Evaluation of Elastic Modulation Gains in Microsoft's Optical Backbone in North America

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Demand is increasing

Conventional wisdom to increase capacity

- add more wavelengths
- light more fiber

To support the exploding demand in the cloud, we need to efficiently use the deployed fiber.

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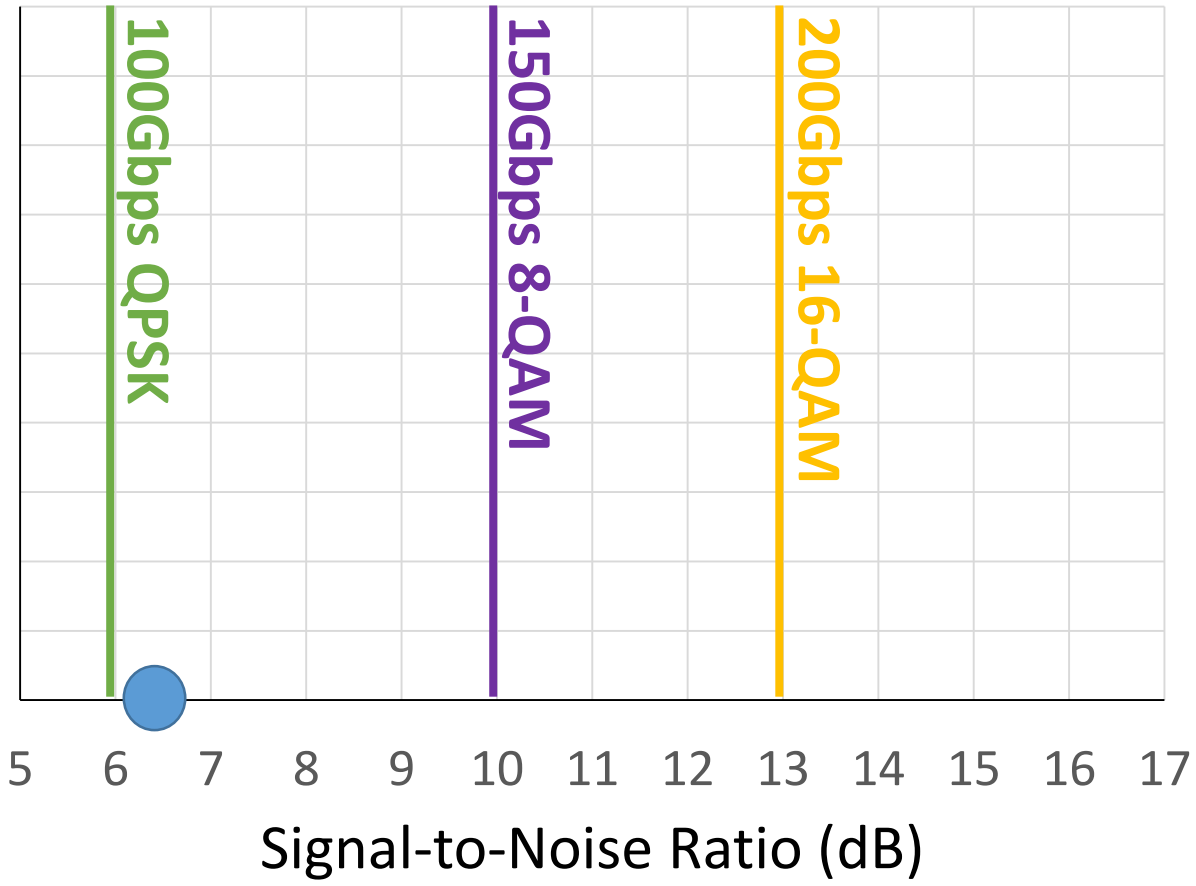
Data

- All fiber paths in Microsoft's North America backbone
- Three-months (Feb-April 2015)
- Poll signal quality (Q-factor) for 100Gbps PM-QPSK line cards
- 1000s of line cards
- Segments length range: 5km - 2600km
- Fiber type: LEAF, SSMF
- 15-min bin samples: min, max, average

