Optical WDM Networks and Multicasting

Pınar Kırcı
Software &Networks
Telecom SudParis
Paris, France
+330160764040, 91011
pinar.kirci@telecom-sudparis.eu

A. Halim Zaim
Computer Engineering
Ticaret University
Istanbul, Turkey
02125114150, 34010
azaim@iticu.edu.tr

ABSTRACT
Bandwidth usage increases day by day and the need for new technologies emerges for devoloping the efficiency. Wavelength Division Multiplexing (WDM) is the most spectacular one of these presented network technologies to be able to use optical fibers. In addition to that, multicasting the network traffic also draws attention for ensuring the growing traffic demand. In multicasting, the transmission is performed between the source node and many destination nodes. The packet delivery is not accomplished by flooding or sending the copies of the packets, thus bandwidth capacity is used as ideally as possible. The packet is sent by the source to the network and the network forwards it to the corresponding destinations.Thus, the number of video conferencing, internet based education and stock information distribution like multicast service based applications gradually increase, in time. This type of point to multipoint transmissions need huge amount of bandwidth in the network and also an effective technology that will meet that drawback. To address these issues in this paper, we present a new protocol structure for multicasting with Optical Burst Switching (OBS) on WDM networks. In addition to this, the simulations are performed over unicast and multicast transmissions which are compared on Just-In-Time (JIT) and Just Enough Time (JET) reservation protocols.

Categories and Subject Descriptors
C.2.2 [**Computer-Communication Networks**]: Network Protocols - *applications (SMTP, FTP, etc), protocol architecture (OSI model), routing protocols.*

General Terms
Algorithms, Measurement, Performance, Design, Reliability, Experimentation.

Keywords
Multicast, WDM, OBS, JIT, JET.

1. INTRODUCTION
OBS comprises the magnificent capacity of fiber technology at switching and transmission areas, which makes OBS an emerging solution for today's great capacity demand. Before the packet transmission in OBS networks, different types of packets are aggregated to form bursts at the ingress node. These bursts are disassembled at the egress node. The transmission of the data burst over a different channel from its control packet is the most remarkable speciality of OBS networks. The control packet includes only the header information about the following burst, for this reason one control channel is adequate for a network. By the way, the control packet is switched electronically but data is switched optically in the network [1,2].

Wavelength division multiplexing (WDM) is the travelling of enormous amounts of data streams simultaneously at high speeds over optical networks in light paths to tremendous distances. Thus, with these advantages WDM networks will be one of the basic technologies for internet. Another remarkable research topic for network technolgy is the multicasting on WDM networks. This point to multipoint structure's main idea is transmitting the data to a definite number of destinations with utilizing the best strategy and less network resource. Many applications and systems need multicasting to gain the best results such as real time control and video on demand systems which are gaining ever increasing popularity between internet users [3-6].

The rest of the paper is organized as follows. In Section 2, some of the studies in literature are given briefly at related work. In Section 3, routing protocols for multicasting are summarized. In Section 4, network model is described and the protocol design is proposed. Simulation results are presented in Section 5, and Section 6 gives some concluding remarks.

2. RELATED WORK
WDM is the mostly preferred technology for multicasting because of its providing efficiency in the routing and wavelength assignment subjects [7]. The multicast traffic is frequently studied on WDM network with light-trees and lightpaths as all-optical. In [8] a multicast dynamic light-tree grooming algorithm is developed. The algorithm is designed for basicly multihop traffic grooming. For multicasting, dynamic structures are more functional and attractive for their flexibility. In [9] dynamic provisioning of multicast sessions is studied to be able to reduce the session blocking probability and used wavelength-links in a session on a WDM network. Optical layer multicasting's dynamic manner with Quality of Service (QoS) on WDM network is inspected in [10]. A routing algorithm is presented for recovering the load balancing and blocking probability rates of the sparse splitting network structure. Another study about dynamic WDM network environment is performed in [11] with three heuristic algorithms for routing dynamically arriving multicast sessions with differentiated reliability requirements and minimum cost at WDM mesh networks. One of the mostly studied topics in WDM networks is the multicast routing and wavelength assignment problem with delay constraint as in [12]. Here, a minimum costed and wavelength consuming light-forest is searched with an integer linear programming model.

