WIRELESS COMMUNICATIONS AND MOBILE COMPUTING
Wirel. Commun. Mob. Comput. 2001; **1**:407–417 (DOI: 10.1002/wcm.38)

A channel assignment scheme for SCM/WDM-based personal communication network

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Summary

As the cover range for the radio cells becomes gradually smaller than before, the procedures for mobile terminals call setup and control become complicated due to the high handoff frequency. The broadcast nature of WDM star couplers makes the handoff scheme easier and reduces the number of reconnections. In this study, we proposed a channel allocation algorithm, called pre-empted assigned offset (PAO) scheme, for the WDM- and SCM/WDM-based PCN architectures. The main idea is to keep the offset conflict probability lower. The simulation results show that the proposed scheme outperforms those previously introduced schemes. Especially in offset conflict probability under a moderate roaming rate for WDM and even under heavy roaming situations for SCM/WDM.

KEY WORDS
wavelength division multiplexing
personal communication network
subcarrier WDM
offset

Published online: 19 September 2001

1. Introduction

To meet the increasing demand for multimedia processing and communication services, fiber optic transmission technology [1,2] has been accepted as the realistic solution for the future growth of the communication network [3]. Wavelength Division Multiplexing (WDM) [4–6] allows the optical bandwidth to be efficiently exploited and each wavelength channel can reach gigabit per second speeds [7]. It is expected that the WDM network will be the proper backbone for the next generation Personal Communication Network (PCN) [8,9].

On the other side of view, subcarrier wavelength-division multi-access (SCM/WDM) [10] network is another kind of improvement of WDM. It has many features such as higher system capacity [11], flexible

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Contract/grant sponsor: National Science Council of Taiwan; contract/grant number: NSC 87-2213-E-259-008.

packet switching access and very fast tuning speed of RF local oscillator [12,13], etc. [14,15]. Generally speaking, the existing protocol for WDM networks can be applied to SCM/WDM networks. However, an optimal wavelength channel assignment for a WDM network may not be optimal in a SCM/WDM network with many subcarrier channels involved.

In the following sections, both WDM-based PCN system architecture [16] and a new WDM-based PCN architecture with SCM involved will be introduced first. Then we'll discuss the *offset conflict problem*. Three offset allocation assignment algorithms are proposed to reduce the offset conflict rate as low as possible in WDM-based PCN networks. For SCM/WDM-based PCN networks, we also modify the algorithms to adapt the new architecture. Finally, for the simulation model, results and conclusion are reported.

1.1. WDM-based PCN system

The WDM-based PCN architecture is based on the single-hop WDM star couplers as illustrated in Figure 1 [17]. In other PCN architectures, like CATV-based PCN [18], the entire geographical area covered is a broadcast domain. That is, data for a user are actually broadcast to all of the other nodes in the network. Thus, this broadcast nature provides the opportunity to design fast and simple handoff procedures. In the WDM-based PCN, the area must be partitioned into several disjoint clusters. Each cluster is a broadcast domain connected to a star coupler and every star coupler is connected to a WDM optical switching that is interconnected by point-to-point optical links with others. Each cluster consists of a set of microcells. Each microcell has a base station within the cell to exchange radio signals with wireless mobile terminals. A database called a home location register (HLR) stores the user profiles, and a database called a visitor location register (VLR), which stores the location information of the mobile terminals, are required to produce a network configuration. We assumed that an HLR is attached to one of the wavelength switches and a VLR is attached to each star coupler. We also need a mechanism to assign appropriate wavelength and offset to users in a broadcast domain called a Wavelength and Offset Assignment Scheduler (WOAS).

In the WDM backbone network, each lightwave channel is assigned to one specific wavelength. The lightwave channels are categorized into data channels and a control channel (see Figure 2). The data channels are then divided into consecutive fixed-length packets named as time-slots. A specific wavelength is reserved as the control channel for transmitting control messages and other available wavelengths are allocated as data channels for transmitting general data. The control messages contain a call setup request, handoff signals, and WOAS wavelength-assignment commands, etc.

Due to cost considerations, each base station is equipped with only one tunable transmitter and one tunable receiver for data transmission, one fixed transmitter and receiver pair for signal control. The following four modules compose the base station (see Figure 3): the wireless module, Media Access Control (MAC), the Radio Frequency (RF) converter, and channel-offset allocation table (COAT). The wireless module is in charge of communicating with mobile terminals within the cell. The MAC protocol defined by IEEE 802.11 [19] can be a protocol for the radio links between the wireless module and mobile terminals. The RF converter is responsible for interchanging the signal format between the wireless RF signals and WDM channel signals. The COAT of

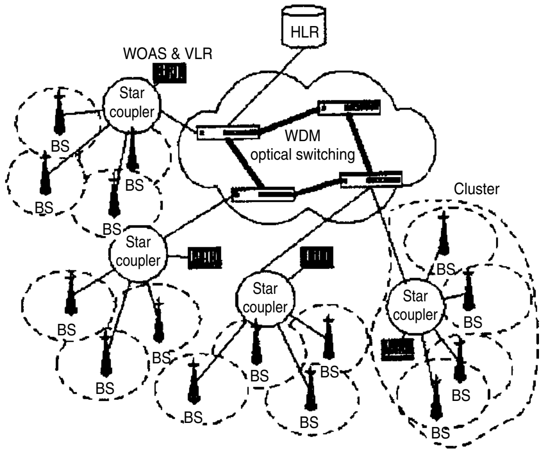


Fig. 1. WDM-based PCN architecture.

