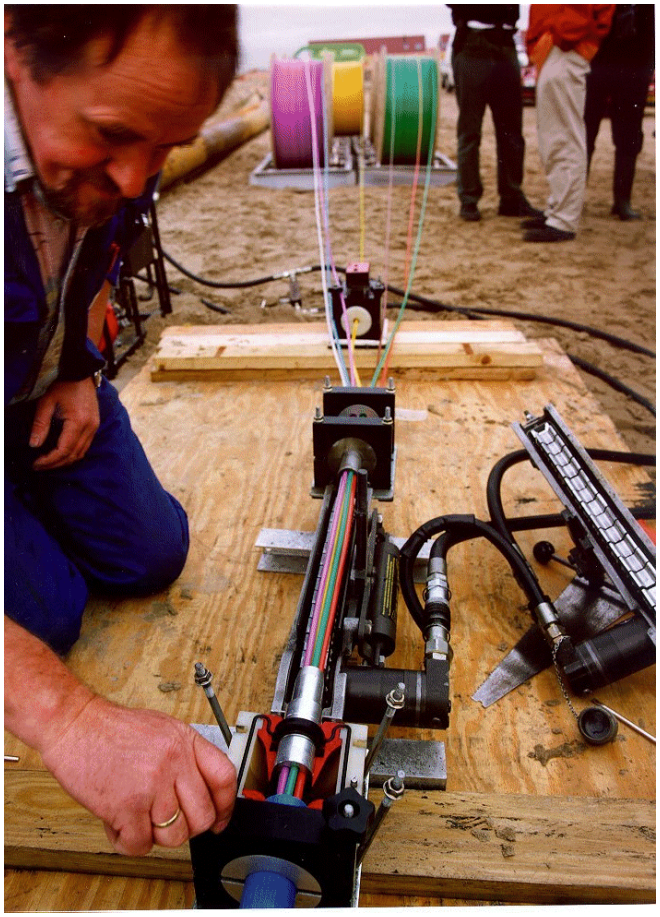

Figure 2 Installation of a bundle of guide-tubes in a protective HDPE duct by blowing

The basis of METRO-net® concept is a composite of an HDPE protective duct and small guide-tubes (see Figure 1). The guide-tubes do not completely fill the space inside and are loosely fitting. This offers excellent (proven) mechanical protection [1,4]. Also access to the guide tubes is easy. The bundle of guide-tubes can be installed, e.g. by blowing, after the protective HDPE duct has been laid (see Figure 2). For mid-span access the protective tube is cut and a splittable Y-connector is easily clipped on (see Figure 3).

A number of outer diameters of the protective ducts are possible, ranging from 25 to 50 mm, offering space for about 3 to 16 guide-tubes with an outer diameter of 7 mm. In these guide tubes cables with a diameter of 4 mm and a fibre-count of 2 and 12 can be installed. For fibre-counts of 24 and 48 a 6 mm diameter cable is used which is to be installed in a larger 10 mm guide-tube. These larger guide-tubes can also be blown into protective ducts but take about twice the place of the smaller ones (this makes a maximum of 384 fibres per protective tube). Combinations of 10 mm and 7 mm guide-tubes are also possible. Each protective duct can, in principle, be used either as trunk, sub-branch or branch to the end-user. For the latter usually the 25 mm duct is used because of its flexibility.

Special miniaturised cables have been developed for METRO-net®. The cables can withstand brute handling and harsh environments as may be encountered in outside plant use. One type of cable is made with a welded stainless steel tube. As an alternative also non-metallic multilayer fibre-optic cables have been developed, based on a new cone extrusion process.