The basic speciality of WDM structure is the ability of providing needed capacity and needed optical device connections for assuring optical level transmission [13]. Also, in [14] the main aim is maximizing the total number of users served by allowing part of a multicast group to be admitted. Multi-hop and single hop networks in TDM-WDM are compared at [15] to examine and improve the throughput and delay parameters.

3. MULTICASTING AND MULTICAST ROUTING PROTOCOLS

Multicast routing protocols are basically investigated as source-based and core-based. Source-based structure forms a tree routed from the source node and connected with every node in multicasting team and the center of the delivering packets is the soure node. These packets are send to their destinations over the multicasting tree. Core-based structure includes a center which is the rendezvous point (RP) of the sources or destinations. A tree is formed with a definite center and spans all the nodes of the group [16-18].

The Distance Vector Multicast Routing Protocol (DVMRP) is one of the well known source-based structure. The Core-Based Tree Protocol (CBT) belongs to the core-based structure.

DVMRP is the first and the most significant protocol in the literature to support IP multicast. The multicast trees are constructed by the Reverse Path Multicast (RPM) algorithm. Here, the packet is sent over the shortest reverse path.

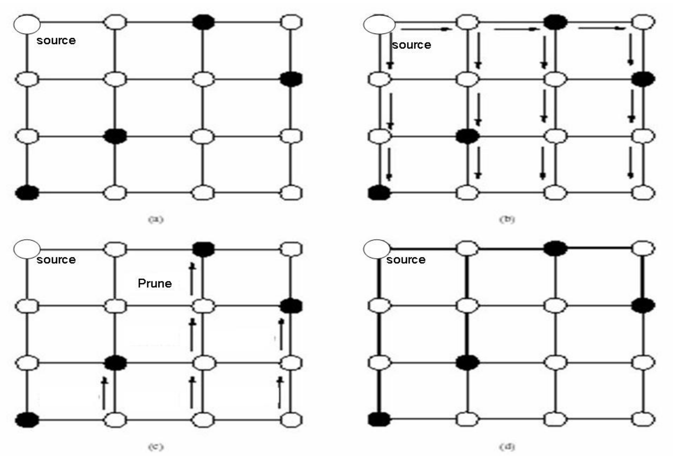

Fig. 1. Tree structure in DVMRP

The packets are periodically broadcasted as in figure 1b. If there is no connected group members at the leaf router, a draft message is sent towards the source as in figure 1c. With this draft message, the routers update their tables. Also, if the draft operation is timed out, then the packet sending and the drafting processes are repeated. The unicast and distance vector informations of the node is designe by the multicasting capable neighbours during the node addition process to the multicast tree.

Here, the multicasting backbone is the only routing region, so the routers have a separate entrance for every one of the sub network in the multicast network at their routing tables. In addition to this, they define every one of the sub networks so they change the routing messages with their neighbours periodically. When there is a topological change occurs at the multicast backbone, then the number of sub networks increase as exponentially, also the routing costs. Then the memory may not be enough, thus the multicast backbone may collapse [19,20].

In CBT multicasting approach, the core based tree is based on a distribution tree, that is, it is shared by a definite group members. The basic structure of the multicasting approach of the CBT is shown in figure 2.

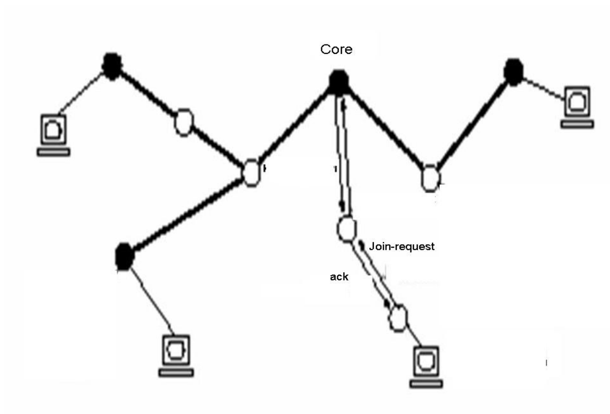

Fig. 2. Tree structure of CBT

The packets are send and received over the same distribution tree, as independent of the source. CBT is a new approach for local and wide area IP multicasting networks. It is a unique approach with its unique distribution tree structure compared with the existing IP multicasting structures' source-based distribution tree approaches as in DVMRP, for this reason CBT has better scaling than the other multicasting algorithms.

