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Digital “Coherent” Transceivers in Optical Networks

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Optical Transmission Technology

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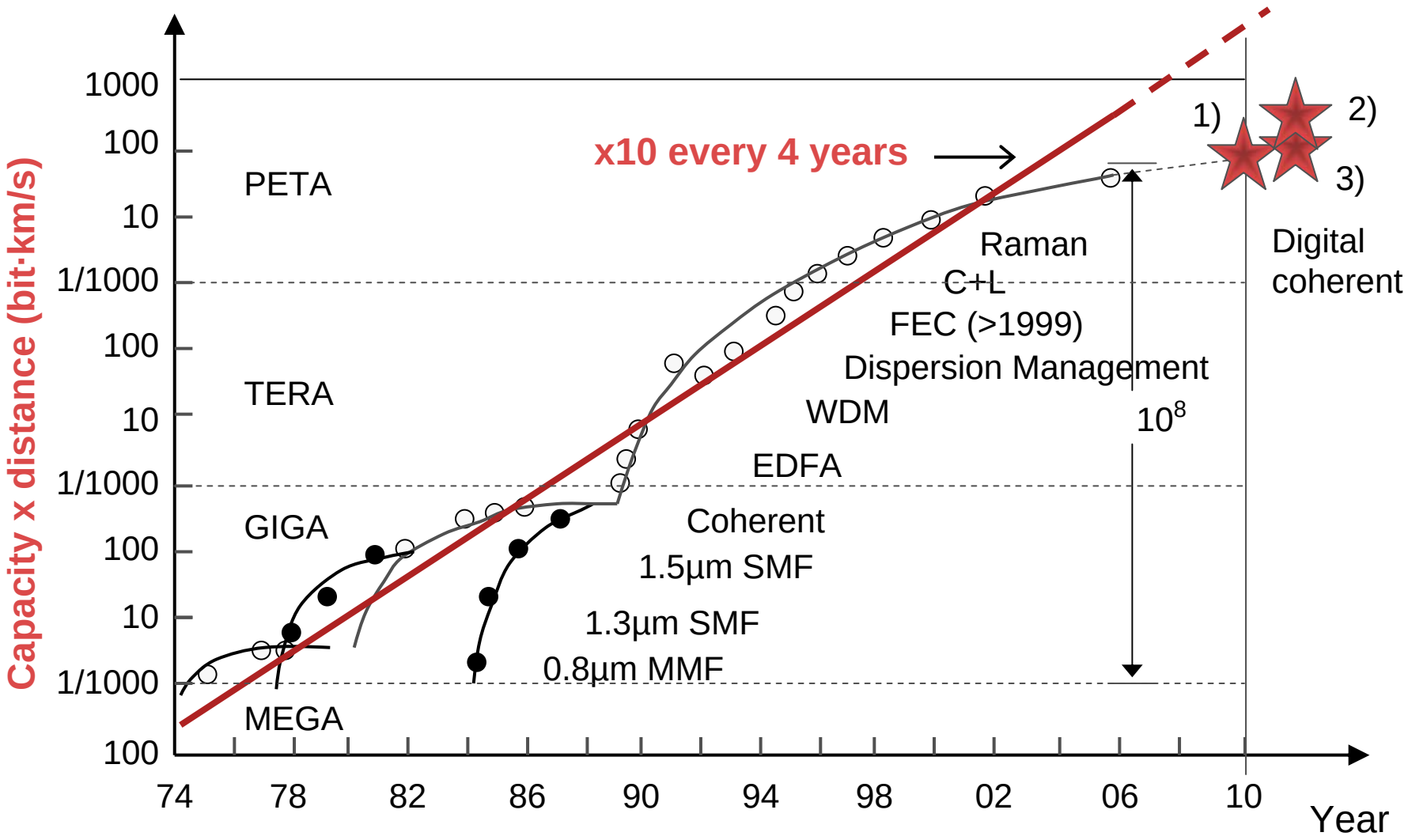
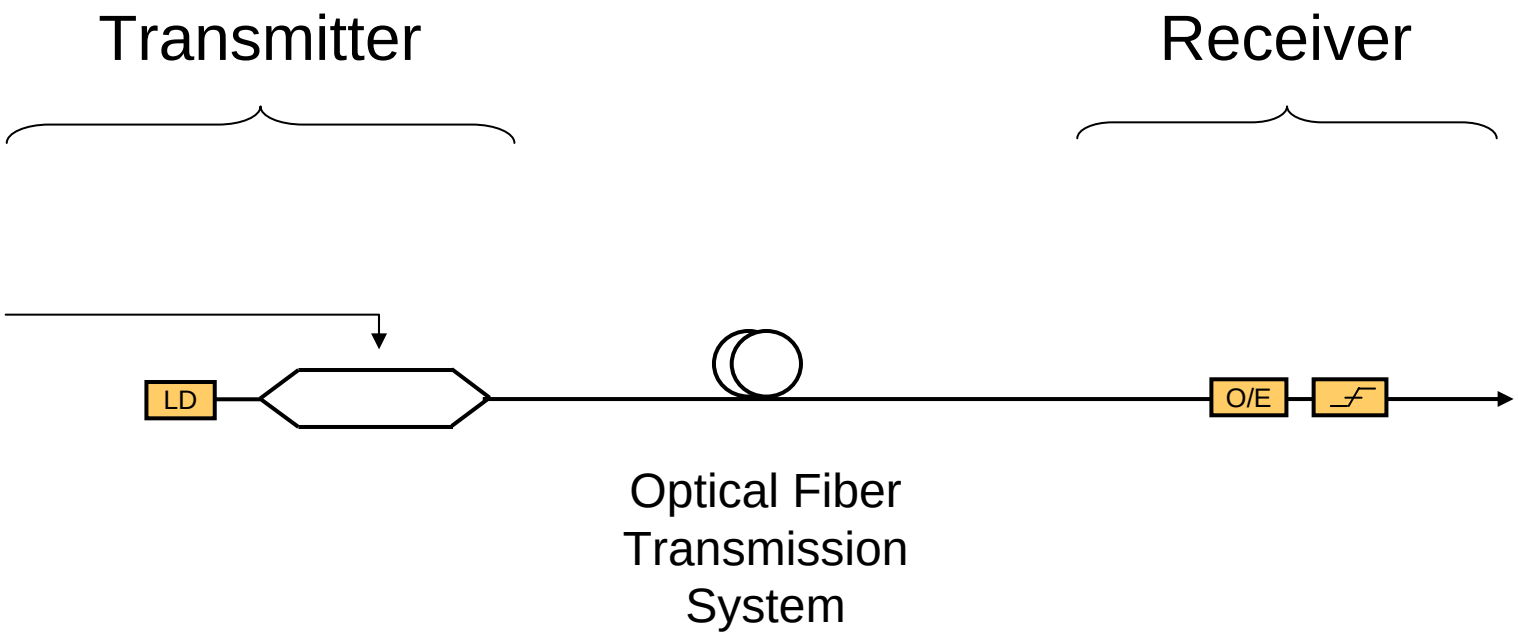
Graph: E. B. Desurvire, “Capacity Demand and Technology Challenges for Lightwave Systems in the Next Two Decades”, J. Lightw. Tech., vol. 24, no. 12, Dec. 2006