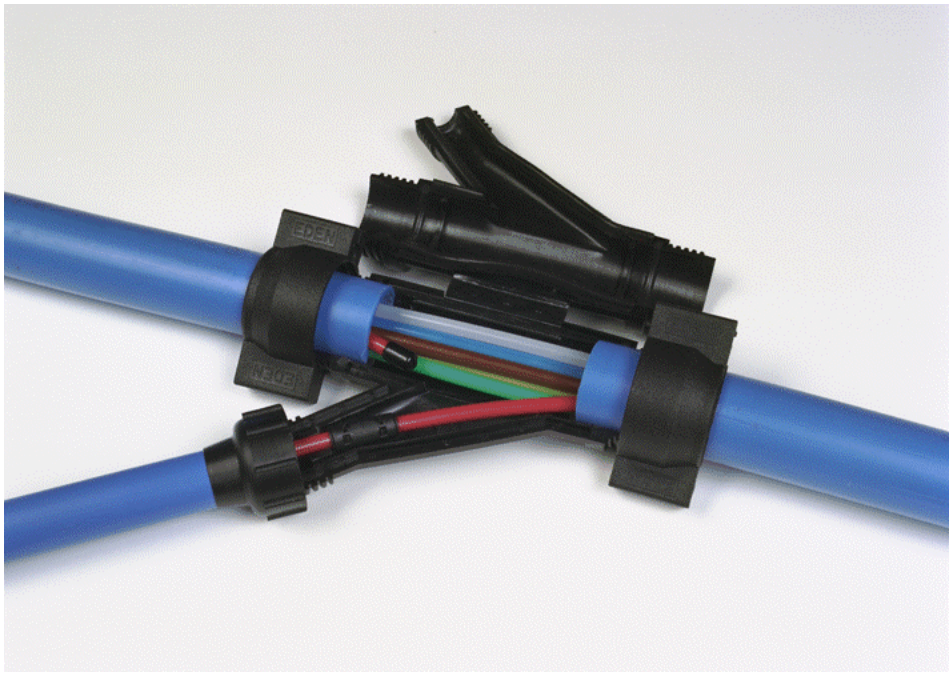

Figure 3 Branch with splittable Y-connector

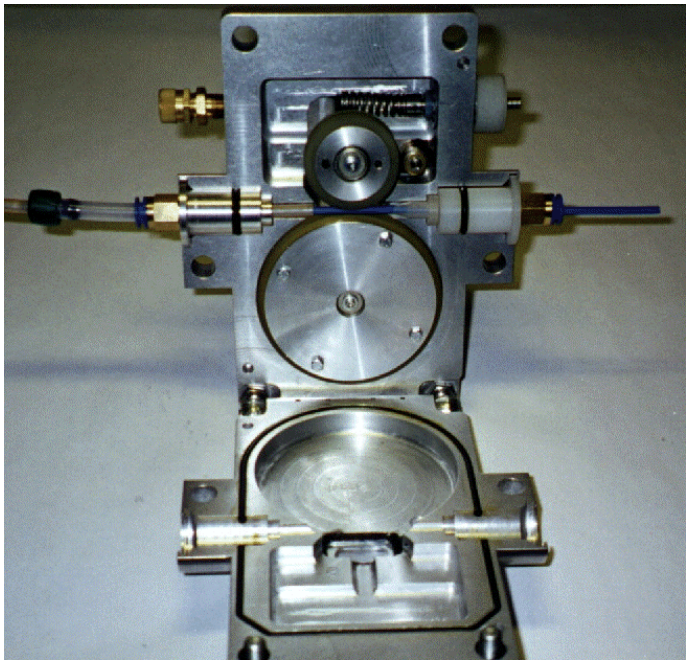

Figure 4 Microjet®, installation unit for blowing cables into guide-tubes.

3. Installation

With the blowing technique a bundle of 10 guide-tubes was easily installed over a length of 2100 m using only one installation unit. For longer lengths the guide-tubes are easily con-

nected to eachother using simple push-pull connectors. A 2-fibre steel-tube cable was pushed into the 7 mm guide-tube over more than 370 m using the Microjet®, a new universal tool for the placement of microcables [5] (see Figure 4). This tool is compact and simple (can be powered by a "Black & Decker") and makes it possible to install quickly and at low costs. With additional blowing (pressure 9 bar) about 1300 m was installed with the same tool in a trajectory with 180-degree bends every 150 m. The 12-fibre steel-tube cable was blown in over about 1150 m in the same trajectory. A first type of 48-fibre steel-tube cable was blown into a 10 mm guide-tube over more than 800 m.

In the METRO-net® concept no window-cuts are needed which makes handling a lot easier. Fibres can be accessed without any problem. Much experience has been gained with the steel-tube cables, the core of which has been extensively used in OPGW cables. Because all cables terminate at the (optional) splice boxes and because of the low cable diameters not much space is needed to store the cable. Small boxes suffice. Splittable mechanical boxes can be used which can be placed at a later stage. They can be re-opened, allowing connection of customers time after time according to single-circuit management. Extension of a bundle of tubes can be done by simple connectors. For reparation a piece of bundled tubes can be replaced and connected. Either new cables are installed over the entire length (no additional splices) or only the intermediate part is replaced and splices are made (comparable to the current technique). In the latter case the described splice boxes can be used.

4. Network examples

METRO-net® can be used advantageously in all parts of the access network, even in the long-distance network. In Figure 5 an example is shown of double-routed connections (2 fibres from each side) between primary nodes and customers. One 40 mm protective HDPE duct only can serve 10 customers in a very versatile way. More customers can be connected single-routed. A mixture is also possible.

