DSP for Optical Fiber Nonlinear Effects Mitigation

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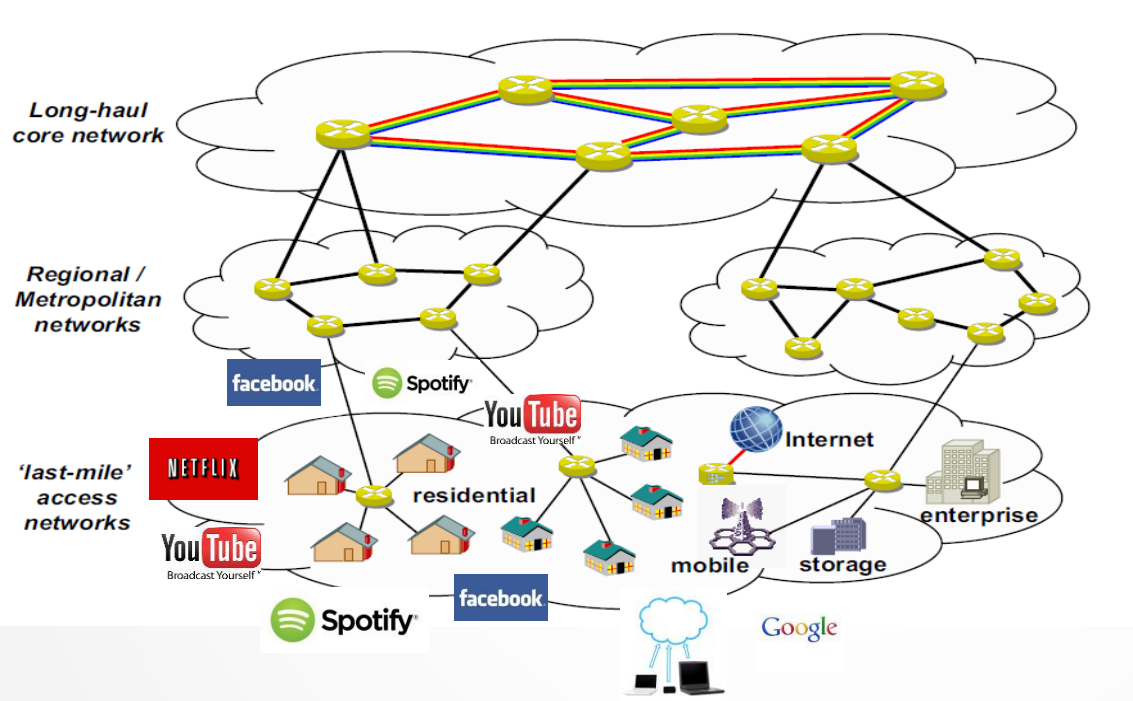
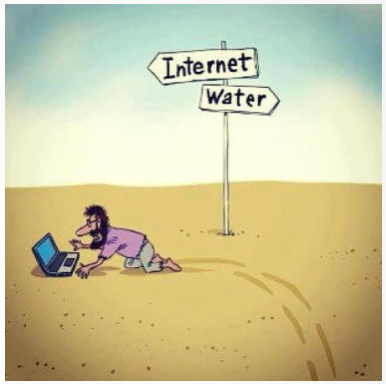
METRO-ACCESS
& SHORT RANGE COMMUNICATIONS

