Selective Multicast in a Dynamic Wavelength Router for DWDM Converged Wired/Wireless Access Networks

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Abstract: Transmission of selective multicast services has been demonstrated in a cost-effective dynamic channel allocation router. The approach envisions heterogeneous infrastructures with unicast, broadcast and multicast-related functions on a radio over fiber access network.

OCIS Codes: (060.4250) Networks; (060.4255) Multicast; (060.4265) Networks, wavelength routing

1. Introduction

In wired access networks, multicast services are increasing in popularity as service providers take advantage of multicasting solutions to efficiently distribute contents to a large number of users. Multicast is an essential functionality for Triple Play Services where voice communication, broadcasting and Internet services must be offered in the access network. In addition, multicast services can provide location based information tailored for users in a specific geographical area e.g. traffic reports, advertisements, etc. On the other hand, radio access network environments featuring multimedia applications with Quality of Service (QoS) requirements present new challenges for multicast routing protocols. As users may move throughout the access network by changing the network access point, the routing protocol has to guarantee the reachability for network services during this handover process, especially in the case of active communications. At present, these networks transmit multicast data using point to point unicast transmission resulting in redundancy and increment of network resource utilization due to the broadcasting nature of multicast services. Moreover most existing multicast routing protocols are IP based handled through standard protocols such as IGMP (Internet Group Management Protocol) [1] [2]. These techniques are focused on the management of multicast group membership and exclude QoS considerations or the static creation of a single optimal multicast distribution tree [3]. As for the radio access network scenario those approaches are far too limited so that the access networks are not consistent in this capability across the entire infrastructure especially when IP multicasting is not ubiquitous to all networks.

While most work on supporting multicast services focuses on the IP layer solution, we propose a wavelength router to support several multicast-related functions at the physical layer for fixed and mobile users including selection of multicast channel to be broadcasted and dynamic capacity allocation through non-multicast-capable channels.

2. System description

The proposed setup for the broadcast of multicast services is shown in Fig. 1. The architecture is based on an Arrayed Waveguide Grating (AWG) and an optical switch in feedback configuration [4]. For the experimental demonstration four channels with 2.5 Gb/s PRBS were broadcasted to all ONU's using one fixed wavelength per ONU (CH1=1546.640 nm, CH-2=1547.440 nm, CH-3=1548.240 nm and CH-4=1549.040 nm).

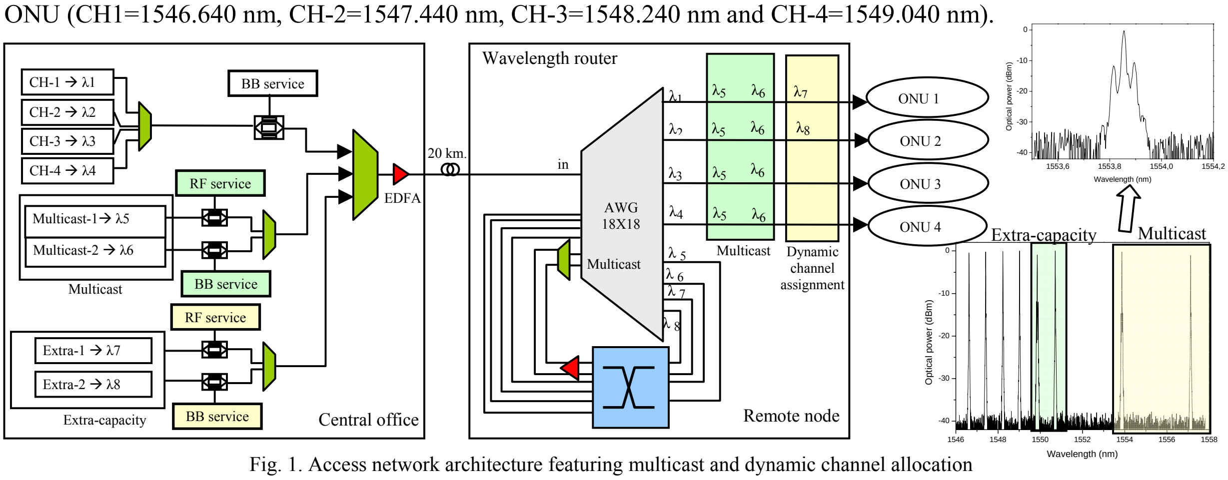

Fig. 1. Access network architecture featuring multicast and dynamic channel allocation

