

75-GHz spacing for 400G Ethernet over DWDM for DCI

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Supporters

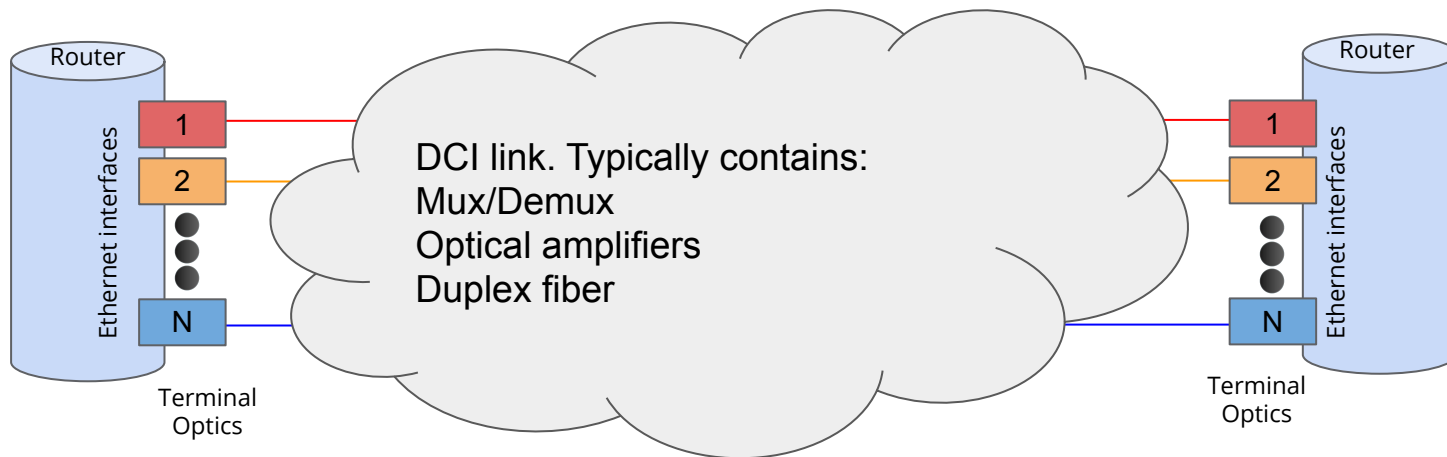
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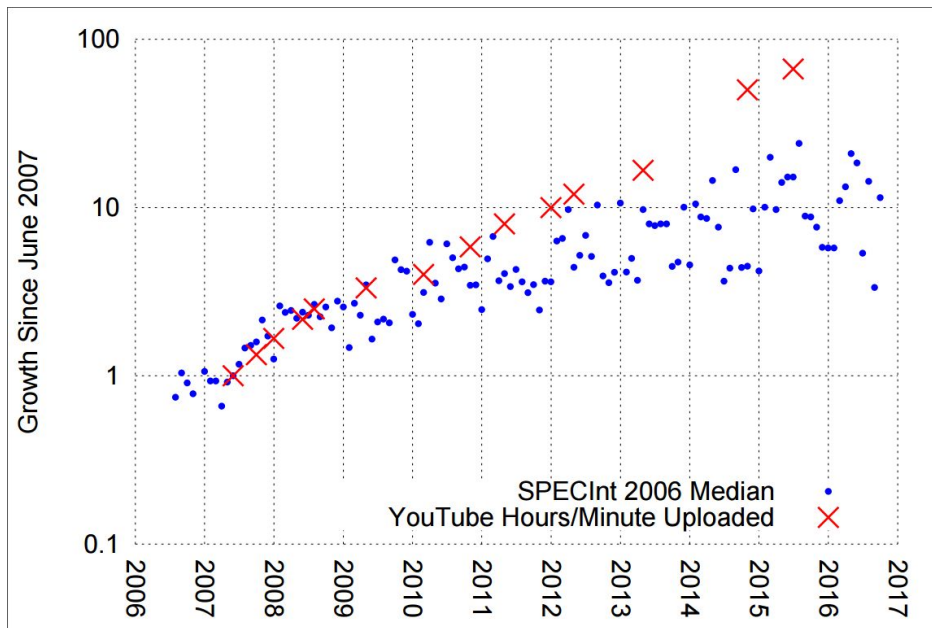
Typical DCI link



- This is the most typical use case of 400 Gb/s DWDM
- Used for all links too long/expensive to use bulk dark fiber, where each fiber-pair carries a single 400 Gb/s stream
- All interfaces are natively Ethernet

Bandwidth growth

- Google's current traffic
 - Already using multiple DWDM pairs for Long-haul links
 - Anticipate needing multiple DWDM pairs for capacity intra-metro DCI links in 1-3 years
 - Traffic growth is not slowing down with compute. Traffic is now outpacing compute growth.