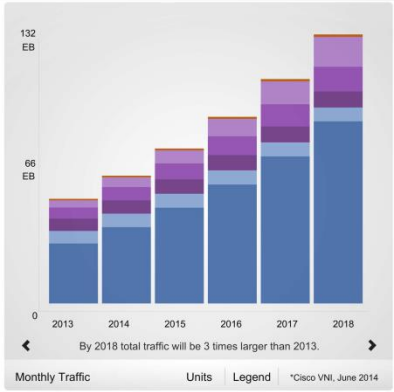
Outline

- Motivation
- Problem
- Challenges
- Approaches
- Targets

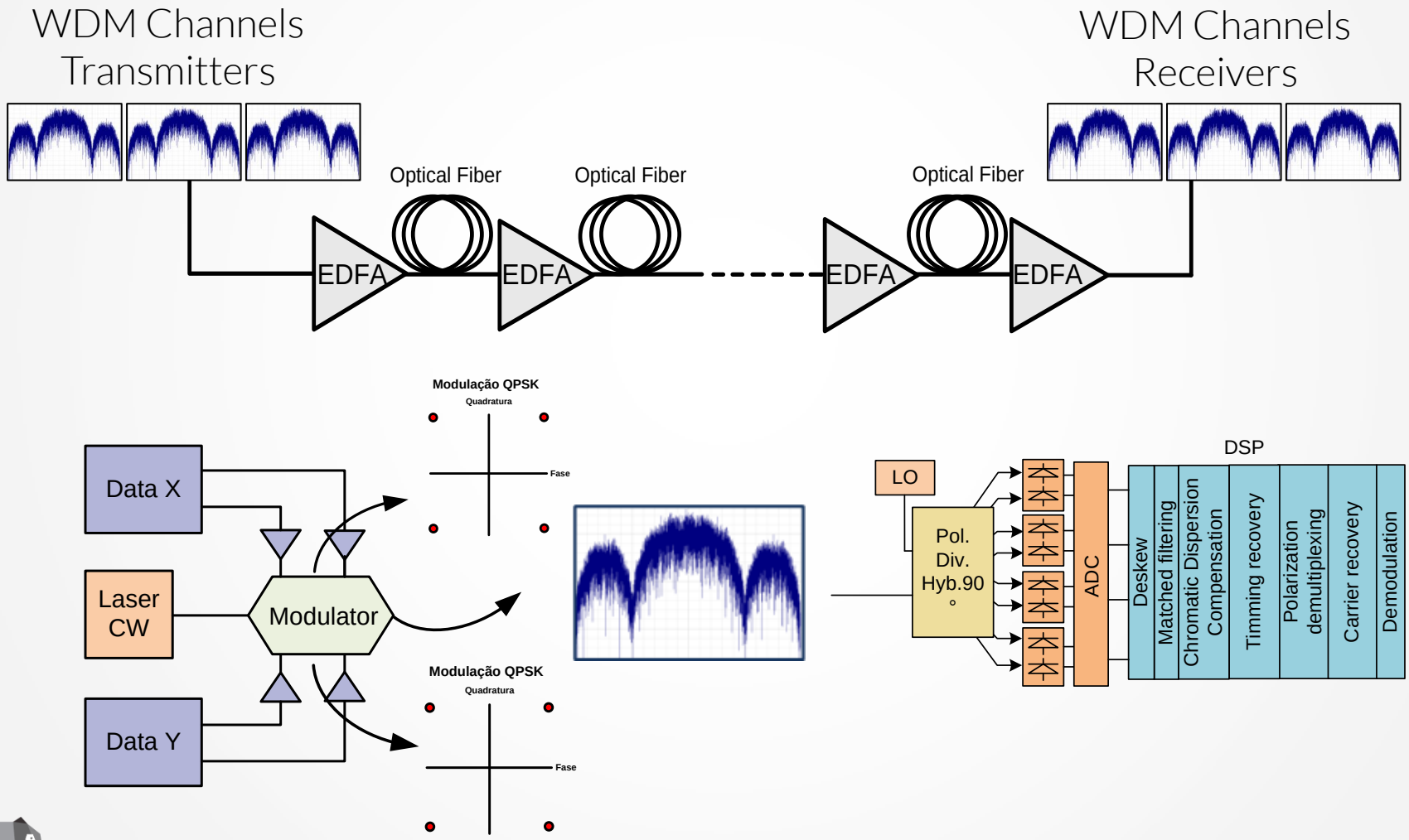
Motivation


Long-haul core network
Regional / Metropolitan networks
'last-mile' access networks
facebook
Spotify
YouTube
Broadcast Yourself
NETFLIX
residential
Internet
enterprise
mobile
storage
Google