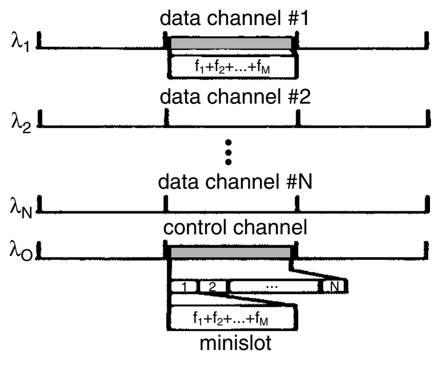
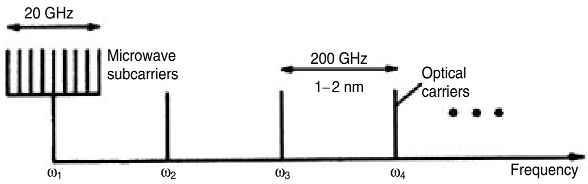


Fig. 2. Data and control channel formats.



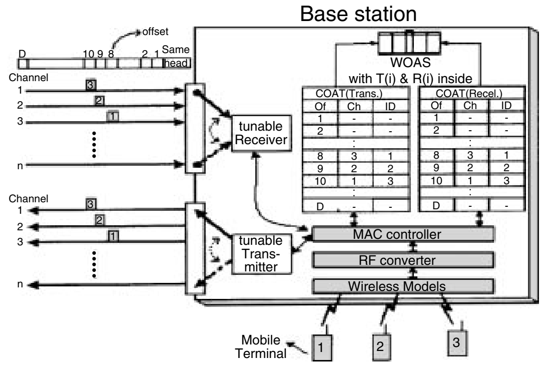


Fig. 3. Architecture of the base station.

each base station keeps the assigned channel and slot (by the WOAS) for each of the serving mobile terminals. Each entry in the COAT is (Ch, Of, ID), which means the offset (Of) of the channel (Ch) is assigned to the mobile terminal whose identity number is ID.

1.2. SCM/WDM PCN architecture

The total bandwidth is limited to well below 1 GHz when coaxial cables are used to transmit the multichannel microwave signal. However, if the multichannel microwave signal is transmitted optically using optical fibers, the signal bandwidth can easily exceed 10 GHz using a single optical carrier. In addition, a combination of SCM and WDM (using multiple optical carriers) has the potential for achieving a bandwidth in excess of 1 THz. Since the signal is transmitted optically, the microwave carrier acts as a subcarrier for the optical carrier, and the technique is referred to as SCM. Figure 4 presents a block diagram of an SCM lightwave system. In this scheme, shown in Figure 5, multiple optical carriers are launched into the same optical fiber using the WDM techniques. Each optical carrier carries multiple SCM channels using several microwave subcarriers.

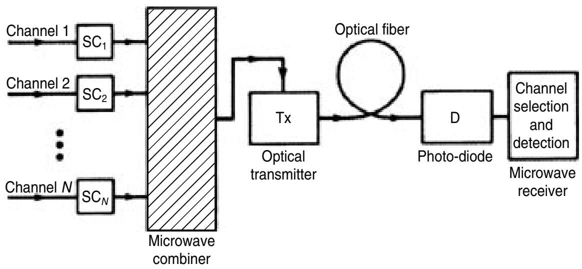


Fig. 4. A multichannel SCM light system.

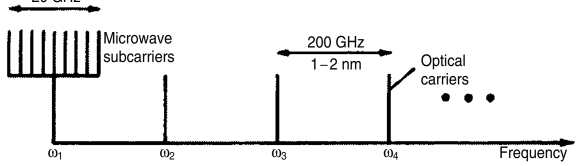


Fig. 5. Frequency allocation in a multi-wavelength SCM network.

Let us consider an SCM/WDM network using a passive optical star coupler and WDM optical switching as shown in Figure 1. Overall, the main architecture is the same with WDM-based PCN. The difference is that we need a mechanism to assign appropriate wavelength, offset and subcarrier (frequency) to users in a broadcast domain called a Wavelength-Frequency-Offset Assignment Scheduler (WFOAS). In the SCM/WDM network, we employ Wavelength Division Multiplexing Access (WDMA), Subcarrier Multiplexing Access (SCMA) and Time Division Multiplexing Access (TDMA) multiplexing techniques. Thus, a connection can be assigned an offset O_j and frequency F_k of a wavelength λ_i by WFOAS and presented as (F_k, O_j, λ_i).

The same as WDM-based PCN, each base station is equipped with only one tunable transmitter and only one tunable receiver for data transmission, one fixed transmitter and receiver pair for signals control. Besides, a pair of tunable RF local oscillators is added. Each base station has five modules (see Figure 6): SCM Tx-Rx (LOs) module, the wireless module, Media Access Control (MAC), the Radio Frequency (RF) converter, and Channel-Frequency-Offset Allocation Table (CFOAT). The wireless module is in charge of communicating with the mobile terminals within the cell. The MAC protocol is the protocol of the radio links between the wireless module and mobile terminals. The RF converter is responsible for interchanging the signal format between the