[Amin Vahdat \(Google Fellow\) - 2018 ONF Keynote](#)

75-GHz vs 100-GHz spacing

For DCI capacities of >15 Tb/s between A and B

- 100-GHz spaced - 48 channels: $400 \text{ Gb/s} * 48 = 19.2 \text{ Tb/s}$
 - X fiber pairs needed per DCI
- 75-GHz spaced - 64 channels: $400 \text{ Gb/s} * 64 = 25.6 \text{ Tb/s}$
 - 3/4X fiber pairs needed per DCI
- Advantages of using 75-GHz channel spacing
 - 6.4 Tb/s increase in capacity per system (64 vs 48 channels)
 - 33% increase in system capacity
- Broad market potential for 400 Gb/s over 75-GHz spaced DWDM
 - Experts affiliated with three hyperscalers (Google, Microsoft, Facebook) are aligned on moving to 400-Gb/s Ethernet AND on 75-GHz spaced, 64-channel DWDM systems for DCI
 - Enable metro-wide ubiquitous Ethernet datacenter networks

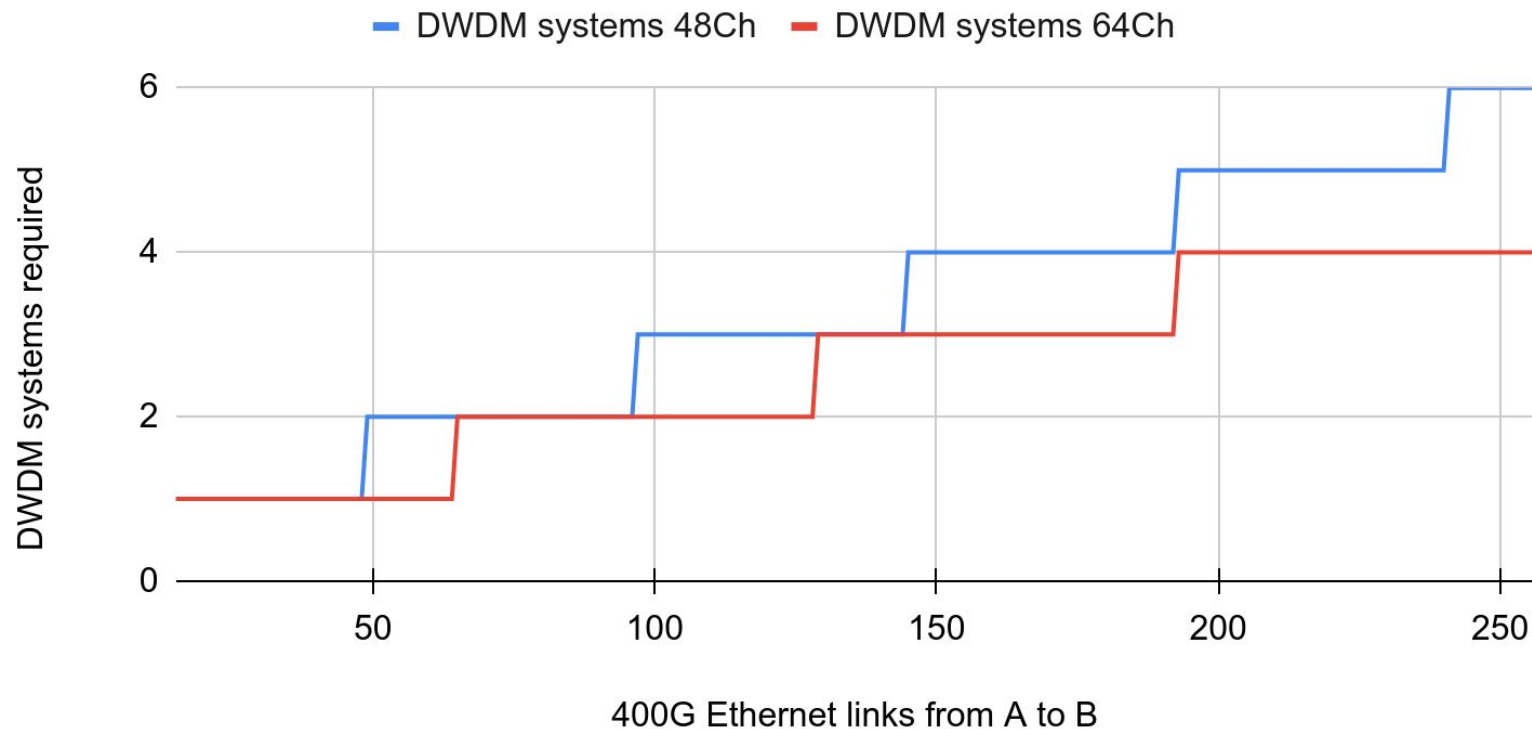
Cost of additional fiber-pairs

- More operational complexity
- Fiber leasing costs
