第 49 卷第 03 期
2022 年 3 月

湖南大学学报（自然科学版）
Journal of Hunan University（Natural Sciences）

Vol. 49. No. 03.
March 2022

Open Access Article

AN INNOVATIVE WAVEBAND SWITCHING TECHNOLOGY REDUCES THE NUMBER OF OPTICAL COMMUNICATION TERMINALS IN WDM NETWORKS

AkshayRisal Singh[1], Dipti Kumari[2*]

[1]Research Scholar, Department of Computer Science and Engineering, RKDF University, Ranchi, Jharkhand, India.

[2]Research Guide, Department of Computer Science and Engineering, RKDF University, Ranchi, Jharkhand, India.

ABSTRACT

Wavelet changing, and the challenge of decrease the quantity of port in optic shows the reason in spectral optical communication systems, are investigated in this paper. Wavelet shifting merges many frequencies into the a unique wavelength region that can be changed by a specific port, cutting the number and exchanges as well as the expense of photonic bridge in typical short wave systems. We propose a novel algorithmic track changing routing technique it's not always the best alternative for integrating wavebands because present bandwidth shifting methods are the shortest route. We suggest utilising both k-shortest path technique as well as a routing problem methodology to enhance the number of nodes over optically bridge. The numerical simulations from our suggested method demonstrate a considerable and prospective improved performance when compared to standard strategy, which ignores waveband types of maintenance.

Keywords: Wavelength-division-multiplexing; Waveband switching; Optical cross-connect; k-Shortest path; Rerouting

Introduction

Wavelength-division multiplexing (WDM) is rapidly evolving, increasing the number of optical cross-connects (OXCs) and therefore increasing the size and cost of OXCs. It has been suggested to decrease the number of ports and OXC expenses by using waveband switching (WBS). The fundamental concept of WBS is to combine several wavelengths into a single waveband that can be switched through a single port, thus reducing the number of switches required in traditional wavelength-routed (WR) networks and saving money on OXCs. The authors in [1]proposed the multi-granular OXCs (MG-OXCs), which include the multi-layer and single-layer versions, to enable WBS and offer efficiency for traditional wavelength switching. Many studies have looked at the issues with WR optical networks, and the WR method is also used in the construction of WBS optical networks, although there is a significant difference between WBS and WR in terms of motives.. WBS optical networks are designed to minimise and optimise the number of consumed switching ports in MG-OXCs, while building WR optical networks is motivated by reducing and optimising the number of wavelength connections or wavelength-hops used. MG-OXC researchers have found that the method for reducing the number of consumed wavelength-links or wavelength-hops cannot effectively reduce the number of consumed switching ports, and even a simple WBS algorithm cannot be obtained by slightly extending the conventional routing and wavelength assignment (RWA) algorithm in WR

Received: December 29, 2021 / Revised: January 23, 2021 / Accepted: February 27, 2021 / Published: March 26, 2022

About the authors：AkshayRisal Singh

Email:

optical networks. Current research in [2]. It's currently believed that an effective WBS algorithm may be able to compromise on performance by using a smaller number of switched ports while still using the same number of wavelength links or wavelength hops. This can save switching ports while also reducing the overall number of switching ports used. Given that WBS and WR have very different goals in mind, approaches that work for WR networks won't always work for WBS networks. New research on WBS-specific techniques such WBS routing algorithms, wavelength or waveband assignment methods and waveshaping systems is thus required.

2. System model and problem statement

2.1. Network model

While G(N, L,W) represents the node set and the link set, W specifies each fibre link's wavelength range. The provided WDM optical network is indicated as G(N, L,W). For simplicity, we'll suppose each node has wavelength conversion, only one connection request arrives at a time, and bandwidth is one wavelength channel. The following definitions provide an overview of several commonly used notations.[3]

j = Fibre link in WDM optical networks.

Costj= Cost of link j , which is determined by the factors, such as physical length, constructing cost, and so on.

CWj= Consumed wavelengths on link j .