Here, the node sends a join-request message to a next hop by its local router towards the core router over the shortest path when it wants to join a multicast group [21]. By the help of the join-request message, permanent join situations are performed over the visited routers. The join-request message travels over nodes till arriving the core or its router over the tree which will send join-acknowledgement message reversely. When a router receives a join-acknowledgement message, it updates its table and sends the join-acknowledgement message to the requesting router backwards. The tree continuity is performed by downward routers, with sending a CBT connection message periodically to parent routers on the tree, when a CBT connection message is received from a child node, an acknowledgement message is send.

Before the timeout of the corresponding timer, if a response is not received, the router sends a close message upwards and also sends clean tree messages downwards to be able to clean all of the branches. Besides, if it is needed, these nodes may be allowed to re-join later. After the leaving of a node from the group, if the nodes connected router has not other connected nodes or other connected downwards routers, then the router sends a close message to its parent router. During the data transmission, data packets flow from sources to parents and child nodes. Parent router sends the packets to all of its children but not the source, till the data packets reach the center. Then all of the data packets are transmitted to all other downwards branches. The main aim of the algorithm is to be able to present that a center in the topology performs a better start for the routing tree, so the tree will have less changes during the processes. CBT may have one center or many. In a many centered structure, the center tree connects every center router or non-center router and the center [22,23].

4. NETWORK ARCHITECTURE

In the paper, a leaf initiated multicasting protocol design is presented and instead of using the query and reply structure as in Internet Group Management Protocols (IGMP), we only consider keepalive messages in the network to be able to aware about the aliveness of the clients. And also the join request messages coming from the clients to inform the source about their video demands. Furthermore, as the reservation protocols, JIT and JET are preferred in the paper.

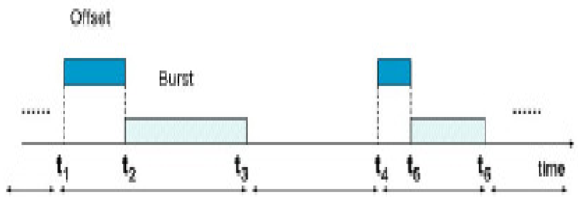

Fig. 3. JIT reservation protocol

The main idea of the Just-In-Time (JIT) is about the configuration of the switching fabric at the intermediate nodes. The switching fabric should be ready, when the burst arrives at the intermediate node as shown in figure 3.

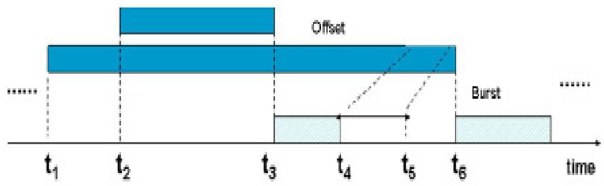

Fig. 4. JET reservation protocol

For OBS networks, Just Enough Time (JET) protocol is proposed as the distributed type protocol, which is also based on hop-by-hop reservation as presented in figure 4. The protocol does not need optical buffering at intermediate nodes, because of the offset time and the burst length informations on the control packet. Here, the bandwidth reservation begins according to the burst arrival time. Also, burst reservations can be scheduled more effectively at the nodes because of the closed ended reservation opportunity in JET [24-27].