1) 96x 100Gbit/s @10,608km, OFC/NFOEC 2010, PDPB10, Tyco (101.8)
2) 115x 120Gbit/s @ 10,181km, ECOC 2011, Th.13.K.3, NEC Lab America (140.5)
3) 40x 224Gbit/s @ 12,000km, ECOC 2011, Th.13.C.5, Alcatel-Lucent (107.5)

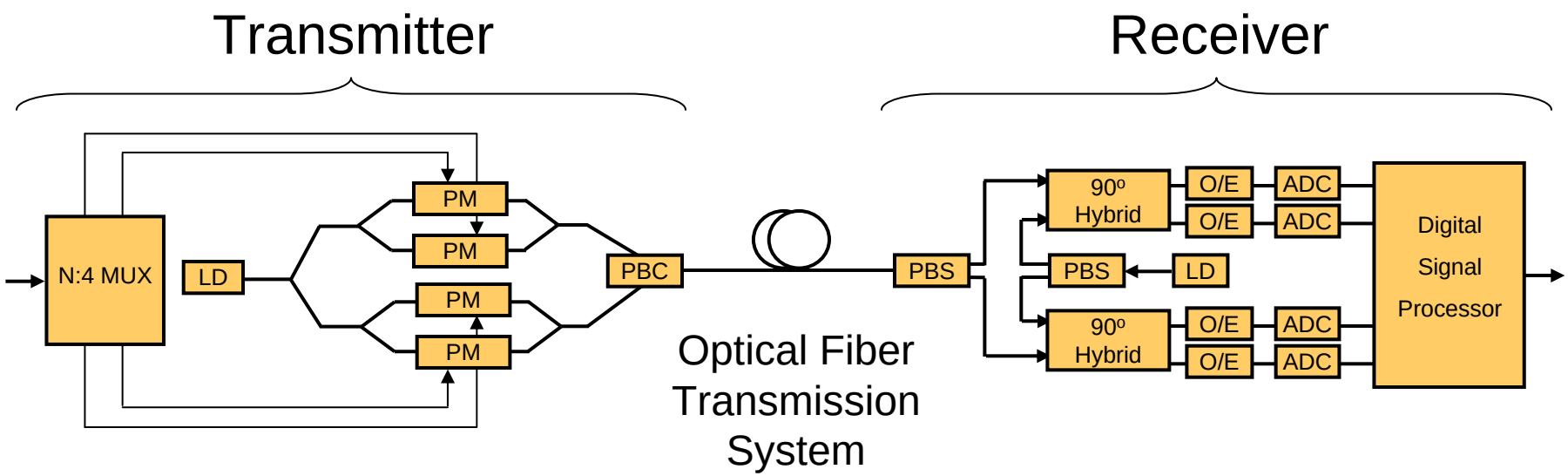
Direct Detection Transceiver



- Long lasting success due to simplicity
- … but difficult to push technology above 10 Gbit/s

Digital Optical Coherent Transceiver

Realization example: 100G DP-QPSK



LD: Laser Diode
PBS: Polarization Beam Splitter
PM: Phase Modulator
PBC: Polarization Beam Combiner