FWj= Free wavelengths on link j , and

CWj + FWj = |W| should be satisfied, where |W| denotes the number of wavelengths on each fiber link.

CRn = Connection request n

CSPn = ($CSP^1{}_n$,$CSP^2{}_n$,...,$CSP^K{}_n$) Set of candidate shortest paths by the k-shortest path algorithm for CRn, where CSPw n (1 w K) denotes the wth shortest path in CSPn.

WPn= Working path for CRn, where WPn∈CSPn. NOL(P_1, P_2) Number of overlapped links between paths P_1 and P_2.

Step 4: If c < CT, rearrange the orders of Q connection requests in MX by the method of random numbers in [9], combine the new matrix NMX, and go to step 5; otherwise, go to step 7.

Step 5: For CRm∈ NMX, select the CSPK m as the working path WPm and let m ← m + 1. If m>Q, let m ← 1, let c ← c + 1, and go back to step 4; otherwise, go to step 6.

Step 6: For CRm∈ NMX, select the CSPwm(∃w ∈ [1, K]) as the working path WPm, where NOL(CSPwm,WPy) = max{NOL(CSPxm,WPy) | ∀x,y∈ [1, K]} can be satisfied. Let m ← m + 1. If m>Q, calculate the number of ports TPc according to [1], let m ← 1, let c ← c+1, and go back to step 4; otherwise, go back to step 6.

Step 7: Let P ← min{TPv | ∀v ∈ [1,CT]} and return P . The time complexity of NWBSR mainly depends on the running times of k-shortest path algorithm in step 2 and the rerouting algorithm from step 4 to step 6. The time complexity of k-shortest path algorithm is O(KN^3), and then the time complexity in step 2 is approximately O(QKN3). In step 6, the time complexity of finding max{NOL(CSPxm,WPy) | ∀x,y∈ [1, K]} is O($L2K^2$), and then the time complexity for reroute algorithm from step 4 to step 6 is approximately O(QCTL2K2). Thus, the time complexity of NWBSR is approximately $O(QKN^3 \pm QCTL2K^2)$.

2.2. Policy of merging waveband

To merge wavebands, the authors suggest several methods, such as the same-source and same-destination scheme, the same-source and different-destination scheme, the different-source and same-destination scheme, and the different-source and different-destination strategy, etc. One of the most effective ways to reduce the number of ports is to use a separate source and destination for each sub-path. This technique is known as sub-path merging (SPM). Figure 1 is an example to demonstrate our point. [5]

According to Figure 1, there are three requests for connections from nodes A, F, and O, all of which originate from source node A, respectively. Figure 1a shows the conventional algorithm's shortest routes for the three connection requests, which are A—B—C—D—E, F—I—J—K—, and L—M—N—O, respectively, with a total of 20 ports used. Figure 1a However, if we look at the SPM scheme in Fig. 1b, the routes for the three connection requests are A–B–C–D–E, F–B–C–D–K, and L–B–C–D–O, respectively[6], where only 16 ports are used since the light paths with wavelengths on links B–C and C–D may be combined. SPM can clearly save a lot of ports, which is why we utilise it in our method to cut down on the number of ports used in this article.[7]