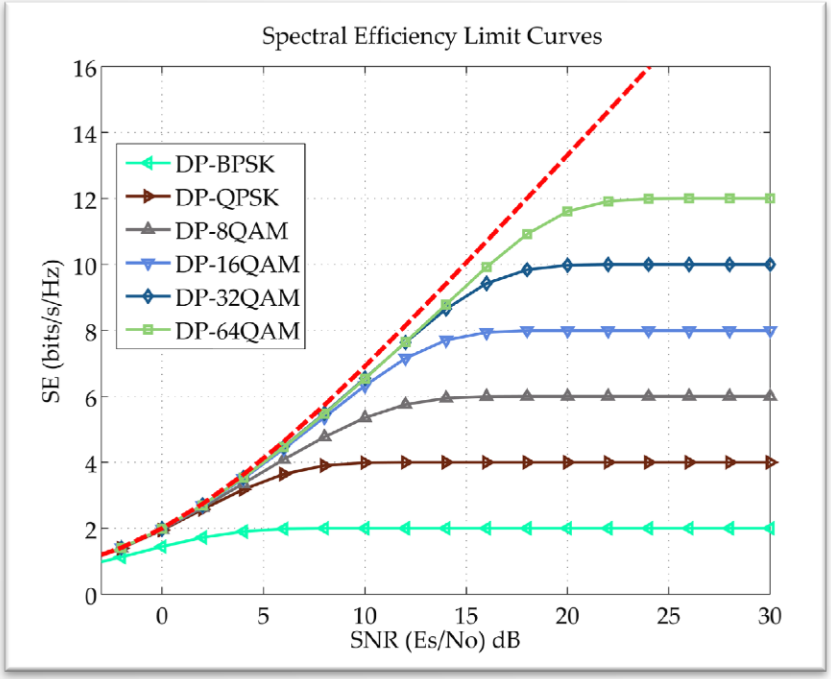

Internet
Water

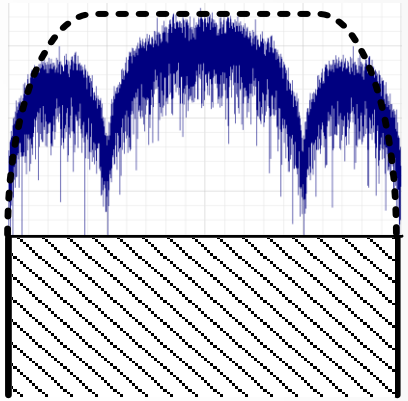

132 EB
66 EB
0
2013
2014
2015
2016
2017
2018
By 2018 total traffic will be 3 times larger than 2013.
Monthly Traffic
Units
Legend
*Cisco VNI, June 2014

Coherent WDM systems



Spectral Efficiency

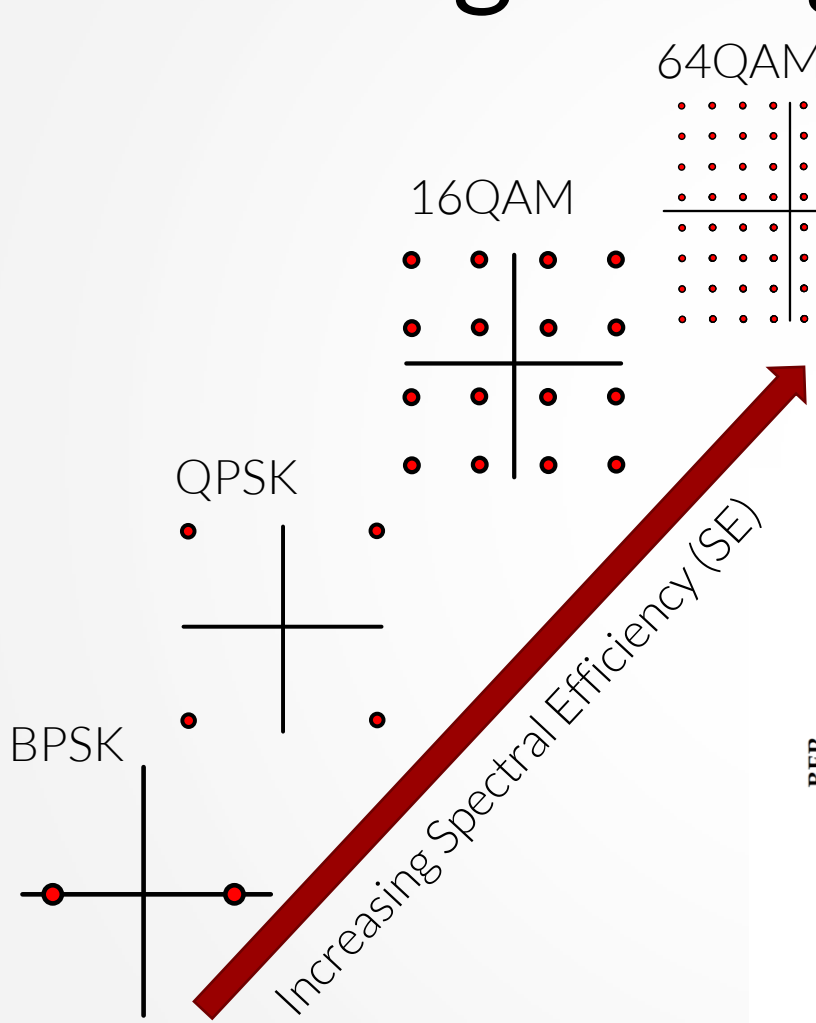


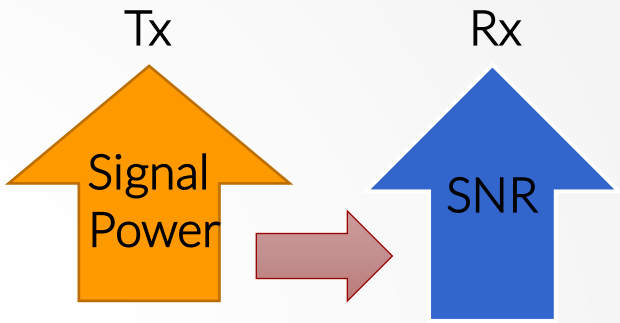


Comercial 100 Gb/s Coherent DP-QPSK transceiver: SE~ 2 b/s/Hz (~8 Tb/s)

