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Integrating broadband services in a Polymer Optical Fibre in-house network

Ton Koonen, Henrie van den Boom, Mohammed Aissi, Frans Huijskens, Frans Willems, Jan Bergmans, Giok-Djan Khoe

COBRA Institute, Eindhoven University of Technology,
P.O. Box 513, NL 5600MB Eindhoven, The Netherlands
e-mail a.m.j.koonen@tue.nl

Abstract

A variety of transport media is used in in-home networks nowadays, to distribute services with quite different characteristics. Coaxial cable networks are deployed for distributing CATV signals and increasingly for data signals, twisted copper pair networks for voice telephony, cat-5 copper pair cables and wireless local area networks for fast data transfer, power lines for control signals and also for some data transfer, etc. Each of these networks is optimised for a particular range of services. The service-dedicated design of the networks, and the lack of cooperation between them, makes it difficult to upgrade services, to introduce new ones, and to establish links between services. These problems would be greatly relieved by a versatile broadband in-house network, which is able to integrate a variety of services on a single transport medium. Due to its transparency and wide bandwidth, optical fibre is an excellent candidate for this. The standard single mode fibre has reached a very high level of performance, but requires precision equipment and delicate handling by highly skilled personnel. Thus, although the costs per unit length of fibre are low, the installation costs are high, and prohibitive for large-scale in-house deployment. Multimode fibre, however, is much easier to install, as splicing is considerably facilitated by its larger core diameter. Multimode polymer optical fibre is even more convenient, due to its very large core diameter (more than 100 micrometer) and its ductility. However, the multimode waveguiding introduces a lot of dispersion due to propagation time differences between the modes, and thus seriously limits the bandwidth.

The disadvantage of having many modes can, however, also be turned into an advantage by dividing the large group of modes into smaller groups, and by using each of these groups as a separate transmission channel. This novel method, which we have termed mode group diversity multiplexing, is based on using a number of independent optical transmitters at one end of the system, each launching a data signal into a different group of modes. At the other end, a number of optical receivers is used, each of which receives a mixture of the signals arriving via the mode groups. This mixture is the result of the statistically varying mode mixing process in the multimode fibre network. After the receivers, an electrical signal processing circuit can reverse the mixing process, thus yielding the separate input data streams again. The signal processing circuit needs to know the mode mixing coefficients for that; these coefficients can be deduced by sending training sequences (similarly as done in wireless LAN multiple-input multiple-output, MIMO, systems). By repeating this training period when detecting flaws in the separated data streams, induced by changes in the mode mixing process, the coefficients can be updated timely.

An analysis has been made how mode groups can be separately excited in polymer optical fibres, and thus how independent communication channels could be established. Also a conceptual system architecture has been defined, including bi-directional operation. The system functionality obtainable with this mode group diversity multiplexing method is similar to wavelength division multiplexing. However, in stead of using wavelength-specific sources and wavelength multi-/demultiplexing subsystems, electrical signal processing is used to establish the parallel communication channels. Provided low-cost integrated electronic circuits can be used, the mode group diversity multiplexing method may economically outperform the wavelength multiplexing method, while offering similar performance. Thus widely differing services such as Gigabit Ethernet and analog video signals could be transported in a single versatile multimode (polymer) optical fibre in-house network.