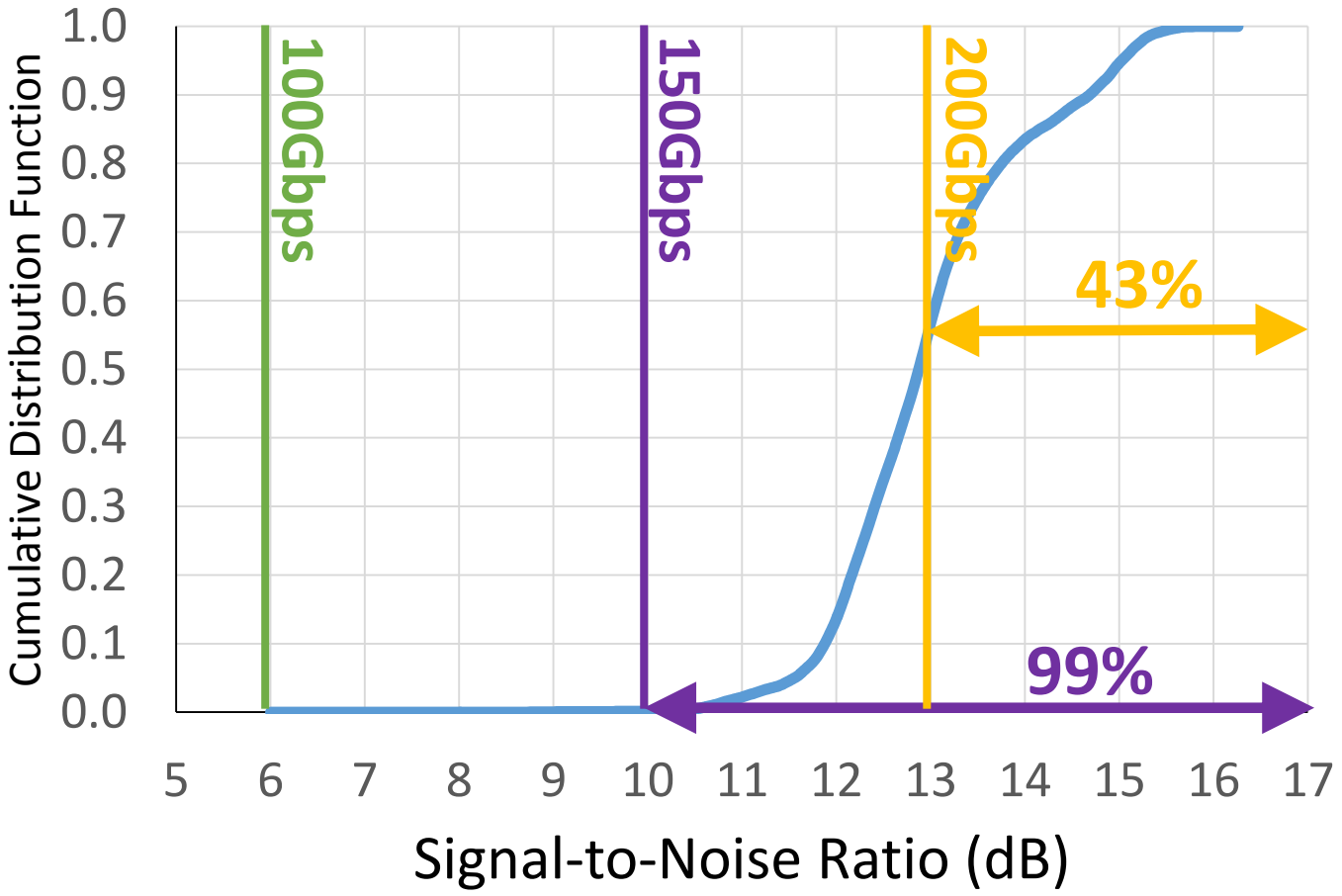
Is there ability to carry more bits?

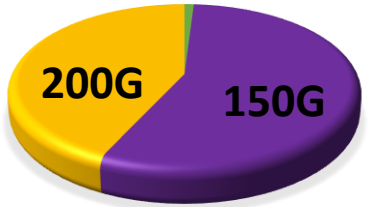
Higher order modulation



- Performance of each channel
- Margins for higher order modulations
- Convert Q-factor to SNR