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Two wavelengths have been used as multicast carriers (Multicast-1=1553.880nm and Multicast-2=1557.120nm). The former one is used to transport 10 MBaud QPSK on a 5 GHz subcarrier and the latter conveys PRBS baseband data at 2.5 Gb/s. Two additional wavelength were used as extra-capacity carriers (Extra-1=1549.860 nm and Extra-2=1550.660 nm). The first extra carrier transports 5 MBaud QPSK on a 5 GHz RF subcarrier and the second one a PRBS signal at 622 Mb/s. Optical powers of different signals were equalized by means of a variable attenuator and system losses were compensated by an Erbium Doped Fiber Amplifier (EDFA) prior to be launched into the dynamic router. Insets in Fig. 1 show the spectra at the remote node input depicting the four static channels for ONU's 1 to 4, the two multicast carriers and the two channels for extra-capacity, a zoom of the Multicast-1 RF (λ5) signal is shown as well. The optical signal is launched into the AWG through input port 1, the outgoing multicast wavelengths in ports 5 (Multicast-1=λ5) and 6 (Multicast-2=λ6) are fed backwards and switched respectively to independent 1x4 optical coupler which outputs map input ports 7-10 (for λ5) and 11-14 (for λ6) of the AWG in order to broadcast both multicast carriers in ONU's 1 to 4. In-line amplification compensates the insertion losses imposed to the multicast signals by the AWG and the optical couplers. In our approach the optical switch can reach any output port independently from the input port so that it offers the flexibility to broadcast both multicast signals at the same time or one at a time resulting in a selective transmission of multicast signals and the capability of creating multicast distribution tree for RF services. Similarly, the extra capacity channels are fed backwards as well but mapped directly to the AWG inputs (2-6). The AWG response in combination with the state of the switch assigns different wavelengths at each ONU.

3. Results and discussions

Fig.2 depicts four different scenarios demonstrating the transmision of multicast services and dynamic channel allocation. Each scenario shows the fixed channels in ONU's 1 to 4, and aditionally: scenario 1 shows the multicast channels in all the ONU's and both extra-capacity channels in ONU4, scenario 2 shows that multicast services are present in all ONU's and extra-1 is in ONU2 whereas extra-2 is in ONU 1. In scenario 3 and 4 the extra-1 channel is in ONU 1 and extra-2 in ONU 3 but scenario 4 only includes the transmission of the second multicast service. In this case the selective function of the multicast channels allows the first multicast service to be broadcasted to another group of ONU's in the access network while the first channel remains in this specific cluster of ONU's.