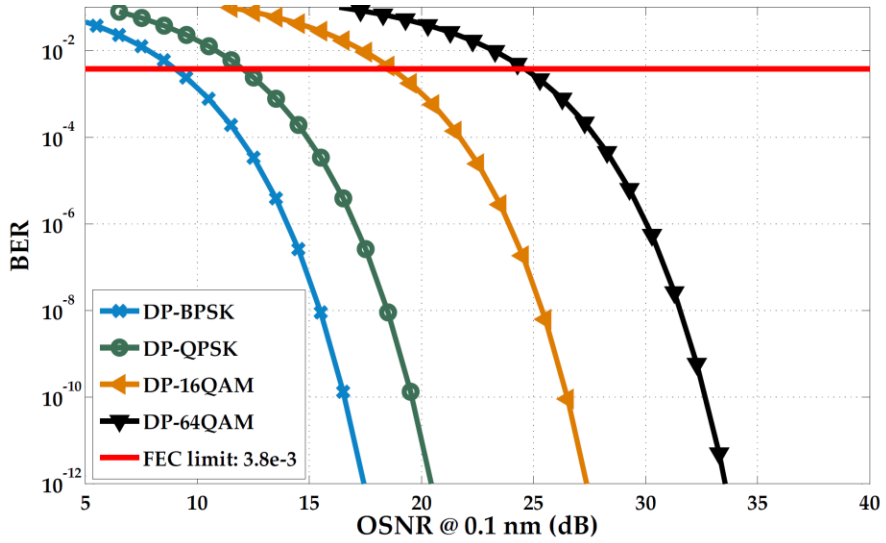
Comercial 400 Gb/s : SE~ 8 b/s/Hz (~ 32 Tb/s)