Higher order modulation





Gain: 70%

Using the same fiber paths, we get more bits

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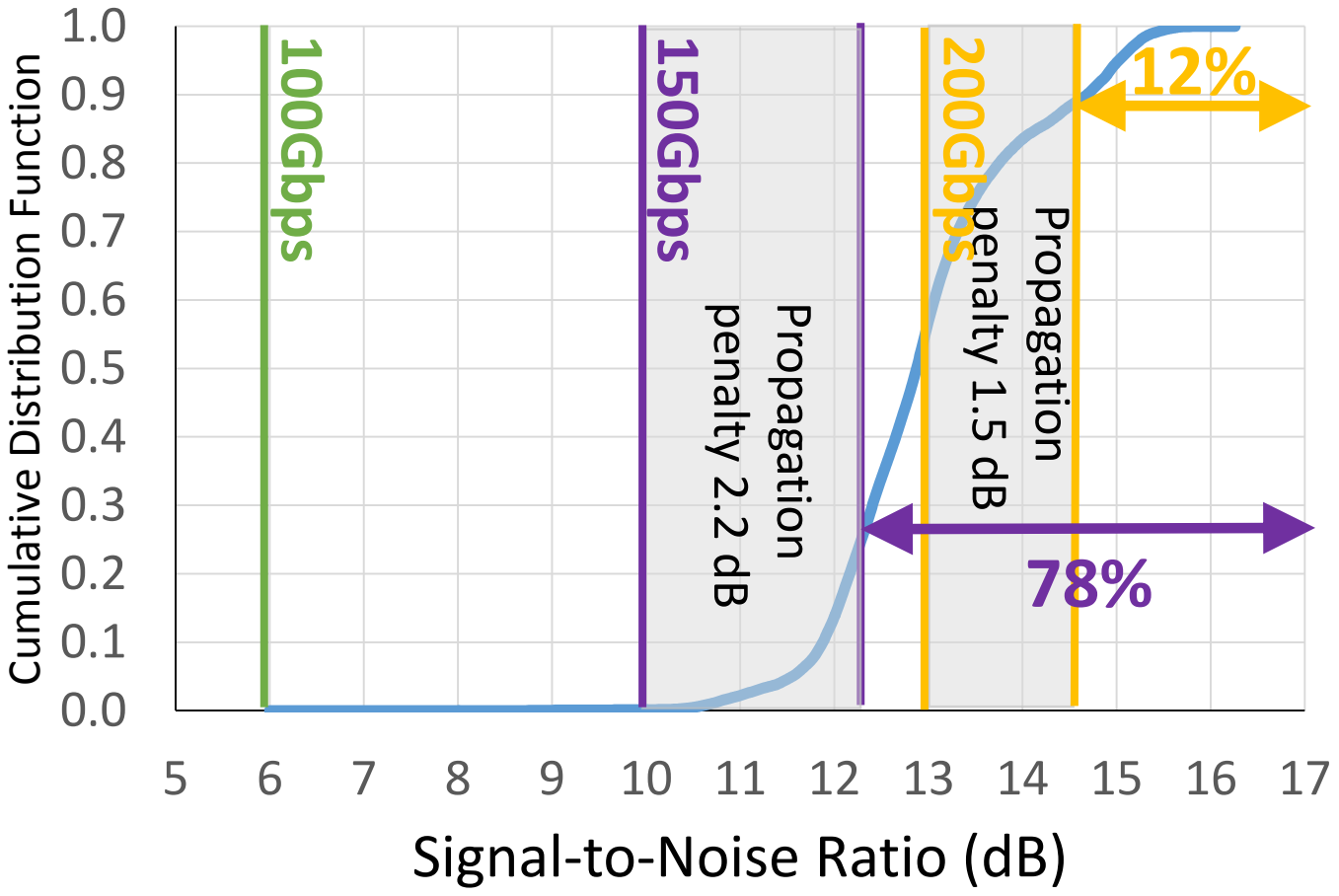