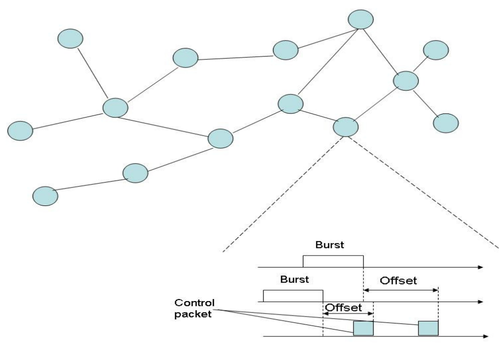

Fig. 5. OBS Network

The basic idea behind the OBS technology is combining the advantages of the IP and WDM technologies. In OBS, the bursts are produced at the ingress node by assembling the IP packets at the beginning of the transmission process. After the the burst production, the ingress node then sends a control packet/ setup over the control channel after a definite offset time as presented in figure 5. During the transmission the control packets are processed electronically but the bursts are processed all-optically. And at the end, the bursts are disassembled at the egress node [28,29].

In our presented protocol, the information about related video programs are broadcasted to the network at the beginning. Thus, the network will be informed about the new coming videos. The broadcast message includes many important informations about the coming video bursts like the arrival time of the bursts, the duration of the bursts and the length of the incoming bursts. In our WDM network, if a client is interested in one of the new coming videos, it sends a join request message to the source over its edge switch and the connected intermediate switch. The corresponding intermediate switch controls its threshold and time-table, if it will be suitable for the client's demand. If the intermediate switch decides that it can supply the client's demand, it sends the join request message towards the source. But if the threshold value of the switch passes the decided value or if the time-table is not appropriate at the video release time, then the demand is rejected. In that case, the edge switch choses another closest intermediate switch and sends the request message again. The edge switch tries to send this message over its first degree connected neighbours. After all, if none of its neighbours accept the join request, then the request drops.

Eventually, with the help of these thresholds at the intermediate switches, the network traffic will not be accumulated in definite areas of the network. Furthermore, our structure does not need acknowledgement messages as in source initiated structure. Also, with the join request message, video demand is declared and the path is decided while travelling over the switches.

5. EXPERIMENTAL RESULTS

The simulation is performed over JET and JIT reservation protocols with poisson traffic generator on multicast and unicast structures on a NSFNET topology. The drop rates of the join requests of clients are examined according to the different λ values in the simulation.

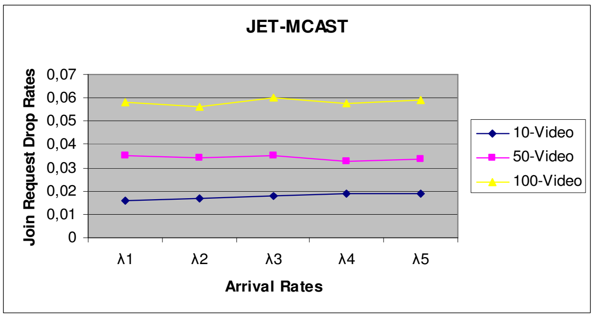

Fig. 6. JET reservation protocol with multicast structure

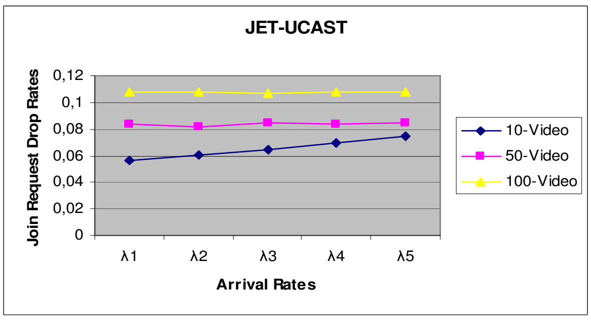

Fig. 7. JET reservation protocol with unicast structure

In figure 6 and figure 7, the multicast and unicast structures and the drop rates are presented over JET protocol. With multicasting, more qualified results are gained from the simulations in the network.

