The Audacity of Fiber-Wireless (FiWi) Networks

(Invited Paper)

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***Abstract*—A plethora of enabling optical and wireless technologies have been emerging that can be used to build future-proof bimodal fiber-wireless (FiWi) broadband access networks. After overviewing key enabling radio-over-fiber (RoF) and radio-and-fiber (R&F) technologies and briefly surveying the state of the art of FiWi networks, we introduce an Ethernet-based access-metro FiWi network, called SuperMAN, that integrates next-generation WiFi and WiMAX networks with WDM-enhanced EPON and RPR networks. Throughout the paper we pay close attention to the technical challenges and opportunities of FiWi networks, but also elaborate on their societal benefits and potential to shift the current research focus from optical-wireless networking to the exploitation of personal and in-home computing facilities to create new unforeseen services and applications as we are about to enter the Petabyte age.**

I. Introduction

We are currently witnessing a strong worldwide push toward bringing optical fiber closer to individual homes and businesses, leading to fiber to the home/fiber to the premises (FTTH/FTTP) networks [1]. In FTTx networks, fiber is brought close or all the way to the end user, whereby x denotes the discontinuity between optical fiber and some other, either wired or wireless, transmission medium. For instance, cable operators typically deploy hybrid fiber coax (HFC) networks where fiber is used to build the feeder network while the distribution network is realized with coax cables. Another good example for wired fiber-copper access networks are hybrid fiber-twisted pair networks which are widely deployed by telephone companies to realize different variants of digital subscriber line (DSL) broadband access solutions.

From a capacity point of view, one might seriously argue that there is no techno-economic need and justification to replace hybrid fiber-twisted pair based DSL networks with all-optical solutions, e.g., passive optical networks (PONs). According to [2], the so-called Copper-PON (CuPON) multidropping DSL architecture is able to provide 50 Gb/s of shared bandwidth in each direction on existing twisted pair of copper telephone lines through exploitation of all modes of crosstalk. Thus, CuPON is able to offer much higher data rates than state-of-the-art standardized access network solutions, e.g., IEEE 802.3ah Ethernet PON (EPON) and ITU-T G.984 Gigabit PON (GPON), without requiring any costly replacement of widely installed twisted pairs by fiber. Note, however, that the speed of CuPON is higher than that of current fiber PONs not because copper has a wider bandwidth than fiber, but because current fiber PONs do not use their extra bandwidth. In fact, optical fiber provides an unprecedented bandwidth potential that is far in excess of any other known transmission medium. A single strand of fiber offers a total bandwidth of 25 000 GHz. To put this potential into perspective, it is worthwhile to note that the total bandwidth of radio on the planet Earth is not more than 25 GHz [3]. Beside huge bandwidth, optical fiber has some further advantageous properties such as low attenuation, longevity, and low maintenance costs which will eventually render fiber the medium of choice in wired first/last mile access networks. This trend can be observed in most of today's greenfield deployments where fiber rather than copper cables are installed for broadband access. On the other hand, in brownfield deployments it is important that installation costs, which largely contribute to overall costs of access networks, be reduced. A promising example for cutting installation costs is NTT's do-it-yourself (DIY) installation of FTTH optical network units (ONUs) deploying a user-friendly hole-assisted fiber that exhibits negligible loss increase and sufficient reliability, even when it is bent at right angles, clinched, or knotted, and can be mass produced economically [4]. Another interesting enabling technology is the so-called plastic optical fiber (POF) which is well suited for simple wiring of low-cost optical home networks. POF provides consumers with user-friendly terminations, easy installation, and tolerance of dirty connections. Furthermore, POF's resistance to bending is comparable to that of twisted pair of copper telephone lines. An interesting application of POF-based networks is the concept of "Fiber to the Display" where POFs are directly connected to a large flat panel display to enable transmission rates of several Gb/s in support of telemedicine or the emerging digital cinema standard for next-generation cinema [5].

FTTH networks are expected to become the next major success story for optical communications systems [6]. Future