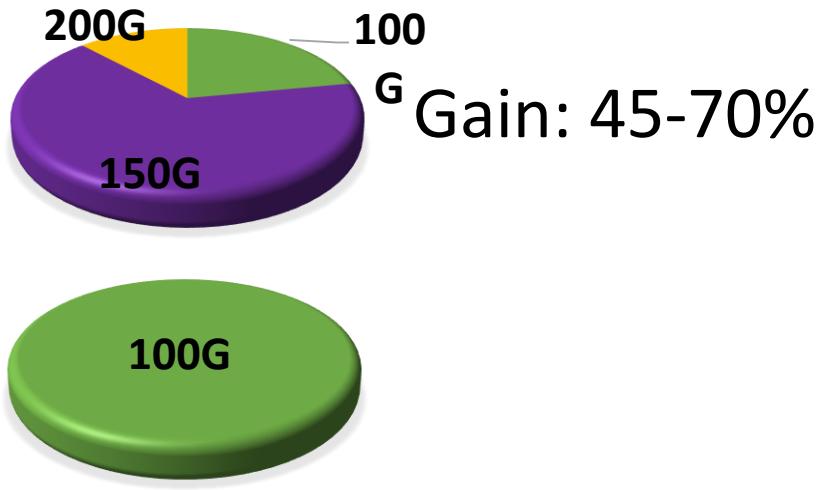
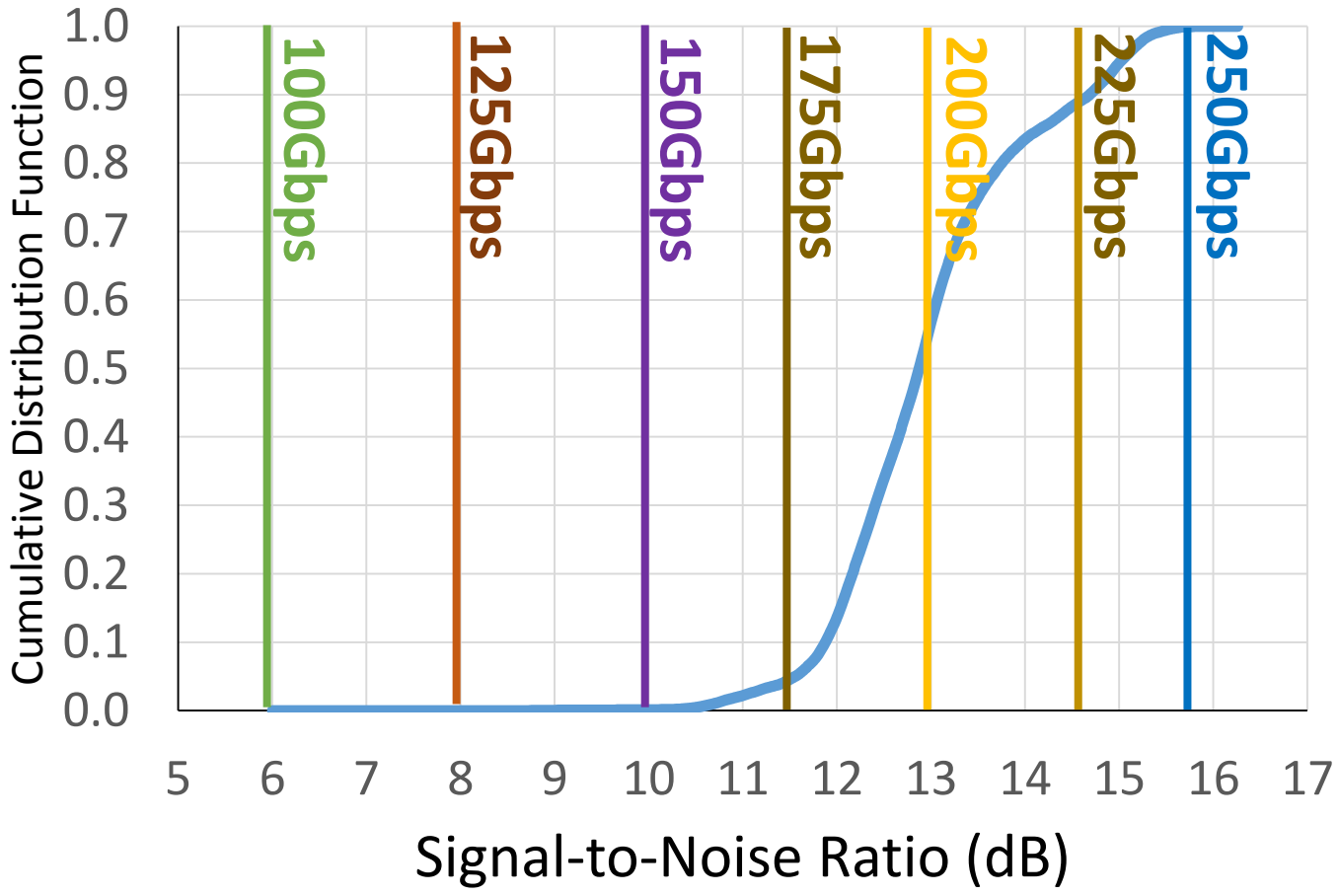
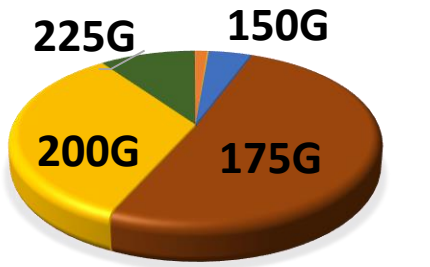
Higher order modulation