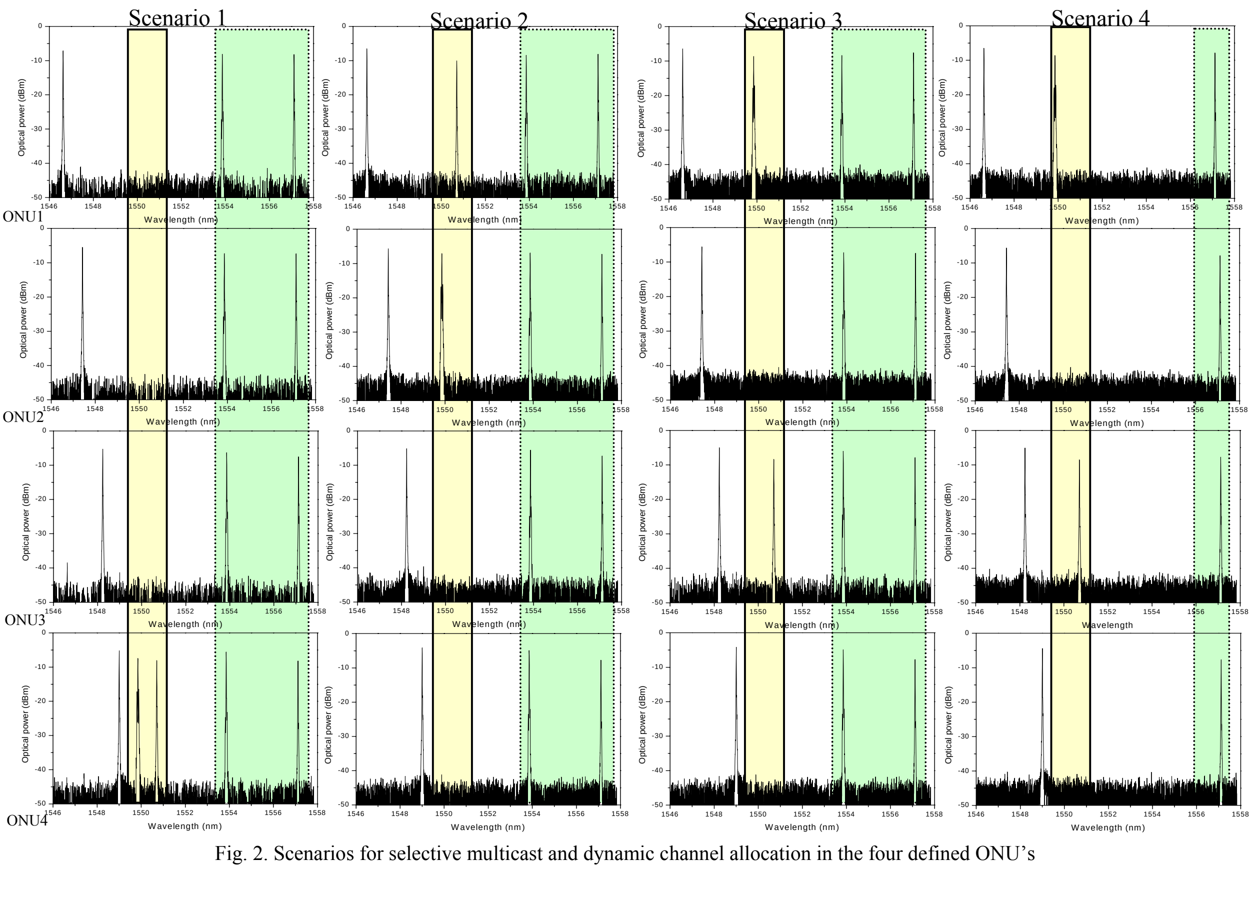

Fig. 2. Scenarios for selective multicast and dynamic channel allocation in the four defined ONU's

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The signal degradation of two relevant scenarios was measured in order to assess the performance of the system. In particular, from scenario 1 the signals in ONU4 and from scenario 3 the signals in ONU1 were analyzed. Fig. 3(a) shows the signal quality in ONU4 of scenario 1: fixed channel + both extra channels and both multicast services. The results show that the fixed signal for ONU4 and the multicast baseband service in scenario 1 presents a positive penalty of 0.7 dB compared to the back to back curve whereas extra-2 signal is penalized in 1.7 dB. Degradation of the QPSK signal (multicast and extra) show a low EVM (error vector magnitude) below 3.7% for received optical powers under -24 dBm and with a degradation of roughly 0.2% compared to the back to back value, the results are shown in Fig. 3(b). As for the quality performance in ONU1 of scenario 3: fixed channel + extra-1 + both multicast services, the results in Fig. 3(c), show a positive penalty of 0.8 dB for the multicast service and 0.7 dB for the fixed channel, in both cases compared to their corresponding back to back curve. Fig 3(d) shows the degradation of the RF services (multicast and extra), the results show EVM values below 3.5% for received optical powers under -24 dBm featuring a degradation of 0.25% compared to the back to back value. Underlying penalties in both scenarios arise from inherent insertion losses of the optical components; larger penalties in scenario 1 for extra-2 signal come from the adjacent crosstalk coming from extra-1 signal that is present in this scenario as well.