Looking for higher SE

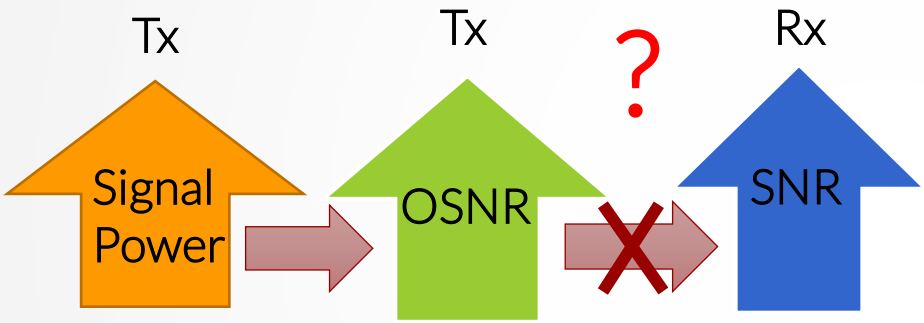


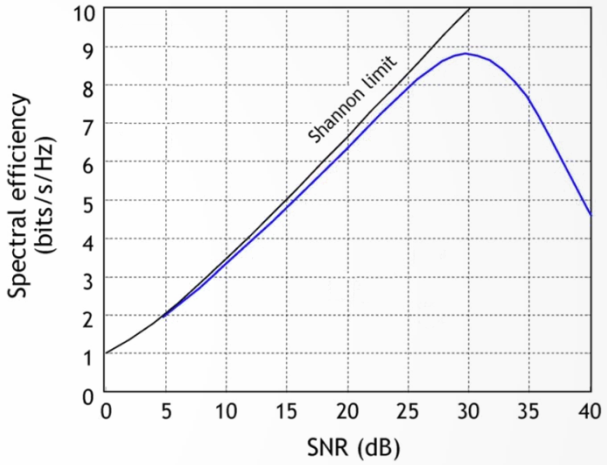


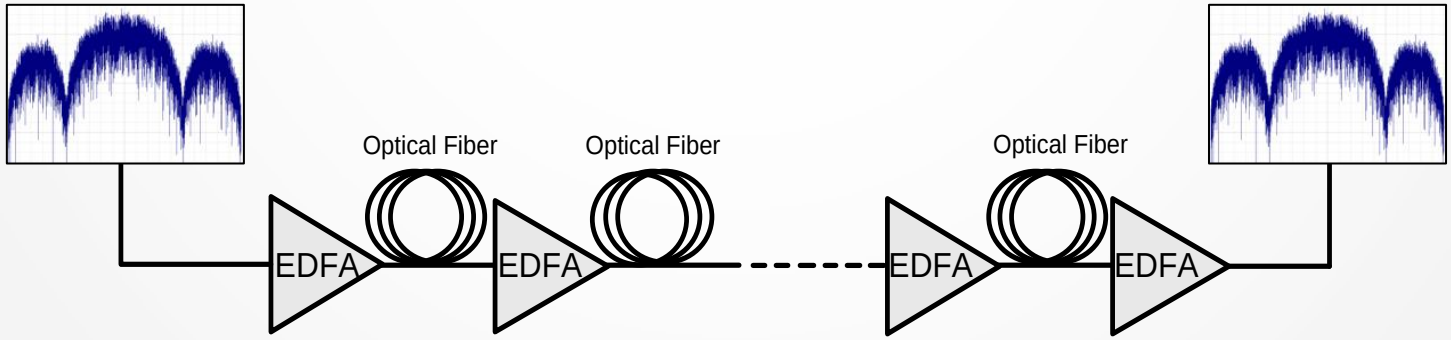
Increasing SNR requirements



Fiber Optic Channel

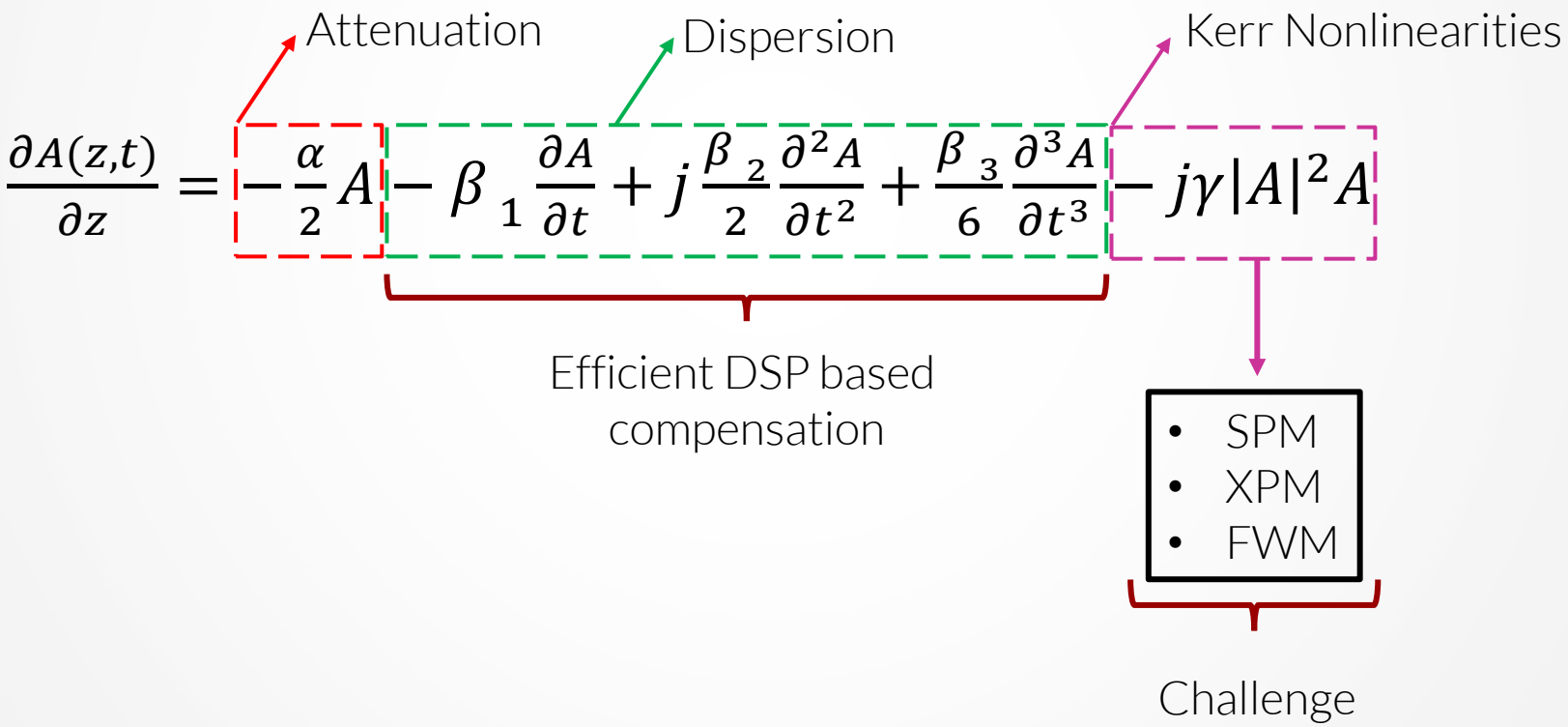