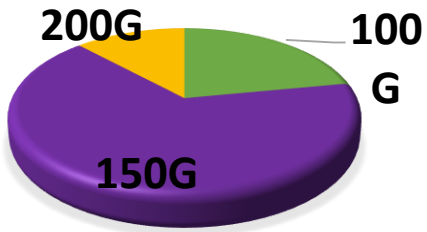


Higher order modulation





Gain: 86%



Gain: 45-70%

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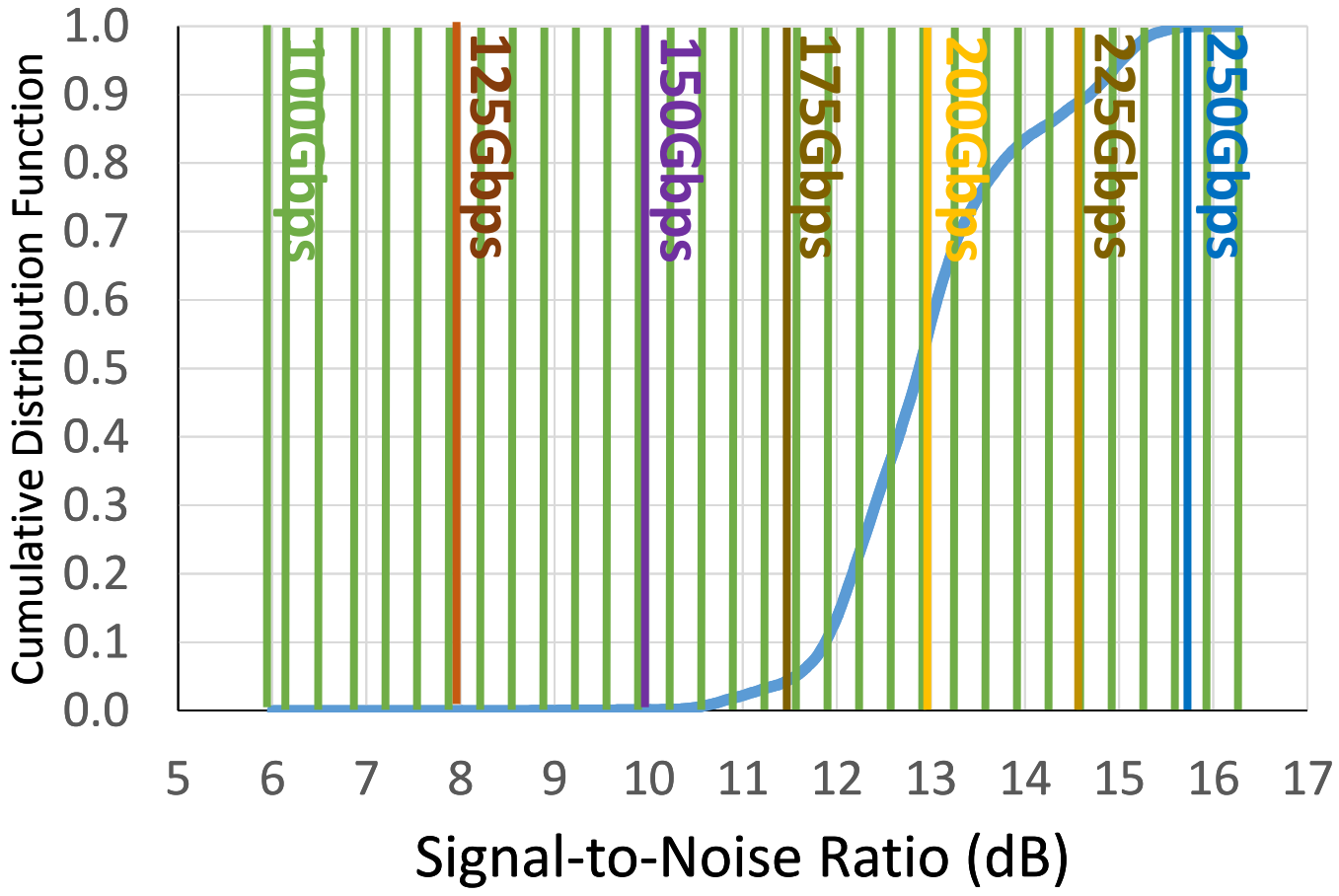
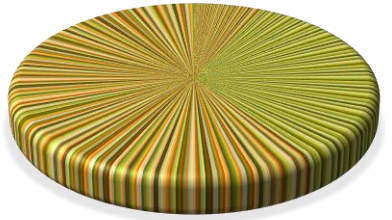
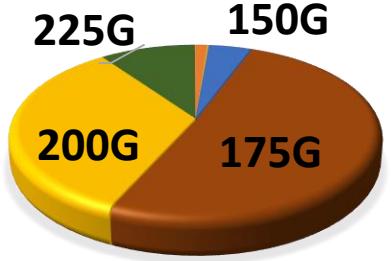
Higher order modulation





Gain: 99%



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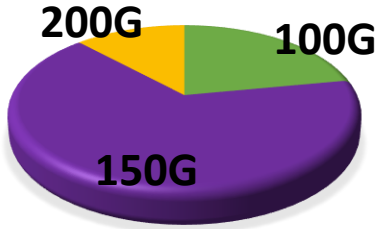

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How to deploy higher order modulations

- Should we use the same modulation for all segments?
  - Different segments have different SNRs.
- Should we use the same modulation for all wavelengths in a segment?
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- Should the modulation for a wavelength be static?
  - SNR varies over time.