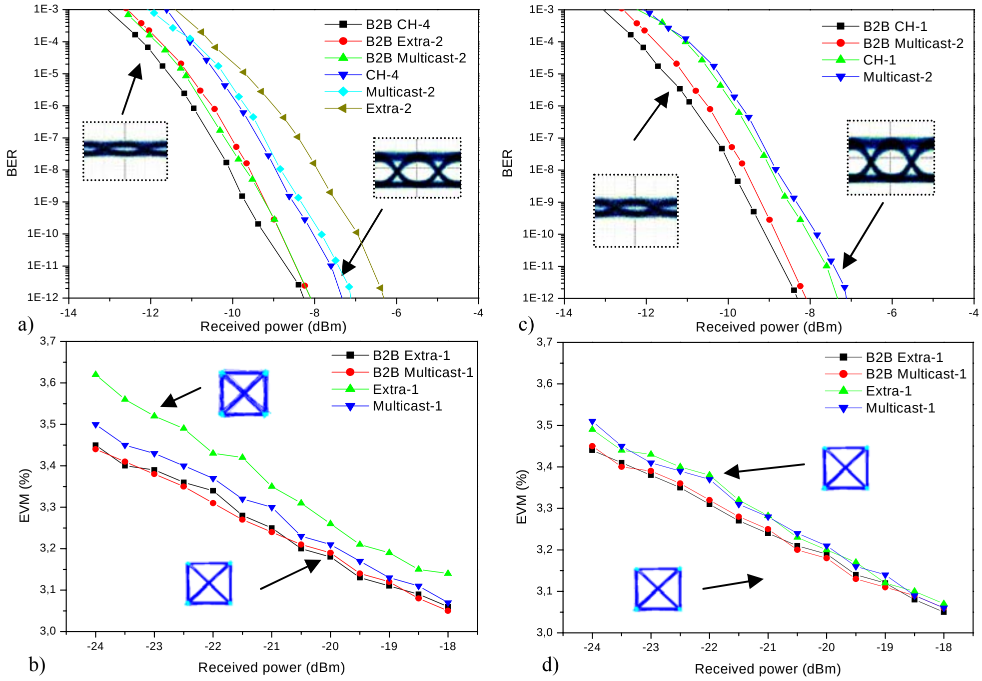

Fig. 3. Experimental results. (a, b) Signal quality in ONU4 of scenario 1. (c, d) Signal quality in ONU1 of scenario 3

4. Conclusion

In this paper we have demonstrated selective multicast assignment in a dynamic capacity allocation capable router for converged wired-wireless access networks. The router uses the cyclical response of an AWG, an optical spatial switch in a feedback configuration and optical couplers to enable the transmission of multicast services while redistributing optical carriers following the actual demand on variable capacity or services. These concepts envision heterogeneous infrastructures comprising diverse wired-wireless systems e.g., FTTH, 2G, 3G, DVB, WLAN, and hence enabling various transmission approaches, e.g., unicast, multicast and broadcast, in a cooperative and complementary manner. Apart from its main advantages related to its compact size, low cost and fully exploited capacity, the experimental measurements confirm the good performance of the system with no noticeable degradation effect on the transported signals, 0.2% degradation for EVM and 1 dB penalty in average for BER values.

5. References

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