2.8. How to find optimal intermediate grooming point?

Recommended number of students: 2-3

Goal: Find optimal intermediate grooming points that minimize the number of lightpaths in the network

Description:

Traffic grooming allows to transmit multiple low-rate services using a single high-capacity optical lightpath, saving spectrum and reducing the number of costly optical transponders. To maximize the savings from grooming, we need to decide where to perform grooming to provision the services with a minimal number of created lightpaths.

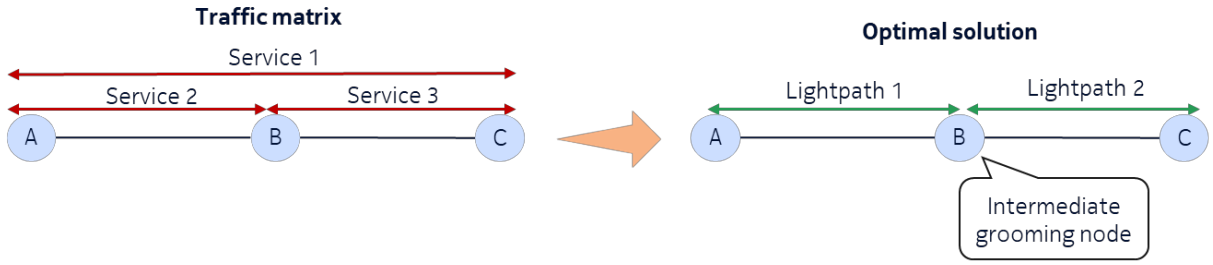

Fig. 9. By performing grooming in node B, we can provision 3 services using 2 lightpaths

In Fig. 9 we show that 3 services can be routed with only 2 lightpaths. Services 2 and 3 are carried by Lightpaths 1 and 2, respectively, while Service 1 is first groomed to Lightpath 1 and then is groomed to Lightpath 2 in node B. Since services are independent from one another and we route them one by one, it might be not obvious to create two lightpaths for the routing of Service 1 (if it comes first in the list of services) and we might create a single end-to-end tunnel for it which might lead to a non-optimal solution with longer or higher number of lightpaths.

Students are invited to propose a heuristic that maximizes network capacity while minimizing the number of established lightpaths. What happens if lightpaths are 1+1-protected?

Simulation assumptions:

For the proposed study, services should be generated between random source-destination pairs at the OTN layer with 10 or 100 Gb/s rate and groomed into WDM lightpaths that have capacity of 100-500 Gb/s. Simulations should be performed for different traffic loads, with a minimum load of 300 services and an incremental step of 100 services, till 1% of services are blocked (i.e., cannot be routed).

When multilayer routing is performed, we must consider both OTN and WDM constraints.

- OTN constraints (see Fig. 10):
  1. The switching matrix of an OTN switch has a limited switching capacity (in Tb/s) and can handle a limited number of ODU frames. If the OTN matrix is fully utilized, no add/drop or intermediate grooming can be performed in that node.

2. Client services access the OTN matrix through I/O cards. OTN switch has a limited number of ports (i.e., a limited number of I/O cards can be connected to it), and each I/O card has a limited number of client ports (i.e., a limited number of client services can use it). If the I/O card is fully utilized, a new one can be installed, but if all ports of the OTN switch are occupied, no add/drop can be performed in that node. Uplinks are also plugged directly into the OTN matrix, and if all ports of the OTN switch are occupied, no new lightpaths can be established from/to this node.

- WDM constraints: The number of WDM channels in the optical link is limited.

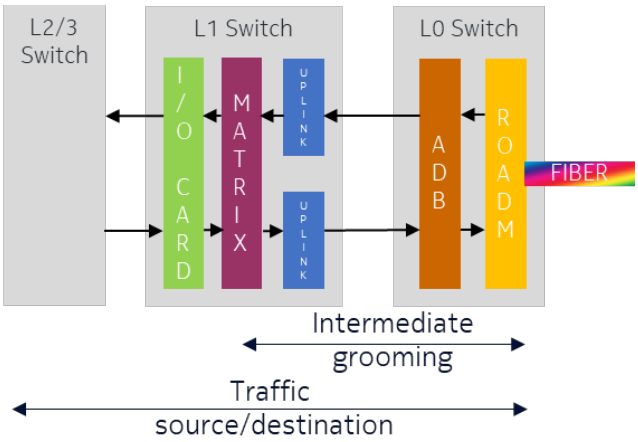

Fig. 10. Node architecture with OTN grooming

WDM constraints: consider only C-band

OTN constraints

OTN switch parameter	Constraint
Maximum number of ODUs (10G and 100G)	100 ODUs
Total switching capacity	12 Tb/s
Number of ports (to connect I/O cards and transponders)	70 ports

I/O-card that interconnects an L2/L3 switch with an L1 switch (see fig. 10) has 100 Gb/s capacity and 10 ports. This I/O card can be used in 2 ways:

- all 10 ports are used by 10 Gb/s services
- one port is used by a 100 Gb/s service

Note that by plugging the I/O-Card into the OTN switch we occupy 100 Gb/s of the OTN switch capacity even if only one port of the I/O card is used by a 10G service.

WDM lightpaths are created as multiple of 100 Gb/s ODUs and can carry between 100 and 500 Gb/s. Note that by plugging an Uplink into the OTN switch we occupy 500 Gb/s of the OTN switch capacity, even if transponder is operating at 100 Gb/s.