Multi-degree ROADM based on massive port count WSS with integrated Colorless ports

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Abstract: We propose a simple multi-degree ROADM architecture based on a massive port count WSS with integrated colorless ports. We create a simple multi-ring network and demonstrate the multi-degree colorless ROADM.

OCIS codes: (060.4254) Networks, combinatorial network design, (060.6718) Switching, Circuit

1. Introduction

Internet users have been demanding high-speed broadband services to allow them to enjoy the benefits of information communication technologies. Supported by the broadband infrastructure, Internet traffic is constantly increasing owing to the availability of various types of services including data communication, VoIP, IPTV, VOD, and cloud services.

The increase in Internet traffic means that metro and core networks must increase their capacity to accommodate the huge volume of traffic. Against this background, reconfigurable optical add/drop multiplexers (ROADM) have been widely deployed for about the last five years. Until now, ROADM operation has necessitated labor-intensive fiber patch work in central offices when a new optical path is provided with a different wavelength or a different direction. On-site fiber patch work takes several hours and thus prevents fast service provisioning and flexible reconfiguration of the path network topology.

Colorless capability is important for enhancing ROADM networking. It enables us to assign an arbitrary wavelength to a path via remote control operation. Thus it is expected to not only reduce operational cost but also provide fast path provisioning and flexible path reconfiguration. We have proposed an optimized multi-layer optical network using in-service ODU / wavelength (OCh) path re-grooming to respond to the various service demands [1], where the colorless function is important to realize adaptive traffic re-grooming (wavelength reconfiguration and ODU reallocation). Simulations have confirmed that adaptive traffic re-grooming can reduce relative node cost by 20% [2]. To realize advanced metro and core networks cost-effectively, a simple colorless ROADM architecture is indispensable.

In this paper, we propose a simple colorless ROADM architecture that realizes the colorless function by utilizing a massive port count WSS. We successfully demonstrate the colorless function in a multi-ring network by using a 1x43WSS.

2. Colorless port integrated multi-degree ROADM

Several kinds of colorless ROADM are proposed and investigated [3-5]. Fig. 1(a) shows the conventional configuration of the colorless ROADM based on 1x9WSS where extra 1x9WSSs and optical couplers are used for colorless ports. The add/drop ratio of the optical node will be up to 50% [6]. A recent 50GHz spaced WDM system offers 80channels, so up to 40 colorless ports would be necessary for network flexibility. WSS cascades, shown in Fig. 1(a), are unfavorable from the viewpoint of optical insertion loss. A massive port count WSS with integrated colorless ports as shown in Fig. 1(b) is desirable to realize simple and low loss node. For example, over 40 port WSS can be used for the node with up to 40 colorless ports. We prepared the 1x43WSS as a massive port count WSS.

In our proposed configuration (Fig. 1(b)), the number of colorless ports and multi-directional ports can be changed to match the traffic pattern (add/drop raio, number of degree). This flexible and simple multi-degree colorless ROADM architecture is favorable for the simple implementation of a node that can optimize multi-layer optical network using in-service ODU / wavelength (OCh) path re-grooming to respond to the various service demands [1].

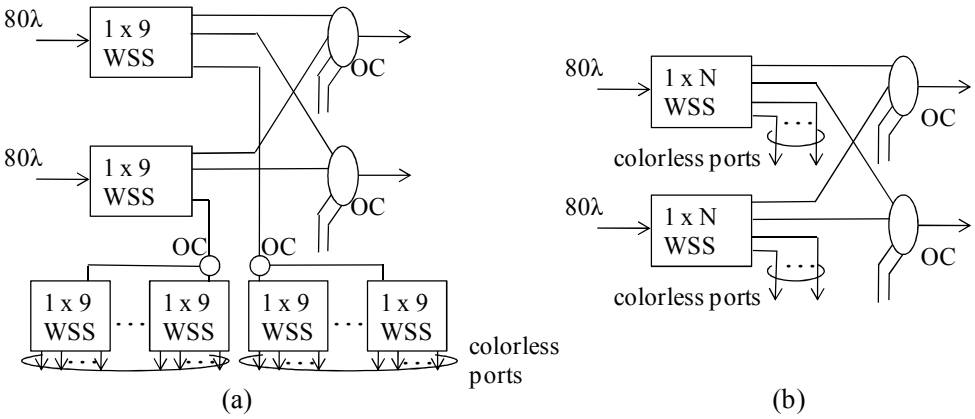

Fig.1 Multi-degree colorless ROADM
(a)1x9WSS based (b)massive port count WSS based

3. Massive port count WSS (1x43WSS)

We have already proposed and demonstrated a 1x43WSS consisting of anamorphic prism pairs and two-axis MEMS mirrors [7]. First of all, we evaluate the characteristics of our prototype 1x43WSS designed 100GHz-spaced 40 channels in the C-band. Fig. 2(a) shows the 40ch level equalized spectrum. Level equalization function is indispensable to the express port to maintain optical level diagram. Optical attenuation was successfully controlled at all channels. Fig. 2(b) shows the measured Q-factor where a 112Gbps DP-QPSK signal was passed through the 1x43WSS and OSNR was set to 15.5dB. The dashed-line indicates the back-to-back Q-factor without 1x43WSS. These results confirm that the prototype 1x43WSS would suit a multi-degree colorless ROADM for 112Gbps WDM systems.