 - Monthly recurring cost for each fiber pair ordered
 - Upfront splicing cost for each increase in the number of strands ordered
 - Carrier hotel patching costs: monthly recurring and upfront for each augmentation
 - Typically costs are by fiber mile so longer links cost more
- Line systems costs
 - EDFAs
 - AWGs
- Traffic growth is outpacing interface rate
 - Cost per bit in transceivers trends down with time
 - Cost per fiber lease and line system components have been more constant
 - Ratio of fiber/line system : transceiver is increasing

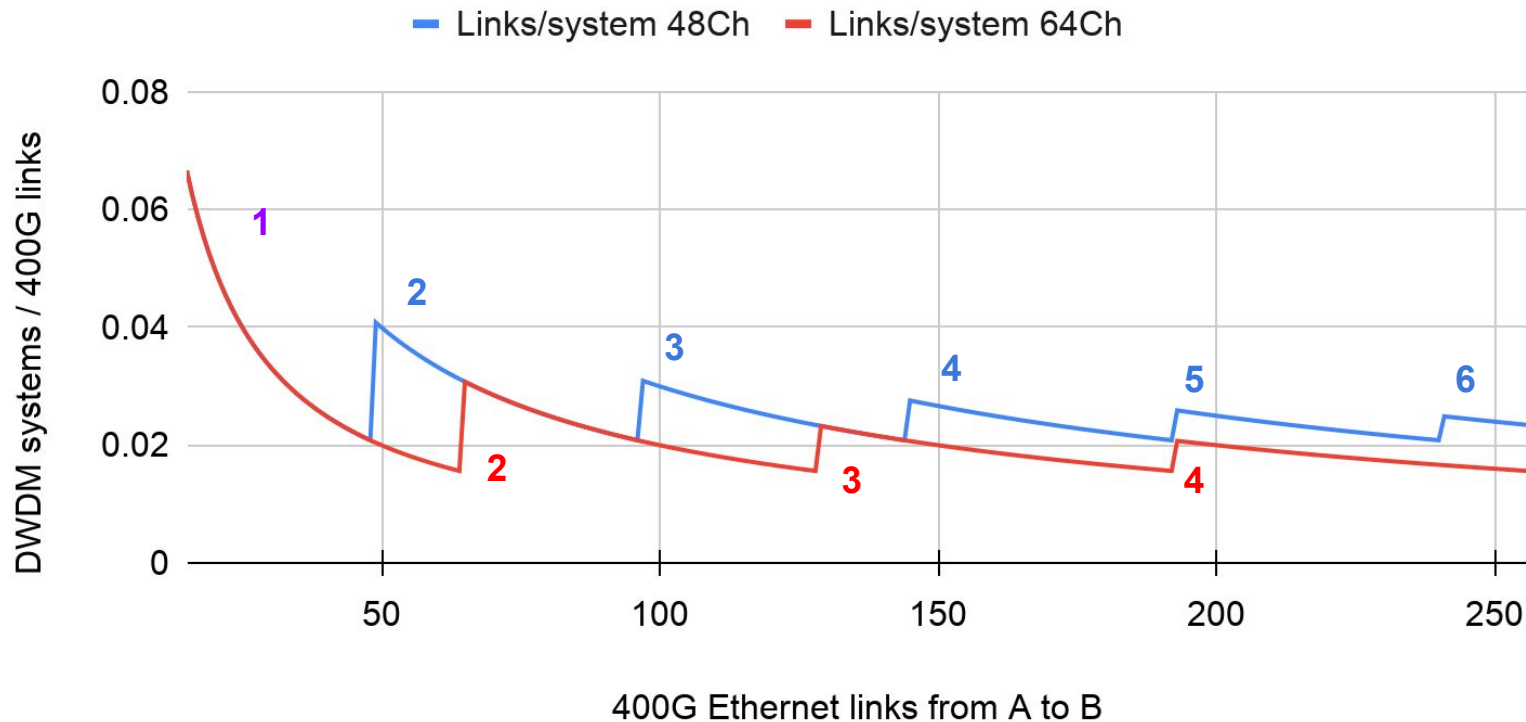
DWDM system and link costs

Cost contributions	“DWDM system”	“DWDM link”
Mux/demux (AWG)	All	None
Optical amplifiers (EDFA)	All	None
Fiber plant setup (CapEx)	All	None
Fiber lease (recurring)	All	None
Intra-building patching	Smaller (system to ODN termination panel)	Larger (transceiver to line system)
Transceivers	None	All