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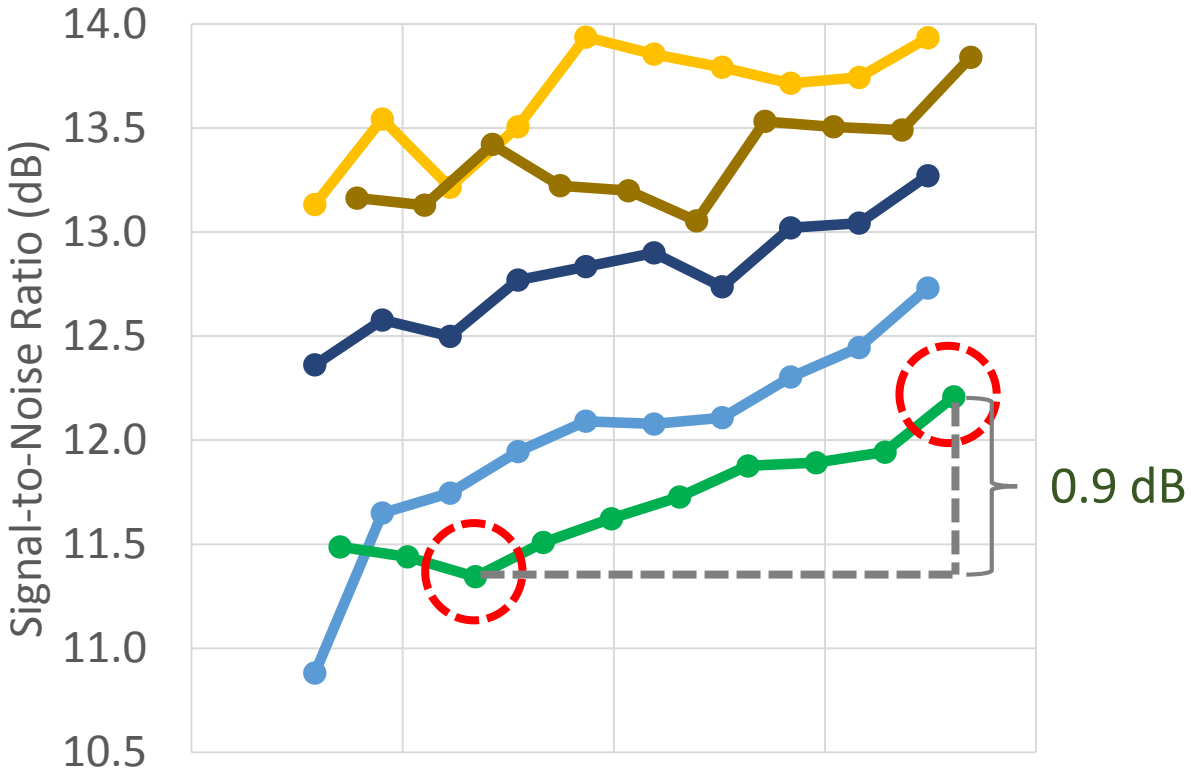
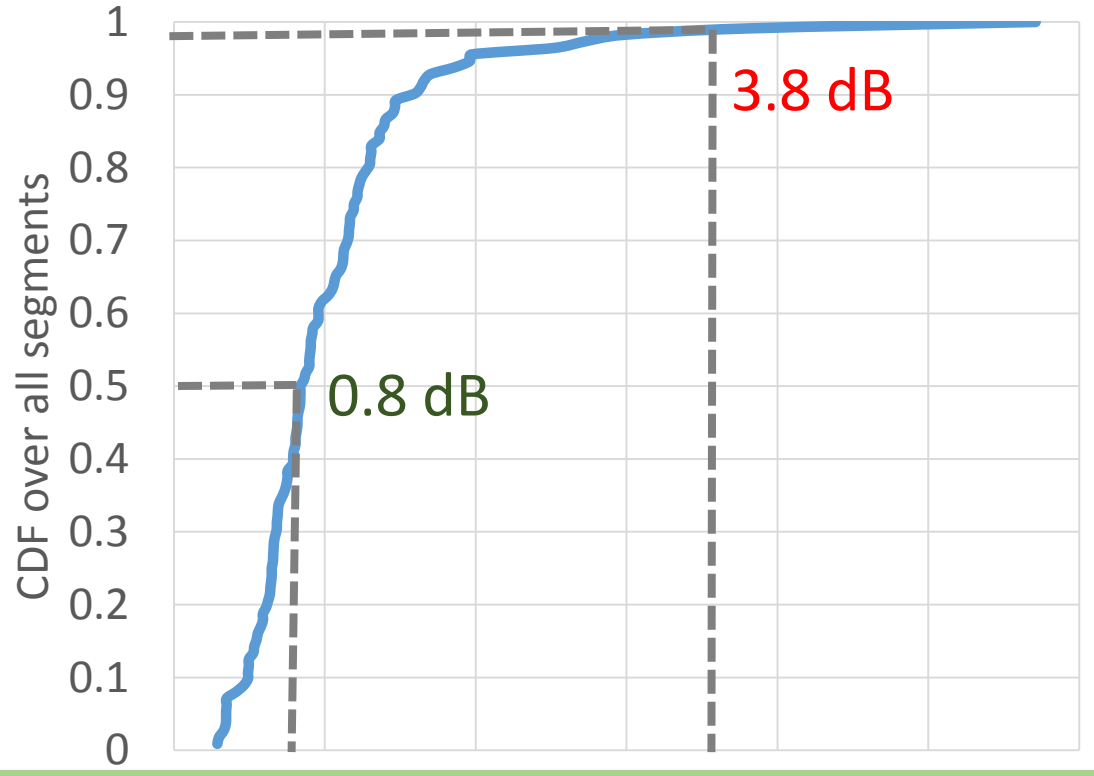
SNR variation across wavelengths





Different wavelengths need different modulation formats even though the path is shared

