# HIGH-SPEED COPPER AND COAXIAL BROADBAND


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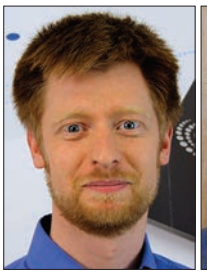
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Legacy copper infrastructure originally designed to provide voice services (twisted pair network) or television services (coaxial network) has performed vastly beyond specification and continues to deliver increased broadband speeds. Today's mature technologies like vectored VDSL2 and G.fast for twisted pair and DOCSIS 3.1 for coaxial networks, are able to surpass present-day demand for broadband speeds in excess of several hundreds Mb/s per end user. The ability to offer gigabit speeds has been fueled by advances in digital signal processing and by a steady migration toward fiber rich access networks where only the last "mile" into the homes remains copper based (FTTx). We often get the question why the industry continues to consider copper access, while fiber is perceived as superior in terms of transmission properties. The answer is one of "And." It is copper "and" fiber. The growth in copper bandwidth is achieved by introducing deeper fiber, thereby shortening the copper loop. And the introduction of deeper fiber is facilitated by the ability to leverage the remaining copper drop for providing ubiquitous gigabit access to everyone within the service area. In contrast, fiber roll-outs that do not leverage the copper network are regional: as region-by-region is upgraded to full fiber, the remaining regions are under-served.

This feature topic addresses copper technologies and deployment practices beyond those currently available. For twisted pair, the article by Oksman *et al.* presents the status of standardization at the International Telecommunications Union (ITU) of Multi-Gigabit Fast Access to Subscriber Terminals (MGfast). This technology, beyond facilitating gradual fiber deployment and providing fiber-like data rates, is also being prepared for delivering quality of service at par or beyond those considered for 5G services. The second article by Lamparter *et al.* presents architectural options for introducing MGfast in operators' networks, and for cost effectively migrating from existing practices based on G.fast. For coaxial networks, the article by Berscheid *et al.* describes Full Duplex DOCSIS, and how it enables the removal of the upstream bottleneck in present-day coaxial access. It presents opportunities and challenges, both from a technology perspective and from a network architectural perspective. The last article in this feature topic by Stockman *et al.* shows that a hybrid fiber coaxial network with a coaxial drop from the last tap can provide in excess of 40 Gbps to each end user by exploiting up to 6 GHz of baseband spectrum.

These four exciting articles on upcoming and maturing copper technologies prove that, for the decade to come, operators can continue to leverage their copper infrastructure to facilitate a gradually deeper fiber penetration and provide services at par with those on an all-fiber network.

## BIOGRAPHIES

JOCHEN MAES [SM] (jochen.maes@nokia-bell-labs.com) currently heads the Fixed Networks Group within Nokia Bell Labs, focused on innovations in optical and copper access networks. He pioneered in Digital Signal Processing for vectored VDSL2. He gradually expanded his research interest to include DOCSIS and PON technologies. He has been a Bell Labs Fellow since 2016. He serves as an editor for *IEEE Communications Magazine*.

RAINER STROBEL (rainer.strobel@intel.com) received the Dr.-Ing. degree from Technical University of Munich in 2017. In his role of concept engineering at Intel, he actively contributes to the ITU G.fast and MGfast standards for gigabit copper access networks covering physical layer aspects.

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