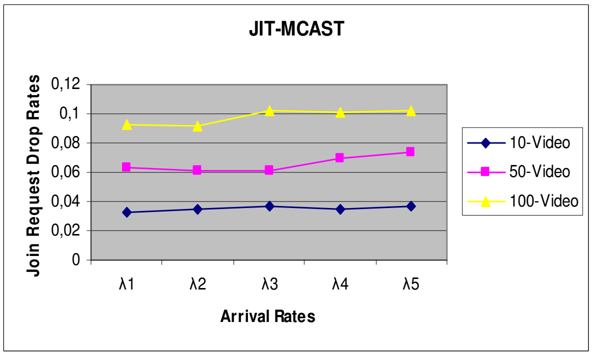

Fig. 8. JIT reservation protocol with multicast structure

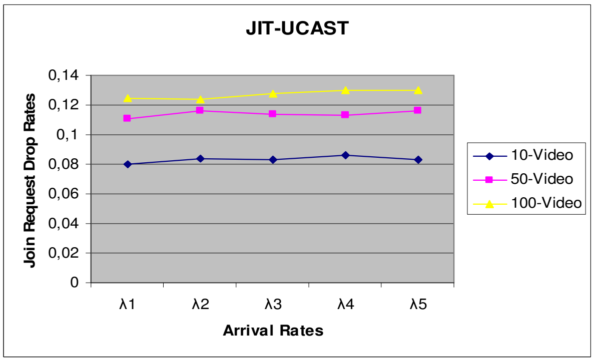

Fig. 9. JIT reservation protocol with unicast structure

The figures 8 and 9 show the simulation results of JIT protocol. Best results are taken from the multicasting with JET protocol simulation. By the way, multicasting in both of the reservation protocols give better results compared with the unicasting.

6. CONCLUSION

The paper includes the optical multicasting with the light splitting optical switches. We basically examined the OBS network structures.

In the paper, a new multicasting protocol structure is introduced. We concentrated on drop rates of the join request messages at intermediate switches according to the threshold and time table conditions with different λ values. According to the received simulation results, it is obvious that the best performance is gained with muticasting on JET protocol with least drop rates.

As a future work, reliability and security challenges should be considered at multicast over WDM networks by using different traffic types and comparing with different protocols.

7. REFERENCES

[1] Y. Chen, C. Qiao, and X. Yu, “Optical burst switching: a new area in optical networking research,” IEEE Network, vol. 18, pp. 16-23, 2004.

[2] C. Kan, H. Balt, S. Michel, and D. Verchère, “Information model of an optical burst edge switch,” IEEE International Conference on Communications-ICC, vol. 5, pp. 2717-2721, 2002.

[3] S. Sankaranarayanan and S. Subramaniam, “Comprehensive performance modeling and analysis of multicasting in optical networks,” IEEE Journal on Selected Areas in Communıcatıons, vol. 21, no. 9, November 2003.

[4] N.Kaliammal, G.Gurusamy, “Resource efficient multicast routing protocol for dynamic traffic in optical wdm networks,” European Journal of Scientific Research,vol.41 no.3, pp.420-429, 2010.

[5] J. He, S.H.G. Chan, and D. H. K. Tsang, “Multıcastıng ın wdm networks,” IEEE Communications Surveys & Tutorials, vol. 4, pp. 2-20, 2002.

[6] L. Xiao, X. Liu, W. Gu, D. Xuan, and Y. Liu, “A Design of Overlay Anonymous Multicast Protocol,” IEEE Parallel and Distributed Processing Symposium (IPDPS), 2006.

[7] L. Liao, L. Li, and S. Wang, “Dynamic Multicast Traffic Grooming in WDM Mesh Networks,” Next Generation Internet Design and Engineering-NGI, pp. 366-370, 2006.

[8] X. Huang, F. Farahmand, and J.P. Jue, ”Multicast traffic grooming in wavelength-routed wdm mesh networks using dynamically changing light-trees,” Journal of Lıghtwave Technology, vol. 23, no. 10, October 2005.

[9] T. Mannan and B. Wang, “Dynamic multicast session provisioning in wdm optical networks with sparse splitting capability,” Springer Science Business Media, Photon Netw Commun, vol.12, pp. 5–13, January 2006.

