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Experimental demonstration of polarization multiplexing for simultaneously providing broadband wireless and wired access

Jianqiang Li [a,*], Kun Xu [a], Yang Jing Wen [b], Songnian Fu [c], Ming Tang [c], Ping Shum [c], Jian Wu [a], Jintong Lin [a]

[a] Key Laboratory of Optical Communication and Lightwave Technologies, Ministry of Education, Beijing University of Posts and Telecommunications, Beijing 100876, China
[b] Institute for InfoComm, Singapore 119613, Singapore
[c] Lightwave Technology Group, Network Technology Research Centre, Nanyang Technological University, Singapore 637553, Singapore

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Abstract

A fiber-based wavelength-division-multiplexing (WDM) network utilizing polarization multiplexing (PolMUX) is proposed to simultaneously provide broadband wireless and wired services. In such a dual-service access network, the wireless and wired services are separately delivered in two orthogonal states of polarization with well independence in a single WDM channel. The impact of several polarization-dependent interferences becomes insignificant due to the relatively short transmission distance in access networks. The feasibility of PolMUX is experimentally demonstrated with a power penalty at BER $= 10^{-9}$ of about 0.5 dB and 1 dB for 2.5 Gb/s wired and wireless downstream services, respectively. The proposed system is compatible with the current reported techniques in either WDM passive optical networks (WDM-PON) or radio-over-fiber (ROF) systems.

Keywords: Access networks; Polarization multiplexing; Passive optical networks (PON); Radio-over-fiber (ROF)

1. Introduction

It is essential and necessary to upgrade or redesign access networks for satisfying the increasing demand of broadband wireless and wired access. Wavelength-division-multiplexing passive optical networks (WDM-PON) have been widely investigated as a promising solution to the realization of fiber-to-the-home (FTTH), where the huge bandwidth of optical fiber is explored to achieve up to multi-gigahertz wired access [1,2]. Taking into account the requirements on flexibility and mobility, radio systems operating at microwave frequency play a crucial role in wireless access networks. However, the conventional wireless communication systems are confronted with a series of challenges, such as the high loss of coaxial cable, frequency congestion, and limited capacity. Recently, millimeter wave (mm-wave) radio-over-fiber (ROF) systems and optical-wireless networks emerge to integrate wireless communications with beneficial fiber-optic technology, which makes it feasible to cost-effectively support both wireless and wired services over the same fiber-optic infrastructure [3,4].

2. The utilization of PolMUX in fiber-based access networks

In the most previous works, WDM-PON and ROF systems were studied separately for supporting either wired or wireless services [1,2,5–8]. Many techniques have been proposed to implement low-cost, flexible, and function-centralized full-duplex operations for either WDM-PON

* Corresponding author.
E-mail address: JQJQLee@gmail.com (J. Li).

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or ROF systems, such as colorless optical network units (ONUs) in WDM-PON [1,2], architecture design [5,6], all-optical frequency up-conversion [7], and wavelength reuse for ROF systems [8]. Although the previous demonstrations have testified that ROF systems are capable of sharing the fiber-based infrastructure with WDM-PON, it is still a challenge to simultaneously guarantee broadband dual-service operations for both wireless and wired access in a single WDM channel. A novel ROF architecture was reported to provide broadband dual-service in one WDM channel [4]. However, this scheme is only suitable for point-to-multi-points applications due to the dependence between the delivered wireless and wired services. Two other methods were demonstrated to simultaneously deliver multiple independent wireless and wired services in one WDM channel [9,10]. In the two schemes, the optical spectrum is extensively occupied by different services in a single WDM channel. The separation of these services requires suitable narrow-band bandpass filters either in the optical or electrical domain. These filters are difficult to fabricate and usually expensive. Furthermore, only the downstream services are considered in [9,10]. When taking into account the bidirectional full-duplex operation, the extensively-occupied spectrum has no more free space to accommodate upstream services. Therefore, the technique aimed at further capability enhancement and easier service-separation is desired in a single wavelength.