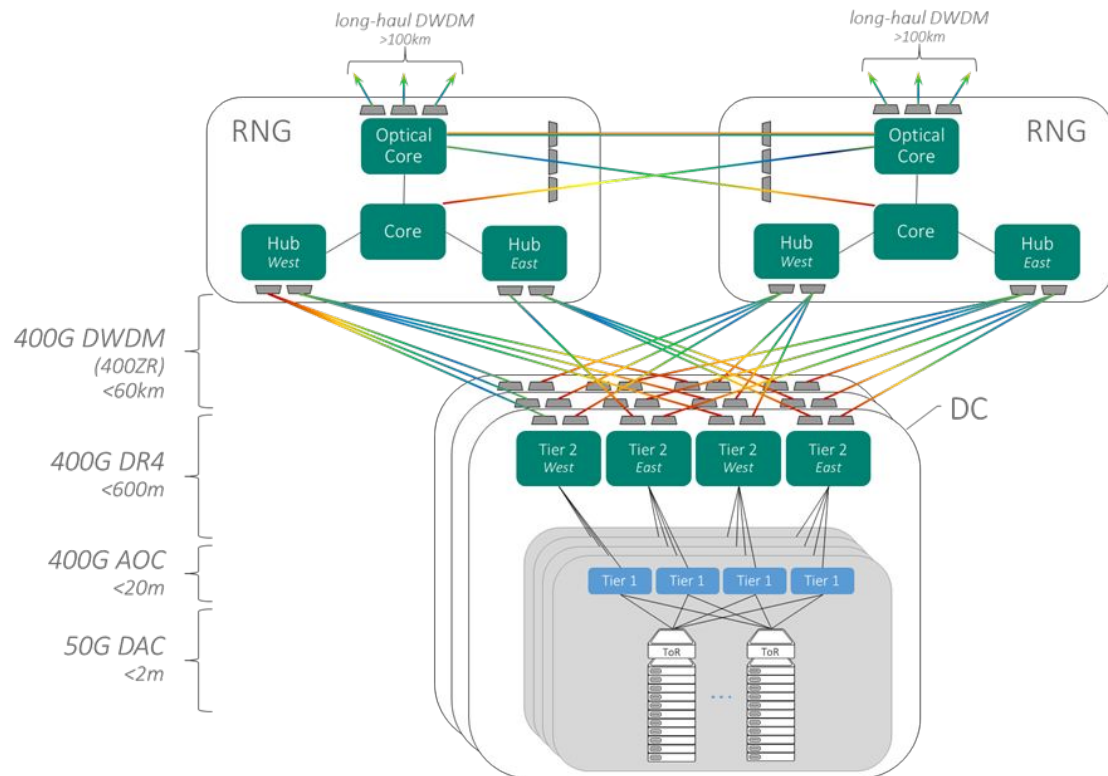
DWDM systems required



DWDM systems per 400G Ethernet link



64-channels is a good number



- Microsoft builds metro areas using a single Clos fabric [[baca 3ct 01 190328](#)]
- This requires groups of 2^n 400G links between any two datacenter locations
- Per-link savings (64Ch vs 48Ch):
50% for 64 channels,
33% for 128 channels
- Ethernet has typically used links with 2^n lanes. There is alignment with IEEE practices to allow for 64 channels

Timing of 400G DWDM Ethernet links

- DCI is the currently the main driver for 400 Gb/s DWDM Ethernet.
 - DCI needs 400G DWDM Ethernet soon
 - DCI needs the extra capacity offered by 64-channels enabled by 75-GHz channel spacing
- DCI has very different traffic patterns to Access networks eg. MSOs
 - Different system architectures
 - Different volume growth

Conclusions

- The demand for 400-Gb/s Ethernet inter-datacenter links is very real
- Optical experts affiliated with three data center operators (Google, Microsoft, Facebook) believe 75-GHz spaced 400-Gb/s DWDM Ethernet links will be the most cost effective DCI solution
- Discussions with AWG, transceiver module, and DSP experts thus far suggest 75-GHz spacing capable modules and 100-GHz spacing capable modules will have identical BOM and DSP algorithms