ADC: Analog-to-Digital Converter
O/E: Optical to Electrical conversion
DP-QPSK: Dual-Polarization Quadrature Phase Shift Keying

ADC/DSP requirements:

ADC: 4x 56 GSa/s, 8 bit

DSP: 1.792 Tbit/s

Gates: ≈100 Million

Optical Coherent Justification

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- Coherent detection much more complex – why use it at all?

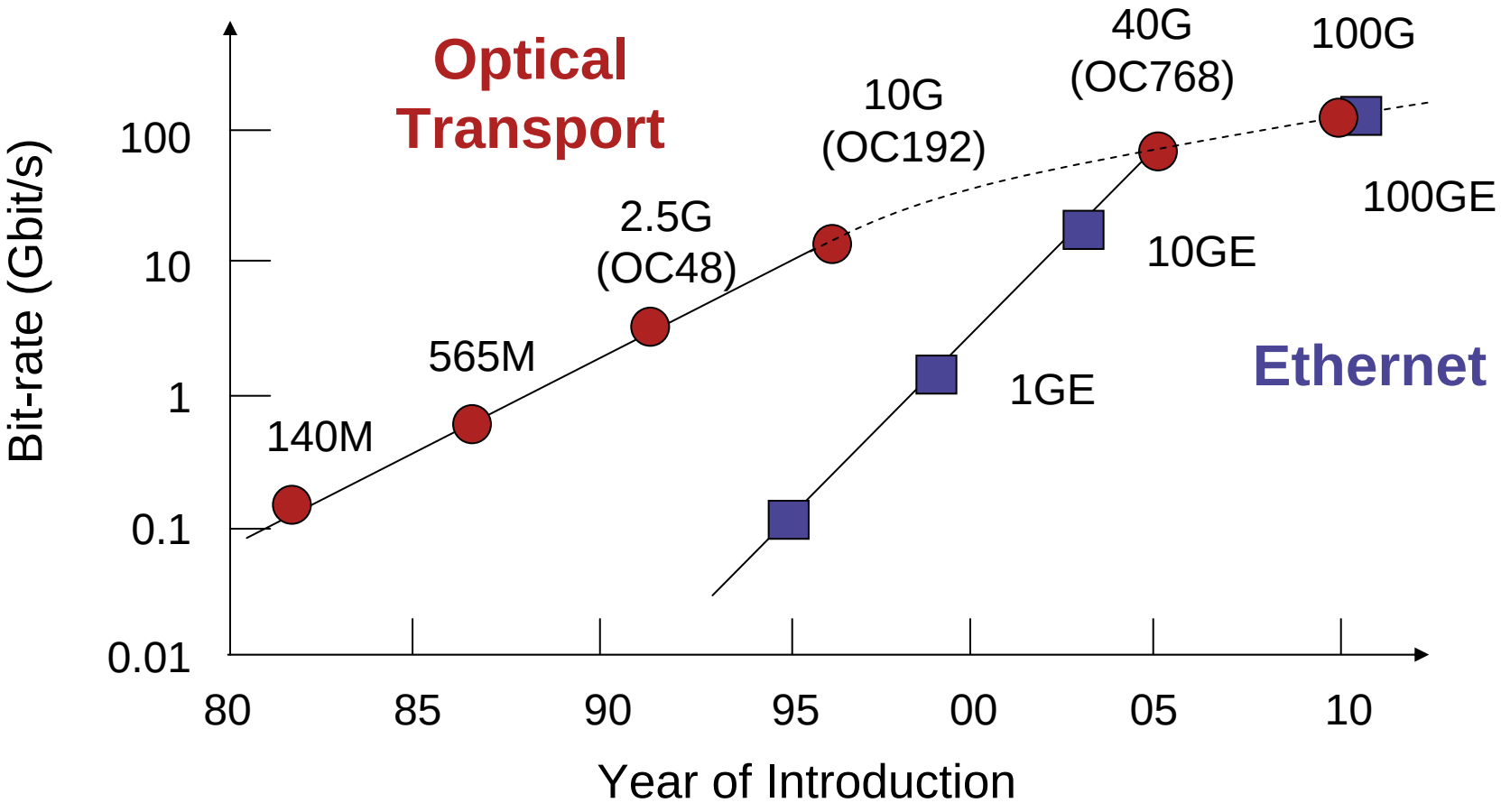
- Line-rate of 100G demanded by
  - 100G router interfaces
  - Efficient use of scarce fiber, e.g. 10x 10GE over 100G line rate

