Designing and Engineering Metropolitan Area Transparent Optical Networks for the Provisioning of Multicast Sessions

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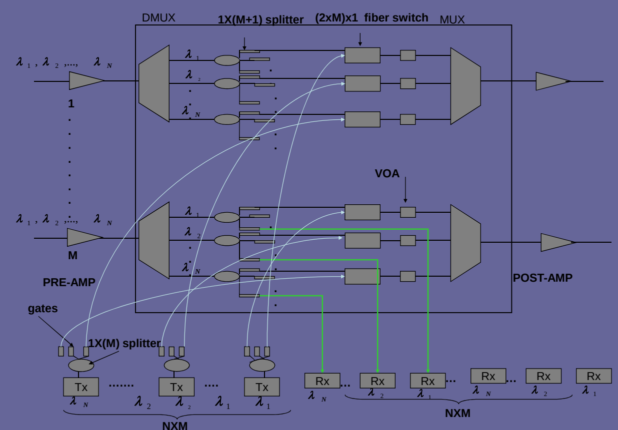
Abstract: We investigate the problem of designing and engineering metropolitan area optical networks for the provisioning of multicast sessions. The Q-factor for each session is taken into account, aiming at maximizing the admitted number of connections.

1.Physical Layer System Modeling

We utilize a typical approach in physical layer system modeling where the required system Q-factor for a target BER is derived. The modeling based on the Q-performance of the connection is used during the provisioning phase where the multicast trees are set up. In our case, a Q-threshold of 8.5 dB is assumed which correspond to BER of 10^{-12}.

2. Network Design/Engineering

32 wavelengths spaced at 100 GHz with 10 Gbps bit rate are assumed. The gain of each post-amp EDFA compensates for the node loss and is engineered based on the worst case insertion loss through the node. Worst case insertion loss is limited either by the maximum splitting loss in the case of fixed Txs, or by the maximum loss of transmitter's switch in the case of tunable Txs. Maximum node degree in the network is 6, thus the maximum times the power is split is 7 to account for the add/drop ports, while the maximum size of the Tx's switch for the tunable Txs case corresponds to a maximum loss of 5 dB. The optical power launched into the system is set to +5dBm. The gain of each pre-amplifier compensates the loss of each preceding span with a fiber loss of 0.3 dB/Km. VOAs are responsible for attenuating the total power to a prescribed value when needed, since our node design includes passive optical splitters. VOAs are needed for PDG compensation. At the destination nodes PIN photodiodes are used and Rx pre-amps have noise figure of 4.5 dB.



Node design for fixed Txs/Rxs. The number of Txs/Rxs allowed equals the number of wavelengths times the degree of node (i.e., NXM).

3. Multicast Algorithms with Physical Layer Constraints

- Steiner Tree (ST) heuristic,
- Shortest Paths Tree (SPT)
- Balanced Light-Tree (BLT),
- Balanced Light-Tree Qtolerance (BLT_Qtolerance).

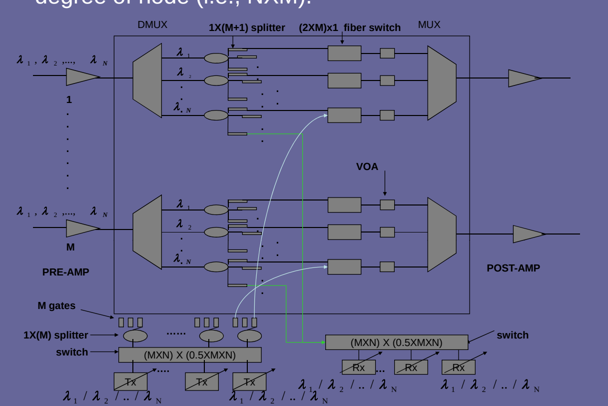
Component	Losses in dB
MUX/DMUX	3
Splitter	10*log(fanout)
Gate	0.6
VOA	0.5
Switch	1

MEMS Size	Losses in dB
X<25	1
25<X<36	1.5
36<X<56	2.2
56<X<68	3
68<X<80	3.7
80<X<100	4.5
X>100	5

Gain in dB	EDFAs NF
G<13	7
13<G<15	6.7
15<G<17	6.5
17<G<20	6
G>20	5.5

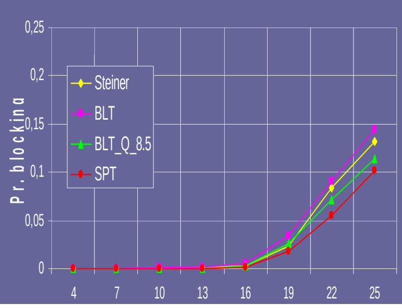
4. Performance Evaluation

We simulated multicast connections on a network consisting of 50 nodes, 196 links, average node degree 3.92, and average distance 60 Km. We used a dynamic traffic model where requests arrive according to a Poisson process and the holding time is exponentially distributed with a unit mean. 32 wavelengths per link were utilized for a network load of 100 Erlangs. SPT tree algorithm performs better than the other algorithms as blocking in this case is not limited by the Q-factor but by the network resources (wavelengths, Txs/Rxs). Node design with fixed Txs/Rxs performs better as the number of Txs/Rxs is larger than the corresponding number in the tunable case.

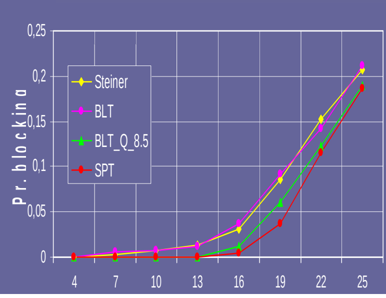


Node engineering for the tunable Txs/Rxs case. Access to 50% of the traffic is assumed.

(a)



(b)



Blocking probability versus the multicast group size for node engineering with
(a)fixed transmitters/receivers,
(b) tunable transmitters/receivers

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