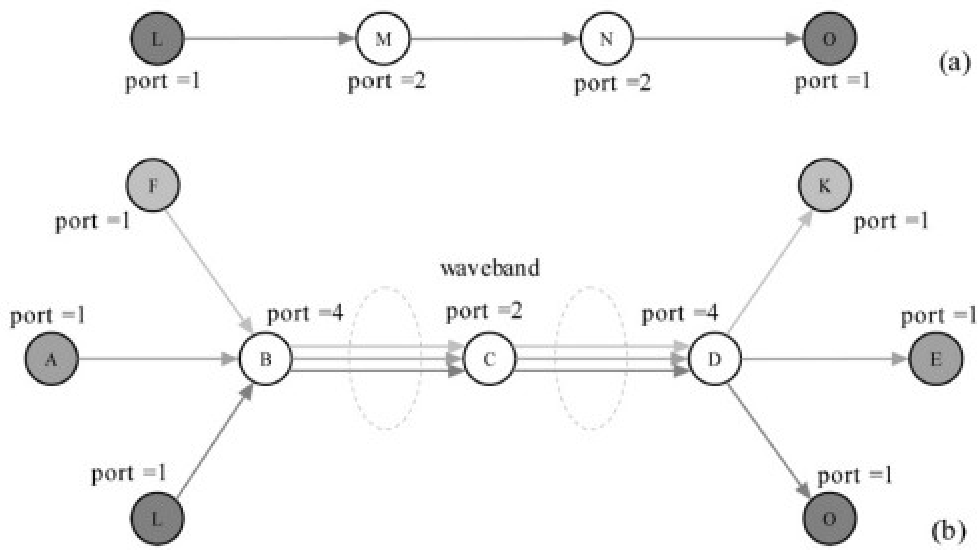

Figure. 1: Merge waveband with SPM scheme[5]

3. Simulation and analysis

We simulate two networks, as shown in Fig. 2, with each connection containing 200 wavelengths and going in both directions. We use a computer programme to create a model with progressively heavier traffic. The matrix of connection requests isn't known ahead of time since this model doesn't use it. Each new request for a connection is received by the network in a sequential manner. [8] An allocated connection request cannot be changed after it has been made available to the network. For the sake of simulation, we'll treat each bandwidth need as a separate wavelength channel. The machine used for the simulation has a 2.8 GHz CPU, 1 GB of DDRRAM, and runs on VC++6.0 software. We compare the efficiency of the NWBSR method with that of the conventional routing (TR) algorithm, which disregards the WBS approach. To begin, we evaluate the effectiveness of the NWBSR algorithm's number of ports while considering various waveband granularities, or the number of wavelengths included inside each waveband. Figure 3 shows that when the granularity of the waveband increases, the number of ports consumed reduces, indicating that a higher granularity of the waveband may lead to less ports being used. This is because as the granularity of the wavebands improves, more wavelengths may be combined into wavebands, reducing the number of ports required. This shows that when the granularity of a waveband increases, a constant, i.e. G wavelengths per band, is reached where the number of ports progressively shrinks to 1. [9] Although the NWBSR has a lower number of ports than the TR, we may observe a substantial and encouraging performance increase ratio of up to 300 percent between the two. Due to the k-shortest routes algorithm and rerouting technique, NWBSR can optimise the number of ports whereas TR cannot. In addition, we can see that when G rises, the number of a and b ports may be reduced even further. The reason for this is that is same with the explanation for Fig. 3

Step 4: If c < CT, rearrange the orders of Q connection requests in MX by the method of random numbers in [9]combine the new matrix NMX, and go to step 5; otherwise, go to step 7.

Step 5: For CRm∈ NMX, select the CSPK m as the working path WPm and let m ← m + 1. If m>Q, let m ← 1, let c ← c + 1, and go back to step 4; otherwise, go to step 6.

Step 6: For CRm∈ NMX, select the CSPwm(∃w ∈ [1, K]) as the working path WPm, where NOL(CSPwm,WPy) = max{NOL(CSPxm,WPy) | ∀x,y∈ [1, K]} can be satisfied. Let m ← m + 1. If m>Q, calculate the number of ports TPc according to [1], let m ← 1, let c ← c+1, and go back to step 4; otherwise, go back to step 6.

Step 7: Let P ← min{TPv | ∀v ∈ [1,CT]} and return P .

The time complexity of NWBSR mainly depends on the running times of k-shortest path algorithm in step 2 and the rerouting algorithm from step 4 to step 6. The time complexity of k-shortest path algorithm is $O(KN^3)$, and then the time complexity in step 2 is approximately $O(QKN^3)$. In step 6, the time complexity of finding max{NOL(CSPxm,WPy) | ∀x,y∈ [1, K]} is $O(L2K^2)$, and then the time complexity for reroute algorithm from step 4 to step 6 is approximately $O(QCTL2K^2)$. Thus, the time complexity of NWBSR is approximately $O(QKN^3 \pm QCTL^2K^2)$.