- 100G direct detection compared to 10G
  - OSNR tolerance 1/10 (reach 1/10)
  - Dispersion tolerance 1/100 (difficult to manage/compensate)
  - PMD tolerance 1/10 (optical compensator)
  - Electrical bandwidth 10x (≈70 GHz electr. bandwidth unrealistic)
  - Spectral efficiency same (would not fit into standard 50 GHz grid)

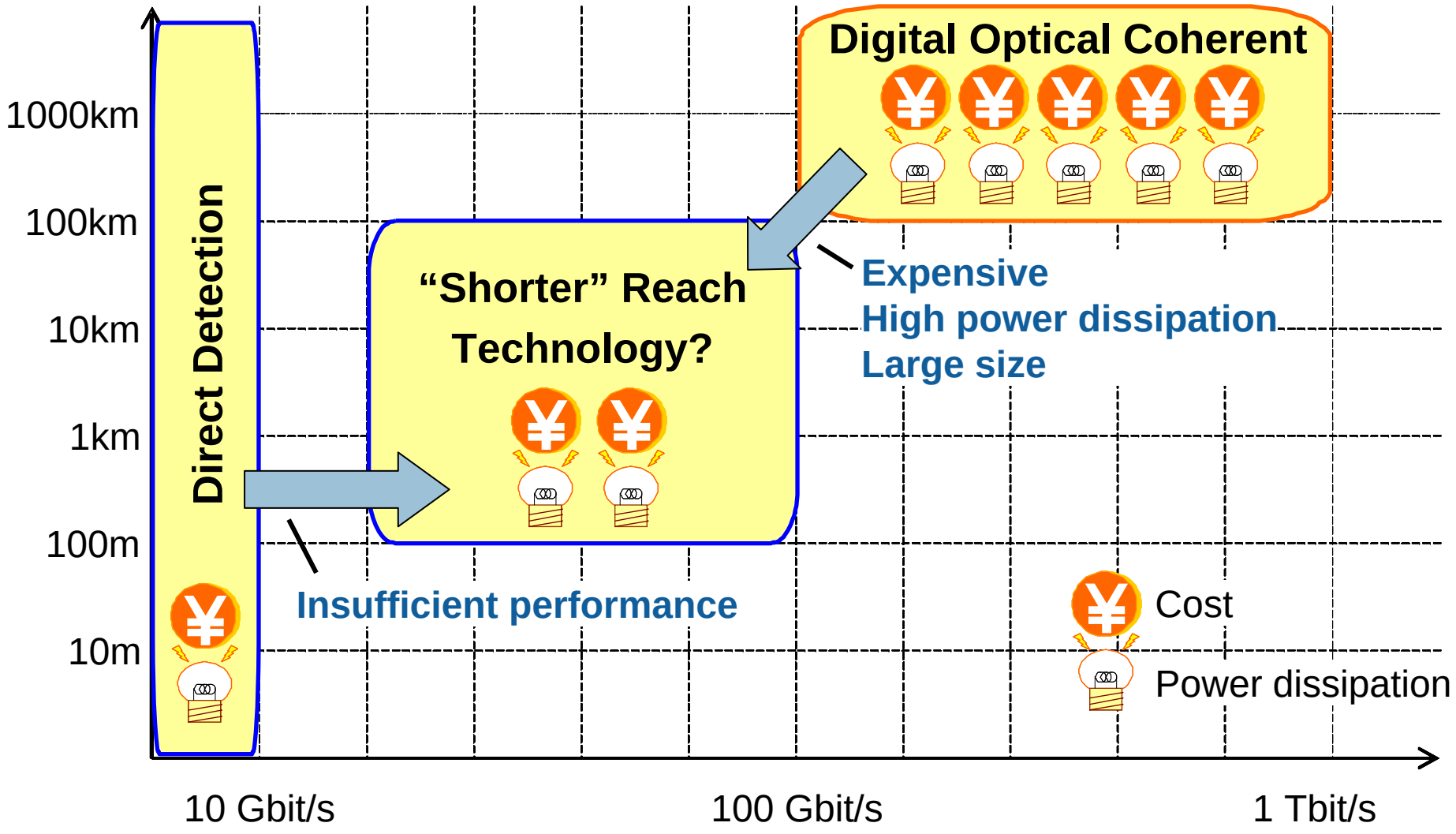
→ Digital optical coherent for ≥100 Gbit/s at >100km