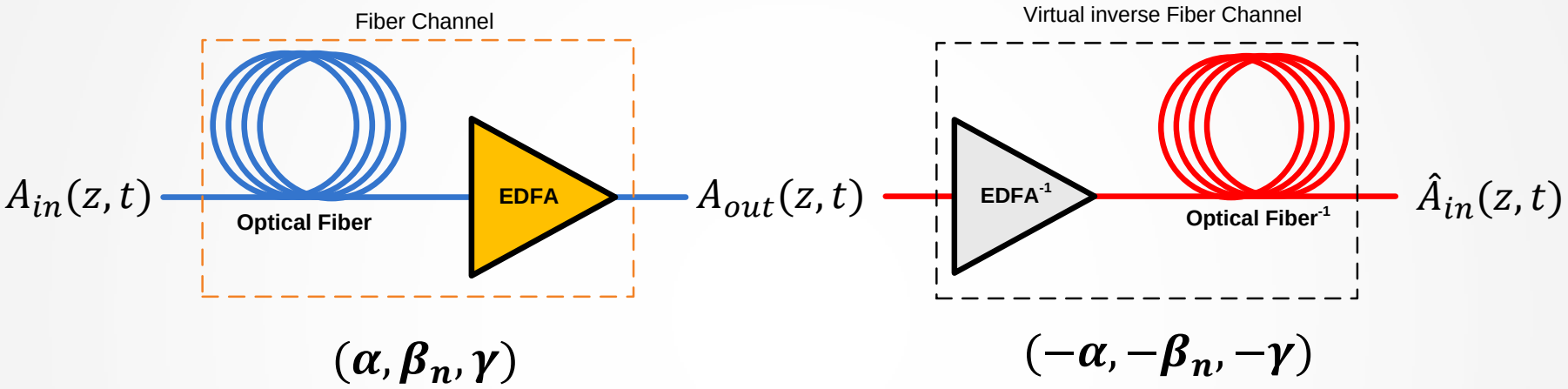
Fiber Optic Channel

» Nonlinear Schrodinger Equation (NLSE):



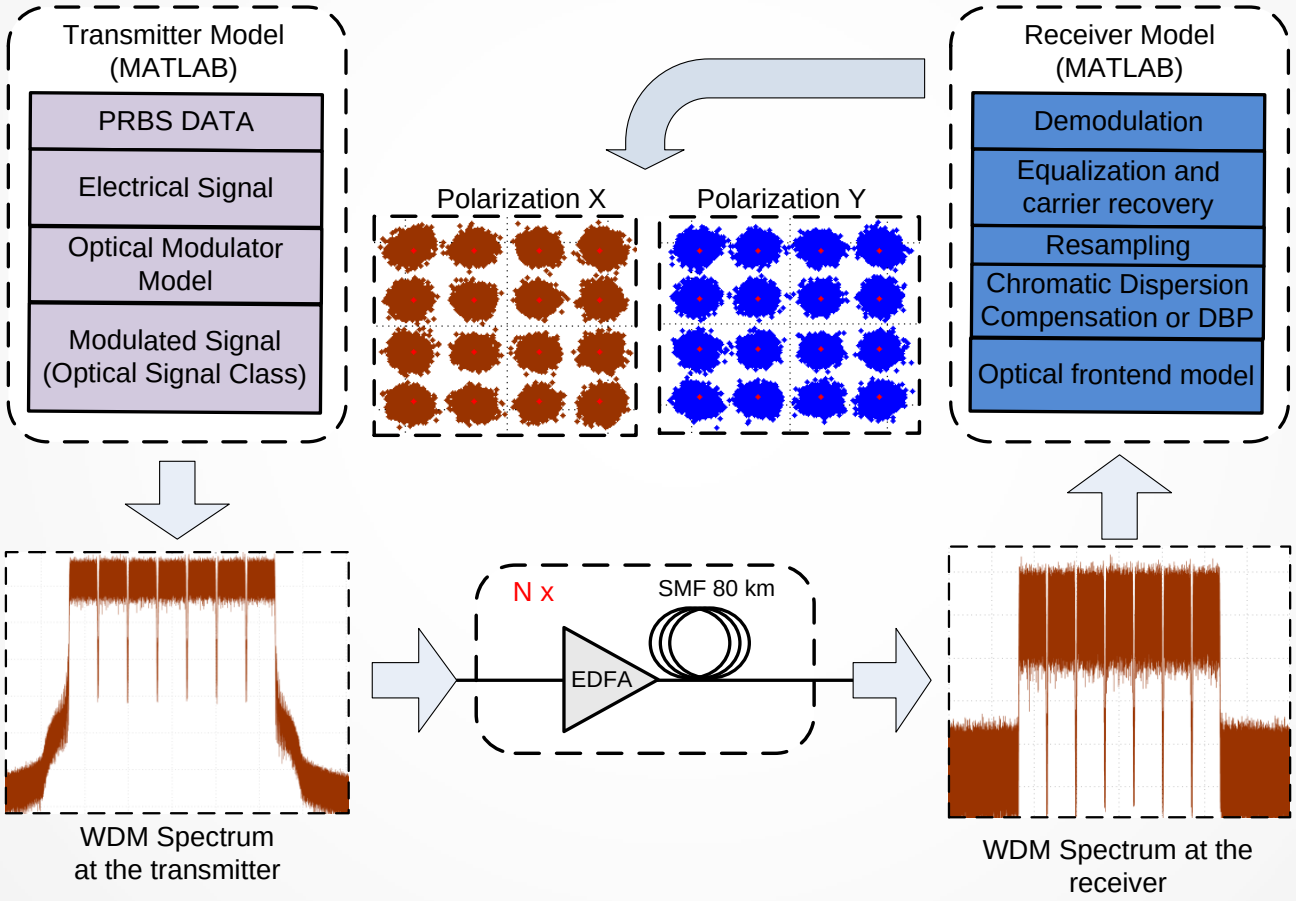
DSP-based Compensation of Fiber Optic Nonlinear Impairments