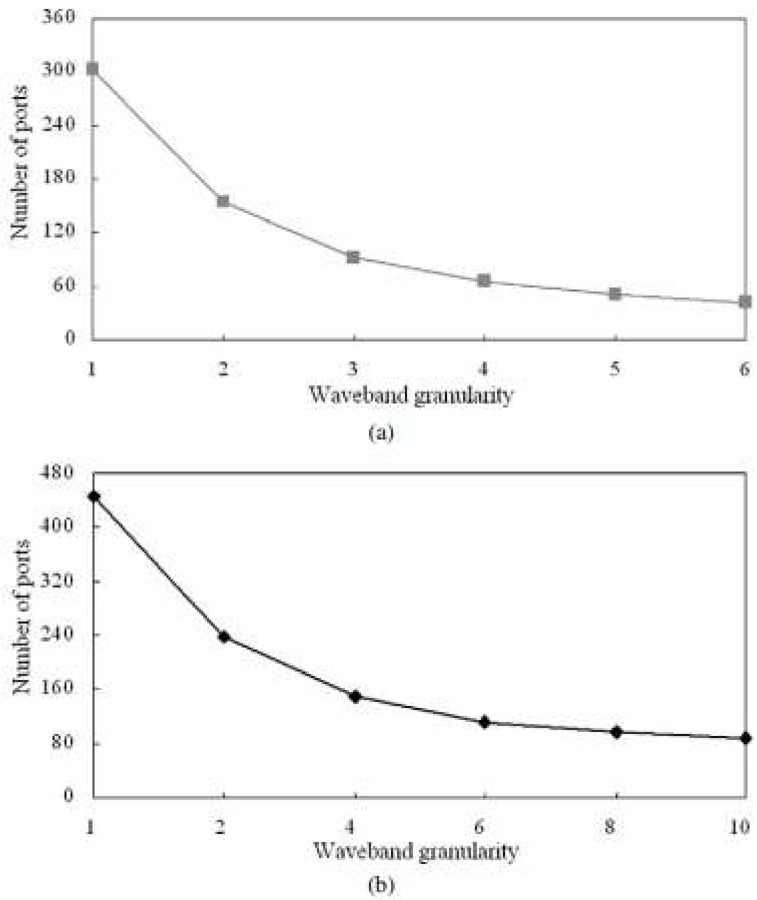

Figure. 3: Number of ports vs waveband granularity in (a) Network 1 and (b) Network 2[3]