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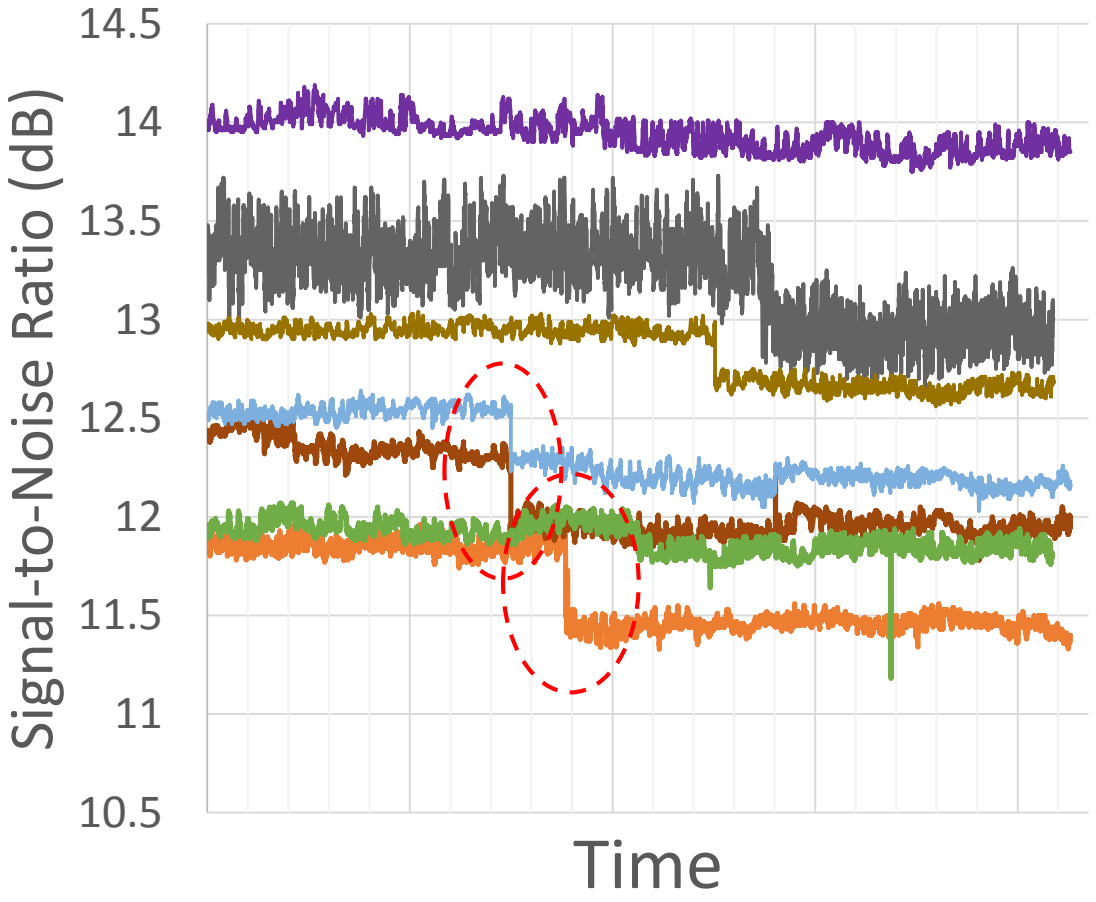
SNR variation over time



Jumps are due to:

- Occasional network changes
- Removal of legacy 10G OOK
- Removal of old optical gear
- Maintenance