Digital back-propagation (DBP)



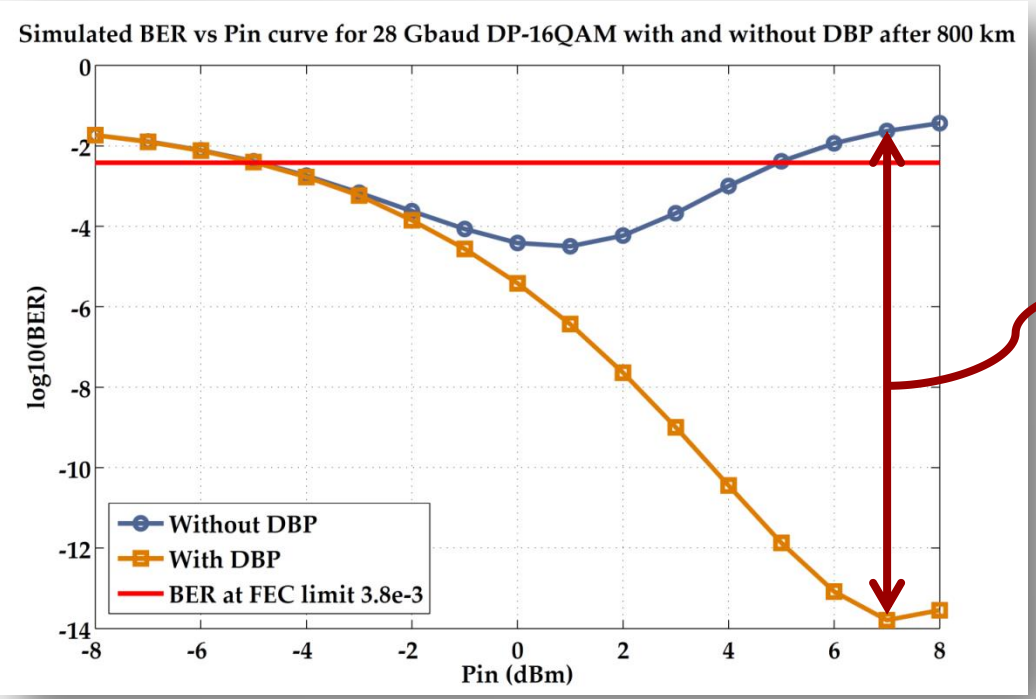
$$\frac{\partial A(z,t)}{\partial z} = \underbrace{\left(-\beta_1 \frac{\partial A}{\partial t} + j\frac{\beta_2}{2}\frac{\partial^2 A}{\partial t^2} + \frac{\beta_3}{6}\frac{\partial^3 A}{\partial t^3}\right)}_{\text{Linear}} + \underbrace{\left(-\frac{\alpha}{2}A - j\gamma|A|^2 A\right)}_{\text{Nonlinear}}$$

Simulation Model



Digital back-propagation (DBP)