On the other hand, polarization multiplexing (PolMUX) can double the capacity in one WDM channel, and has been successfully demonstrated in the optical transmission experiments by transmitting independent signals in two orthogonal states of polarization (SOPs) [11]. Therefore,

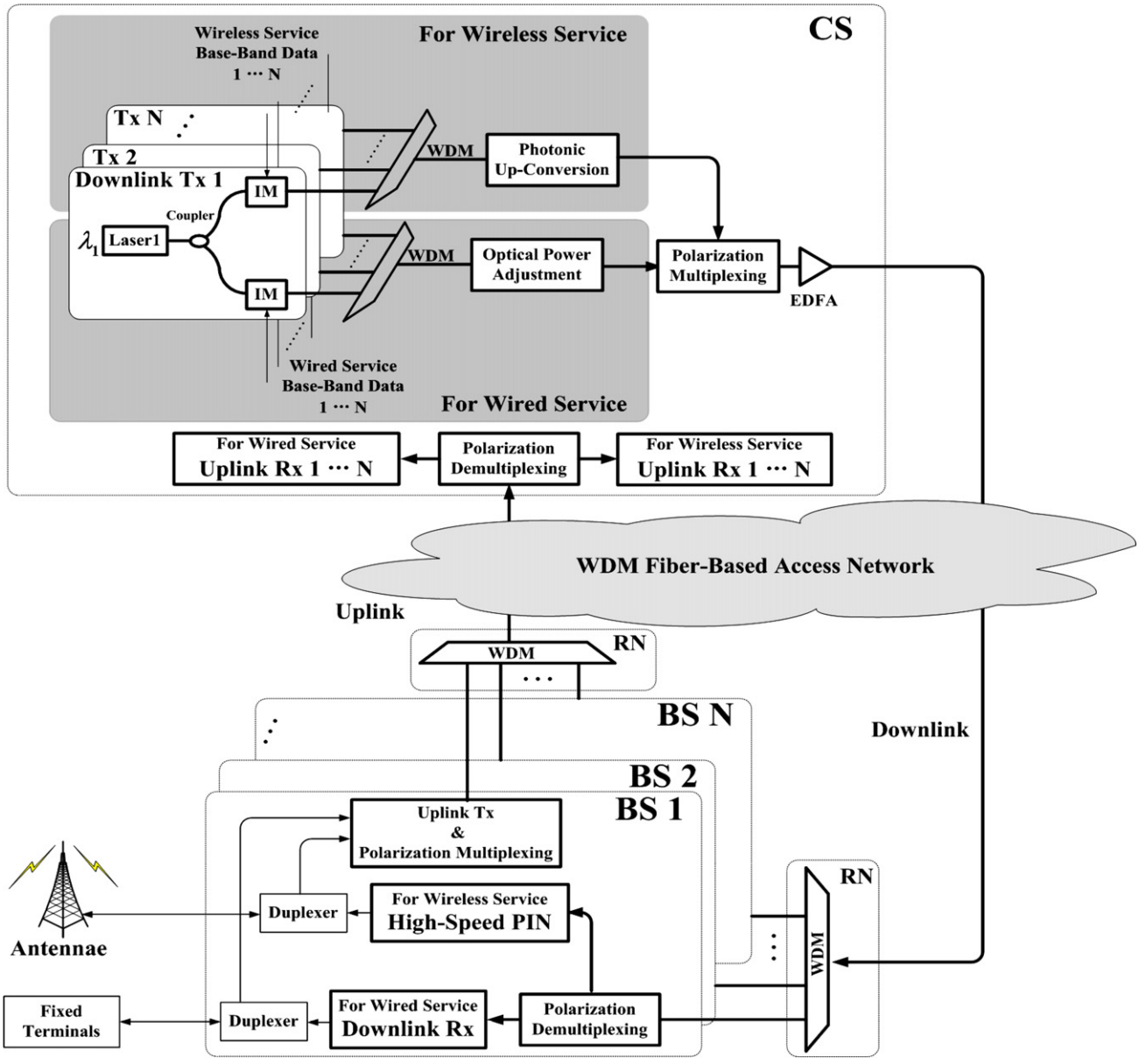

Fig. 1. Proposed scenario for fiber-based access networks utilizing PolMUX.