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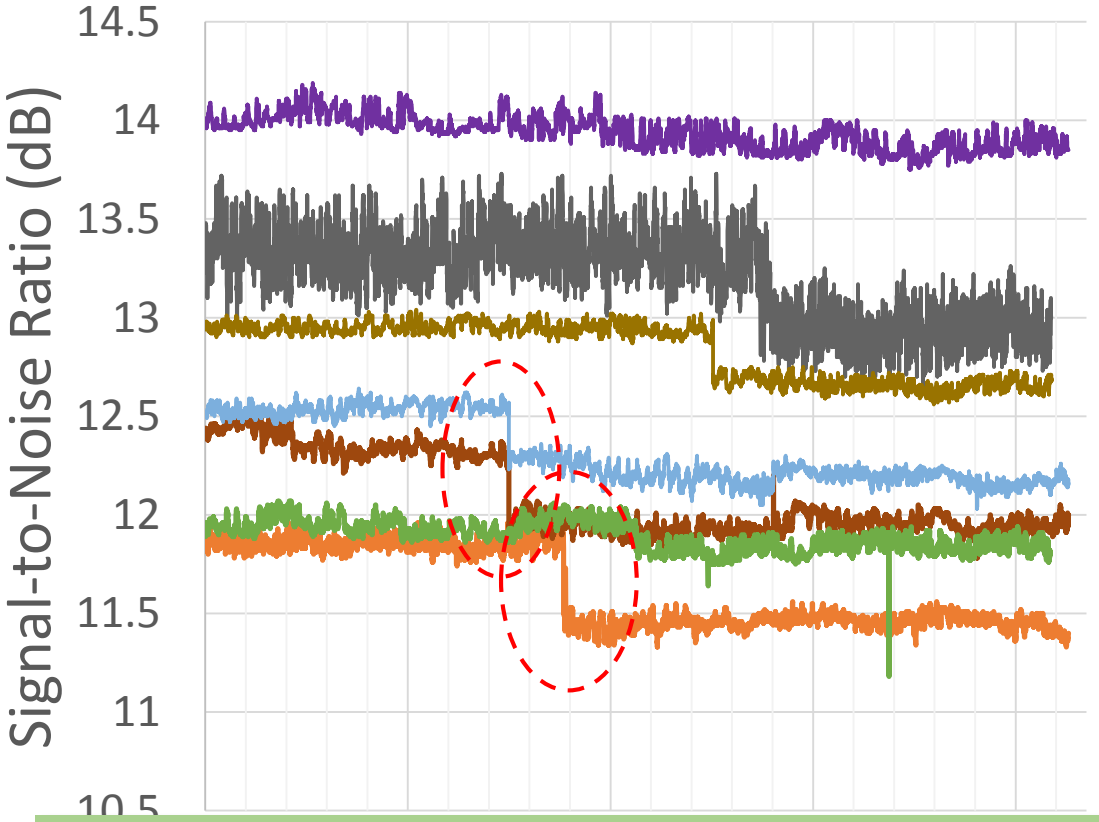
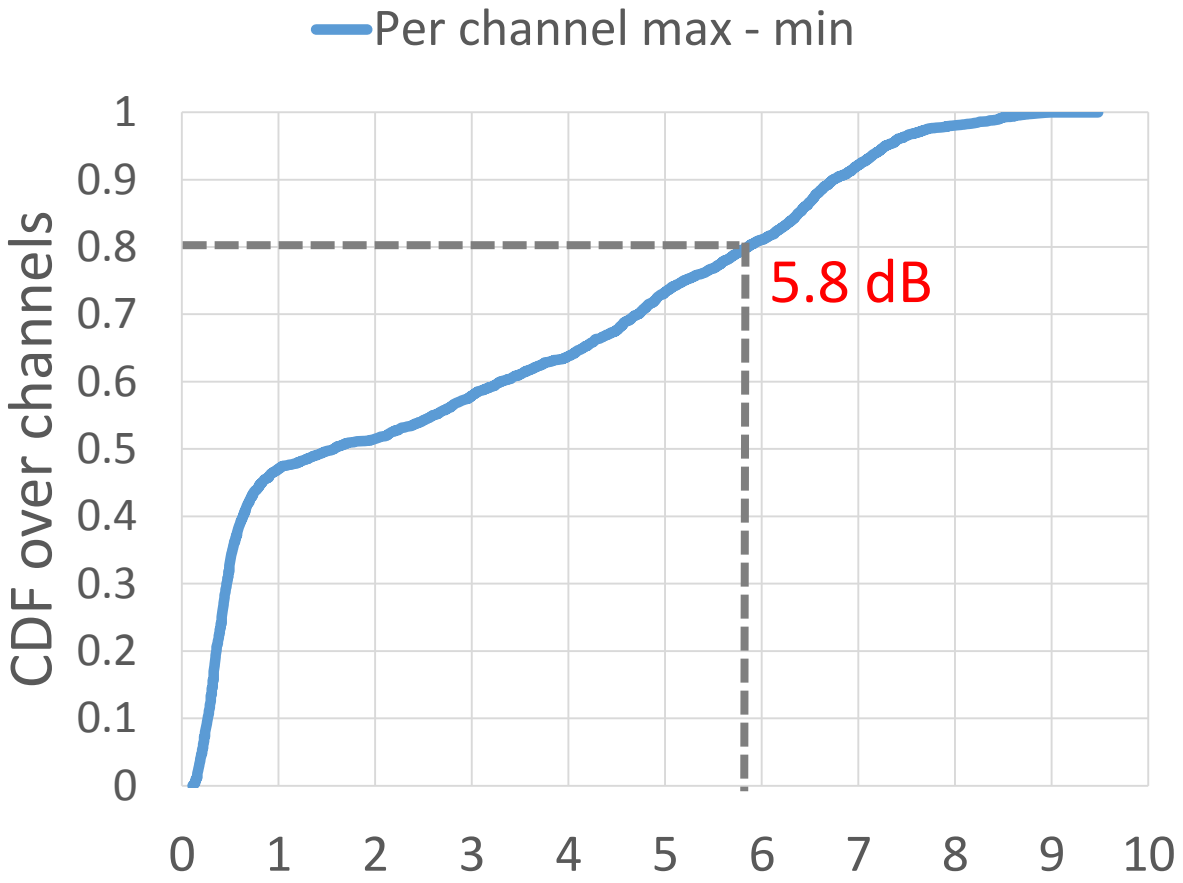
SNR variation over time





SNR changes over time, depending on changes in infrastructure

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Bandwidth Variable Transponders

Conclusions

- Existing fiber can support higher order modulation
- Deployment should be realized using bandwidth variable transponders