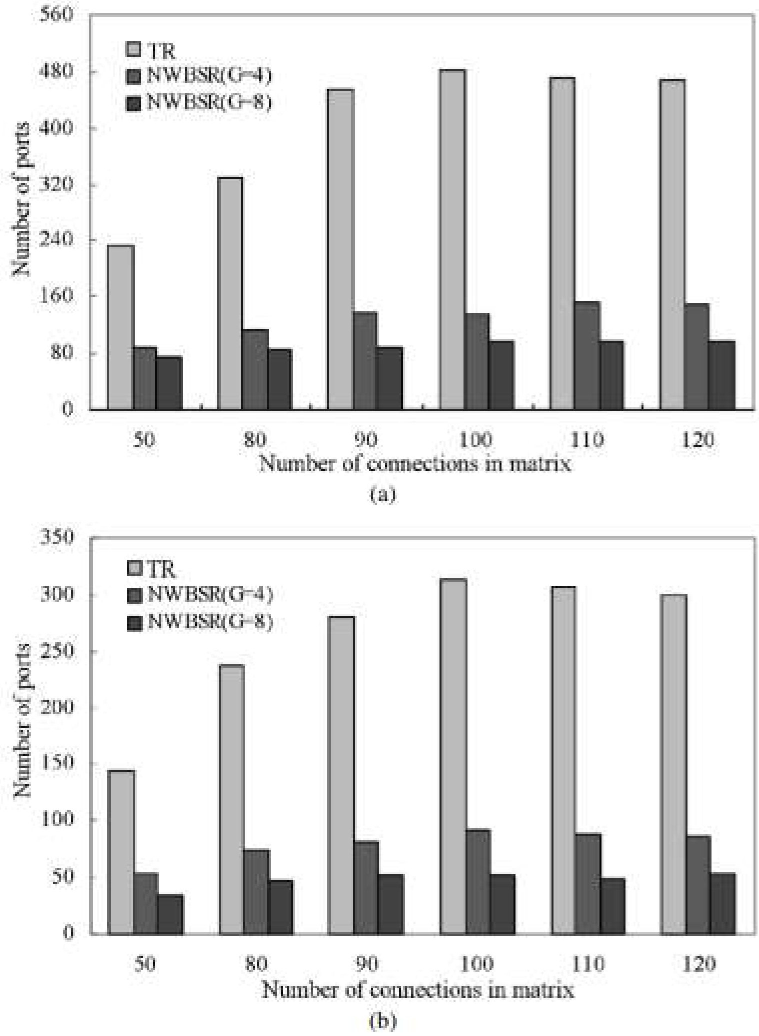

Figure. 4: Number of ports by TR and NWBSR in (a) Network 1 and (b) Network 2[1]

4. Conclusion

We investigated the bandwidth switch approach in this study to minimise optically bridge expenses, which unites many frequencies into an unique wavelength region that could be controlled only by one ports in optically inter. We devised an unique heuristic approach in this study since traditional techniques employ the path strategy, and also the pathways which are created may not always be the optimal possibilities for unifying wavebands. To maximize the amount of optic bridge ports, our recommended technique employs the kshortest path technique and a rerouting method. When compared with the conventional approach that does not employ the bandwidth shifting approach, the findings of our recommended individual's simulation show a significant and promising improved performance.

References

[1] X. Cao, V. Anand, and C. Qiao, "Framework for waveband switching in multigranular optical networks: part I-multigranular cross-connect architectures," *J. Opt. Netw.*, vol. 5, no. 12, pp.

1043–1055, 2006.
[2] X. Cao, V. Anand, and C. Qiao, “Framework for waveband switching in multigranular optical networks: part II--wavelength/waveband conversion and survivability,” *J. Opt. Netw.*, vol. 6, no. 1, pp. 48–62, 2007.
[3] M. Lee, J. Yu, Y. Kim, C.-H. Kang, and J. Park, “Design of hierarchical crossconnect WDM networks employing a two-stage multiplexing scheme of waveband and wavelength,” *IEEE J. Sel. Areas Commun.*, vol. 20, no. 1, pp. 166–171, 2002.
[4] X. Cao, V. Anand, and C. Qiao, “Waveband switching in optical networks,” *IEEE Commun. Mag.*, vol. 41, no. 4, pp. 105–112, 2003.
[5] X. Cao, V. Anand, J. Li, and C. Xin, “Waveband switching networks with limited wavelength conversion,” *IEEE Commun. Lett.*, vol. 9, no. 7, pp. 646–648, 2005.
[6] Z. Luo *et al.*, “Two-dimensional material-based saturable absorbers: towards compact visible-wavelength all-fiber pulsed lasers,” *Nanoscale*, vol. 8, no. 2, pp. 1066–1072, 2016.
[7] M. Li and B. Ramamurthy, “Dynamic waveband switching in WDM mesh networks based on a generic auxiliary graph model,” *Photonic Netw. Commun.*, vol. 10, no. 3, pp. 309–331, 2005.
[8] L. Guo, J. Cao, H. Yu, and L. Li, “Path-based routing provisioning with mixed shared protection in WDM mesh networks,” *J. Light. Technol.*, vol. 24, no. 3, pp. 1129–1141, 2006.
[9] R. Parthiban, R. S. Tucker, and C. Leckie, “Waveband grooming and IP aggregation in optical networks,” *J. Light. Technol.*, vol. 21, no. 11, p. 2476, 2003.