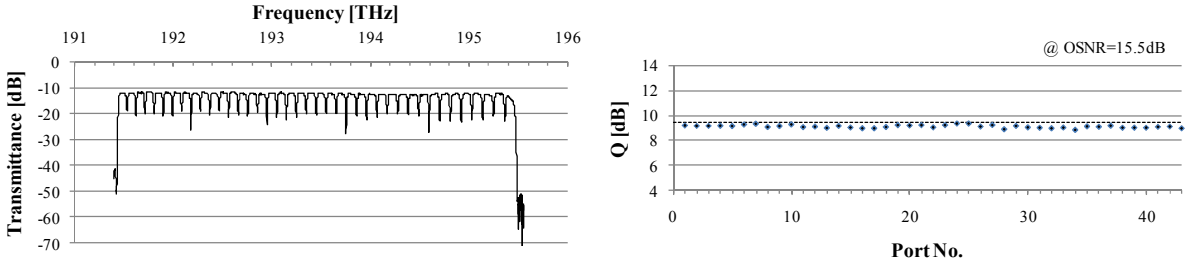

Fig. 2 (a) 40ch level equalized spectrum, (b) Q-factor of 112Gbps signal passed through 1x43 WSS

4. Demonstration of multi-degree colorless ROADM in a multi-ring network

We confirmed the feasibility of multi-degree colorless ROADM in a multi-ring network. Fig. 3(a) shows the configuration of the multi-ring network where a multi-degree colorless ROADM (node#1) and two colored ROADMs (node#2, node#3) are linked with 50km of SMF. The configuration of multi-degree colorless ROADM is shown in Fig. 1(b) where two 1x43WSSs are used as massive port count WSSs. A 1x2WSS based on DLP (Digital Light Processor) technology was used in the colored nodes. Fig. 3(b) shows the optical paths to verify all of the optical node function where the solid line indicates the "path-a" (193.6THz) and the dashed line indicates the "path-b" (193.7THz). 100GHz-spaced 8ch (193.0THz – 193.7THz) 112Gbps DP-QPSK signals were transmitted through the nodes. The transmitted signal data were processed off –line. The average signal power launched into the SMF was about 0dBm/ch.

Fig. 4(a) shows the output spectra at node 1. In Fig. 4(a), the spectrum labeled "drop" corresponds to the signal dropped at node #1 and the spectrum labeled "XC (#2→#3)" corresponds to the signal transmitted from node #2 to node #3. The level equalization function by two 1x43 WSSs is verified; extinction ratio was confirmed to be about 40dB. Fig. 4(b) shows the received constellation diagrams of "path-b". No impairment due to the proposed colorless nodes was observed.

To confirm the colorless function, optical frequencies of "path-a" and "path-b" were changed. No error was observed in any path configuration. All switch functions such as drop, cross-connect, level equalization and colorless drop were confirmed by the successful transmission in the multi-ring network.

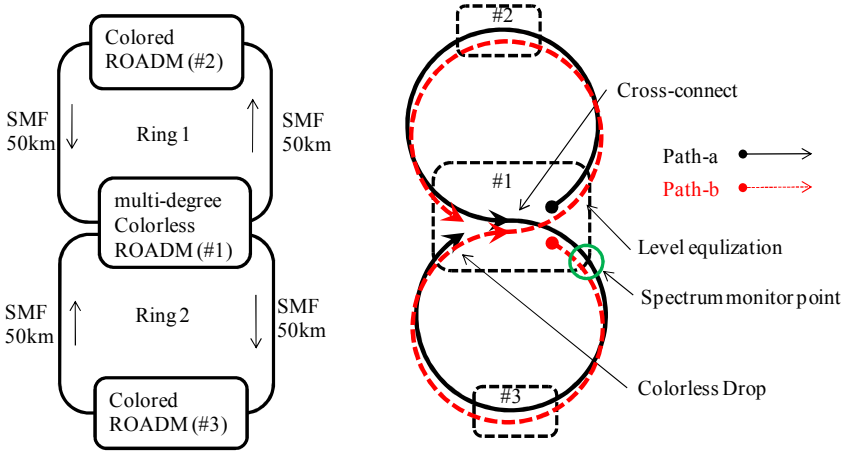

Fig. 3 Demonstration setup (a) multi-ring configuration
(b) optical paths to verify the optical node function

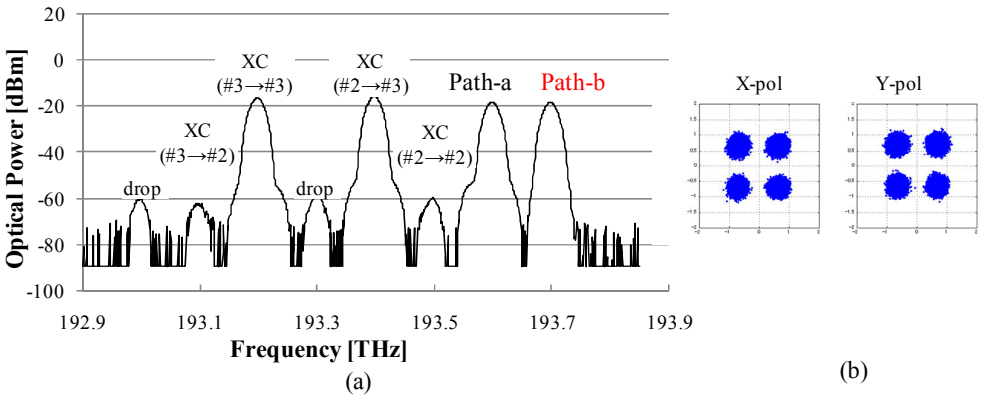

Fig. 4 (a)Optical spectra at node 1 (b)constellation diagram of path-b

5. Conclusions

We proposed a simple multi-degree ROADM architecture where colorless ports are integrated into a massive port count WSS. We evaluated our prototype 1x43WSS as an example of a massive port count WSS. We also experimentally demonstrated the multi-degree colorless ROADM using our 1x 43WSS in a multi-ring network.

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7. References

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