[10] T. Hu and H. T. Mouftah, “Dynamic constrained multicast routing in wdm networks: blocking probability, qos and traffic engineering,” Proceedings of the 11th IEEE Symposium on Computers and Communications (ISCC'06), 2006.

[11] H. Luo and L.Li, “Routing multicast sessions with differentiated reliability requirement in wdm mesh networks,” Elsevier, Int. J. Electron. Commun (AEU), vol. 64, pp. 231–242, 2010.

[12] M.T. Chen, B.M.T. Lin and S.S. Tseng, “ Multicast routing and wavelength assignment with delay constraints in wdm networks with heterogeneous capabilities,” Elsevier, Journal of Network and Computer Applications, vol. 31 pp. 47–65, 2008.

[13] Y. Wang, Y.Yang, “Multicasting in a class of multicast-capable WDM networks,” Journal of Lightwave Technology, 20(3): 350-359, March 2002.

[14] J. He, S.H.G. Chan, D.H.K. Tsang, “Routing and wavelength assignment for WDM multicast Networks,” IEEE, 0-7803-7206-9-01.

[15] M.A. Marsan, A.Bianco, E.Leonardi, F. Neri, A.Nucci, ”Multi hop packet scheduling in WDM/TDM broadcast and select optical networks with arbitrary transceivers tuning latencies,” IEEE, 0-7803-4984-9/98.

[16] A. Ballardie, “Core Based Trees (CBT) Multicast Routing Architecture", Internet Request for Comment, 2201, 1997.

[17] P.G. Ranjitkar, I.M. Suliman, P. Geil, M. Kuipers, R. Prasad, “IP multicast implementation based on the multicast extensions to OSPF protocol”, IEEE, 0-7803-5893-7/00.

[18] F. Font, D. Mlynek, “Applying clustering algorithms as core selection methods for multiple core trees”, IEEE Communications Society, 0-7803-8533-0-04.

[19] B. Wang, J.C. Hou, “Multicast Routing And Its Qos Extension Problems”, Algorithm and Protocols, IEEE network, Vol.14, Issue.1, pg.22-36, 2000.

[20] A.S. Thyagarajan, S.E. Deering, "Hierarchical Distance-Vector Multicast Routing for the MBONE", ACM SIGCOMM Computer Communication Review, pp.60-66, 1995.

[21] A. Ballardie, "Core Based Trees (CBT version 2) Multicast Routing", Internet Request for Comment 2189, 1997.

[22] C.A.S. Oliveira, P.M. Pardalos, "A Survey Of Combinatorial Optimization Problems In Multicast Routing", Computers & Operations Reserach, Cilt 32, Sayı 8, 1953-1981, 2005 .

[23] X. Zhang, J. Wei, C. Qiao, "On fundamental issues in IP over WDM multicast", IEEE, 0-7803-5794-9-99.

[24] J.Teng,G.N.Rouskas," A Comparison of the JIT, JET, and Horizon Wavelength Reservation Schemes on A Single OBS Node", In Proc. of the First International Workshop on Optical Burst Switching,2003.

[25] I.Baldine, G.N. Rouskas, H.G. Perros, D.Stevenson, " Jumpstart: A Just in Time Signalling Architecture for Wdm Burst Switched Networks", IEEE Communications Magazine. 0163-6804/02, 2002.

[26] A.H Zaim, I. Baldine, M. Cassada,G.N.Rouskas, H.G. Perros, D. Stevenson, Formal Description of the JumpstartJust in Time Signalling Protocol Using Efsm, Journal of Optical Engineering. Vol.42, Issue 2, pp.568-585, 2003.

[27] J. Teng, G.N.Rouskas, "A Detailed Analysis and Performance Comparison of Wavelength Reservation Schemes for Optical Burst Switched Networks," Photonic Network Communications. 9:3,311–335,2005.

[28] D.Q, Liu, M.T Liu, Optical Burst Switching Reservation Process Modeling and Analysis, IEEE ICCS. 0-7803-7510-6/02, 2002.

[29] C.Qiao, Y. Chen, J. Staley, The Potentials of Optical Burst Switching (OBS), OFC . Vol.1, TuJ5, 2003.