The number of customers for one protective duct can even be enlarged when using splice points, the METRO-joints (MJ's). An example is given in Figure 6 (cross-section of the tubes in Figure 7) where 18 customers are connected double-routed. Here 2 guide-tubes are still free. They can be used for many purposes, e.g. to place more MJ's (up to 30 double-routed customers) or to feed the MJ's with more fibres when even more customers ask for (single-routed) connection.

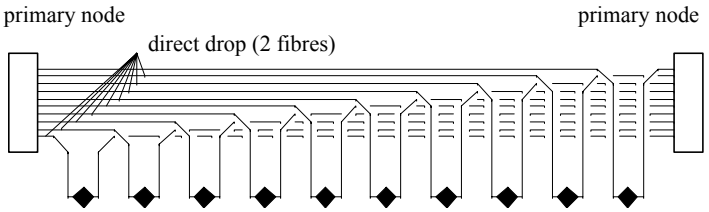

Figure 5 Example of 10 double-routed connections through one 40 mm protective duct.

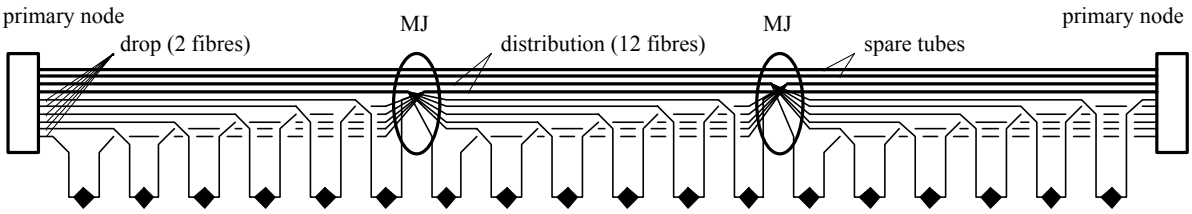

Figure 6 Example of 18 double-routed connections through one 40 mm protective duct using joints (MJ's).

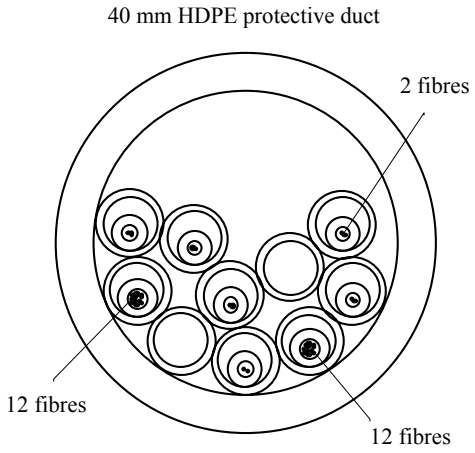

Figure 7 Cross-sectional view of tubes and cables for network-structure of Figure 6.

5. Advantages

The new concept is far more versatile than traditional techniques to install optical fibre in the access network. It is solves today's problems connecting business customers and brings FTTH within reach. It can be used for the whole (primary, secondary and tertiary) access network, even for the trunk network. Typical advantages with respect to current technology are:

- Initial investments are lower than those for present technology, growing with the market. Parallel upgradeability (filling tubes) and serial upgradeability (connecting bundles of tube, saves digging).
- Installation of latest technology optical fibre (still on the move [6]).
- No (expensive) pre-determined splice boxes with cable overlength needed for branching. Low-cost branching.
- No extra protective ducts needed along distribution route (to avoid digging again from splice box to branch).
- More customers per protective duct (order of magnitude more!), less trench space.
- Mid-span access at any time (living fibres not disturbed)
- Mid-span access at any place.
- Splice-boxes can be made smaller because cables terminate there (no window-cut).

- Limited number of splices.
- Less splices at reparation (the less customers, the less fibres).
- For high fibre counts reparation time can be reduced by splicing at different locations.
- Less total fibre length (in case of single-routed connection).
- Easy upgrade from star- to (redundant) ring-structure.
- Branch-offs for redundant customers can be located close to each other, saving trench length.
- Fast installation technology and short response time.
- Spare tubes can be used to install localisation wire.
- When a customer moves or ends its subscription (and no new customer is expected at this location) the guide-tube in the bundle can be made free and is easily used again for a new location.
- In green-field areas: possible to connect customers later than street-work.
- Matching with commonly used HDPE ducts for optical cables.

6. Conclusions

METRO-net® is a versatile concept, ideally suited as an alternative for today's optical outside plant technology. It matches the needs for access networks. It has been shown that installation of the network is easy and expansion can be done quickly.

7. Acknowledgements

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8. References

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