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The Evolution of Optical CATV Transport Systems and Radio over Fiber Transport Systems

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Following with the evolution of optical fiber transport techniques, embedding both broadband wireless services and cable television (CATV) services into such high-capacity and low-attenuation optical fiber links becomes a clear tendency in the communications field. In this direction, radio-over-fiber (RoF) technology that integrates large-capacity fiber optics and flexible wireless communications is considered as a promising candidate to offer high-speed wireless connections for clients. By transmitting radio frequency (RF) signals directly from a central office (CO) to base stations (BSs), parts of the signal processing components can be removed from the BSs resulting in a greatly simplified structure. In this case, the connections among consumers’ mobile devices and service centers are more flexible and easier, so the services management can be easily accomplished [1, 2]. Similar with embedding such RF signal into optical fiber transport links, the widely deployed analog/digital CATV services can also be embedded in current optical fiber to the home (FTTH) network systems. Based on the low attenuation characteristic of the optical fiber, the optical CATV transmission distance can be resourcefully extent from few kilometer in coaxial cable networks to tens kilometer without the assistance of optical amplifier. As a result, integrating both optical CATV and RoF services into a common optical fiber transport network has become much more prevalent when the popularity of triple-play multi-media services is rising.

In an integrated optical CATV and RoF transport system, various multimedia services, such as CATV programs, video/voice on demand (VoD) and on-line games, can be easily encapsulated and transmitted from COs to remote units. However, when those broadband signals reach the consumers’ premises, the capacity of current in-door wire and wireless local area networks (LANs) is not large enough to simultaneously deliver the arrived signals to dedicated devices located in each room [3, 4]. The very last in-door connection becomes a critical bottleneck in successfully transmitting high quality multimedia services all the way from a CO to the home and then to the consumer devices. To overcome the challenge, a new kind of in-door network medium is required to boost up the LAN capacity and to replace the presented coaxial cable or twisted pair networks, which are installed to deliver video, telephone, or internet services, etc. The plastic optical fiber (POF) with its low cost, high capacity and EMI free characteristics is therefore becoming a main candidate to bridge the arrived optical signals to consumers’ living room or bedrooms without utilizing any extra interface. Clear advantages have been provided by graded index-plastic optical fiber (GI-POF) network systems [5-9]. As a result, integrating FTTH and POF in-house networks also becomes one of the research tendencies in hybrid optical CATV and RoF transport systems.

In parallel with penetrating the fiber connection into home-area networks, simplifying the overall optical network architecture is also an important research direction in optical communications field. Traditionally, the CATV signal with its high-power and large modulation factor requirements in nature will cause serious optical power variation when intensity-modulated with an optical carrier, so the RF and CATV signals in a hybrid RoF and CATV optical communications system are normally delivered by two individual optical carriers [10-12]. This phenomenon, utilizing two optical wavelengths to deliver both signals for a customer, will significantly limit the number of connected clients in an optical transport system because the available virtual point-to-point channel number is limited. Thus, re-use optical wavelength becomes a popular and widely applied technique in modern optical transmission systems [13-15]. In this case, the optical network installation process will become easier and the service providers will be able to manage the network resources more flexibly.

In summary, three types of research directions are currently developed to promote the progress of building up all-optical networks in the field of hybrid CATV and RoF transport systems. The first one is to simplify the network structure by directly modulating RF signal with the optical carrier. This can efficiently reduce the CAPEX and promote the willing of the potential customers to set up an optical in-door LAN. Following that, the second research topic is to provide the transparency between optical access networks and in-house LANs which can further
simply the network structure, reduce the construction cost and to ensure quality of service (QoS) by eliminating the wavelength converting process between the optical access networks and the in-house LANs. In this direction, the network traffics flowing among a CO and consumers’ devices can be managed easier by a CO. Finally, with the purpose of efficiently utilizing the limited number of available optical wavelength channels in future multi-wavelength optical transport systems, various wavelength re-use schemes are developed and applied in modern fiber optical transport systems. Such three research directions reveal prominence in simplicity and cost-effective to compose an all-optical network environment in future.

References:

Ching-Hung Chang was born in Kaohsiung, Taiwan in Dec. 1976. He received the M.Sc. degree from the school of Electronic, Communication and Electrical Engineering, University of Hertfordshire, UK in 2004, and received the Ph.D. degrees from the Science and Technology Research Institute, University of Hertfordshire, UK in 2008. From 2008 to 2010, he was a Research Assistant in the school of Electronic, Communication and Electrical Engineering, University of Hertfordshire, UK and in the Department of Electro-Optical Engineering, National Taipei University of Technology, Taiwan, respectively. In 2010, he joined the Department of Electrical Engineering, National Chiayi University, Taiwan, as an Assistant Professor. His research interests include MAC protocol designs, optical communication systems and the radio-over-fiber systems.