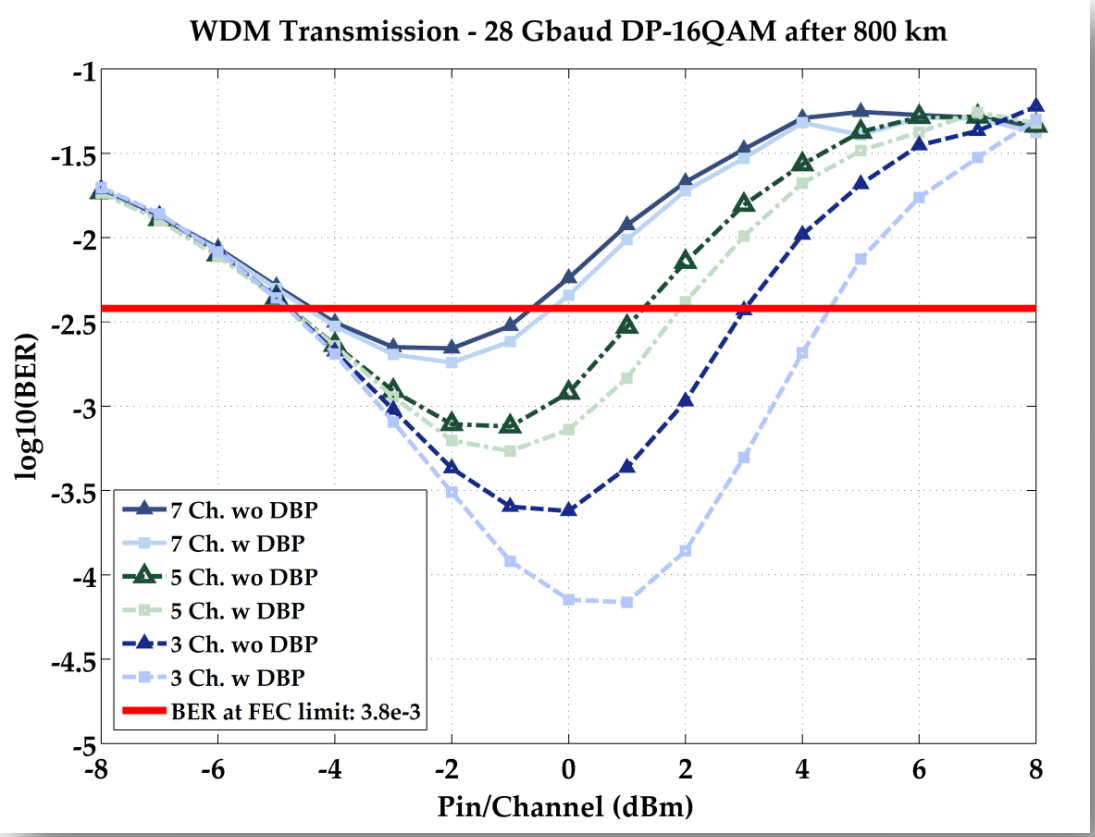
» Single channel case (224 Gb/s DP-16QAM):



OSNR gain ≈ 10 dB

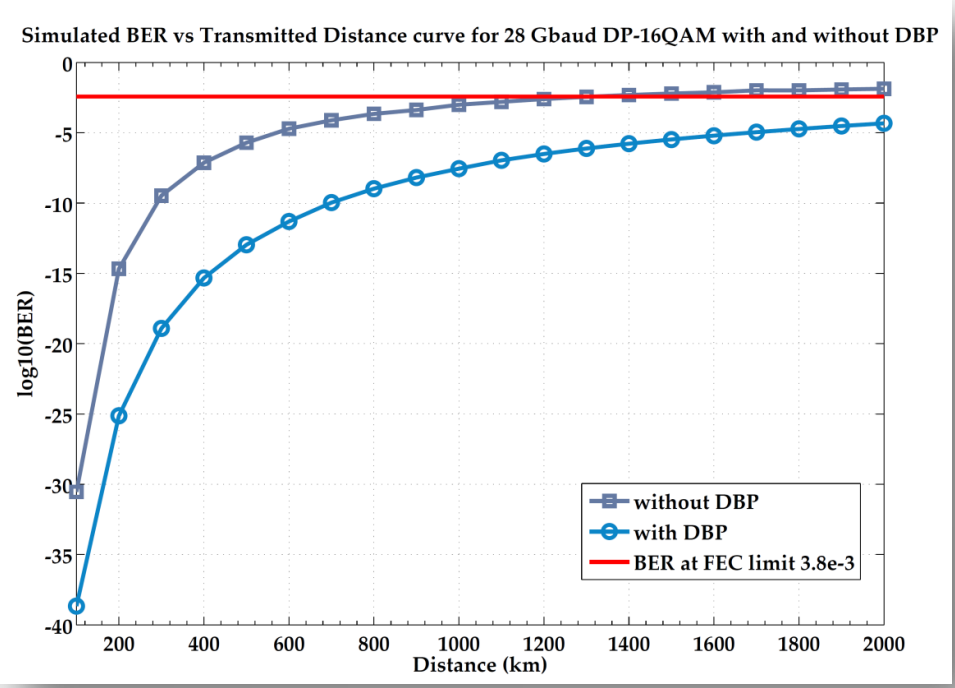
WDM Model and Performance

» Estimated BER vs Input power per channel:



Single Channel Model and Performance

» BER vs Reach, with and without DBP:



Parameter	Value
Pin	3 dBm
Step size	10 km
Span length	100 km
Dispersion coeff.	16 ps/nm/km
Dispersion Slope	0.1 ps^2/nm/km
Att. (α)	0.2 dB/km
Nonlinear coeff. (γ)	1.5 (W.km)^-1

Compensating Fiber Impairments with DBP

- Advantages:
  - Performance;
  - Modulation format independent;

- Disadvantages:
  - High computational complexity (a lot of effort has been made to reduce this complexity);
  - Requires the knowledge of the fiber parameters (difficult in deployed systems);

Targets

- Reduce NLC computational complexity and/or improve performance gains beyond the state of the art solutions presented so far based on:
  - The use of DBP together with nonlinearity dedicated channel coding;
  - The use of DBP together with channel estimation techniques;
  - Unexplored DSP techniques: machine learning.

THANK YOU

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