Interface Rates

- Past: Optical transport introduced fastest rates
- Present/Future: Ethernet rate = Optical transport rate



Optical Transceiver Positioning



“Shorter” Reach Transceiver Technology

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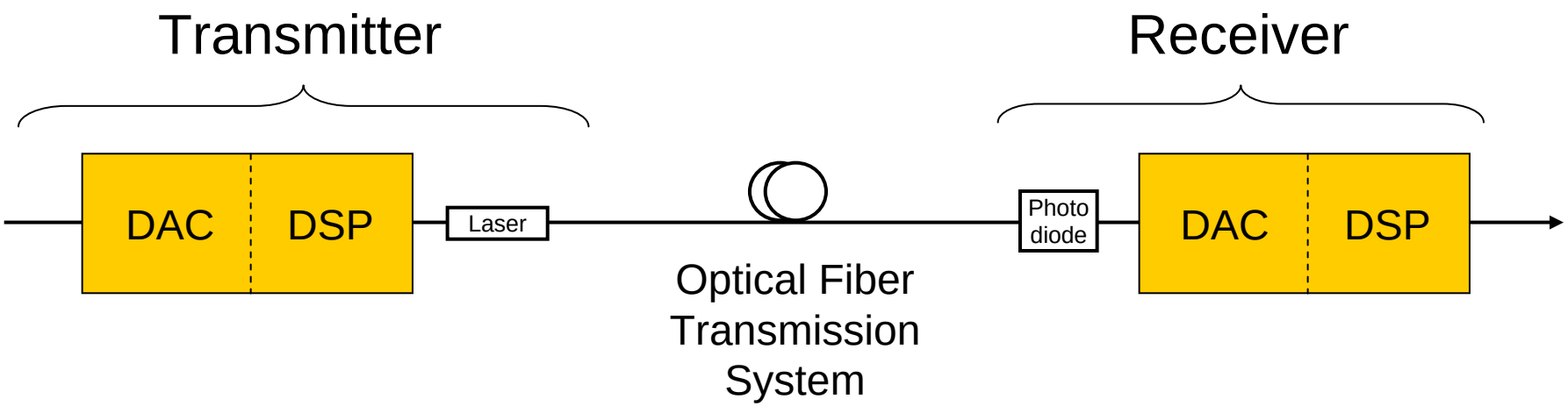
- Inexpensive optical components
  - Single, low-bandwidth photodiode
  - Single, direct modulated laser
- Discrete Multi-Tone (DMT), or similar
- Digital signal processing



- Key: ADC/DAC & DSP, Silicon Photonics, Packaging
  - Technology development
  - Standardization

DMT – First Experimental Results

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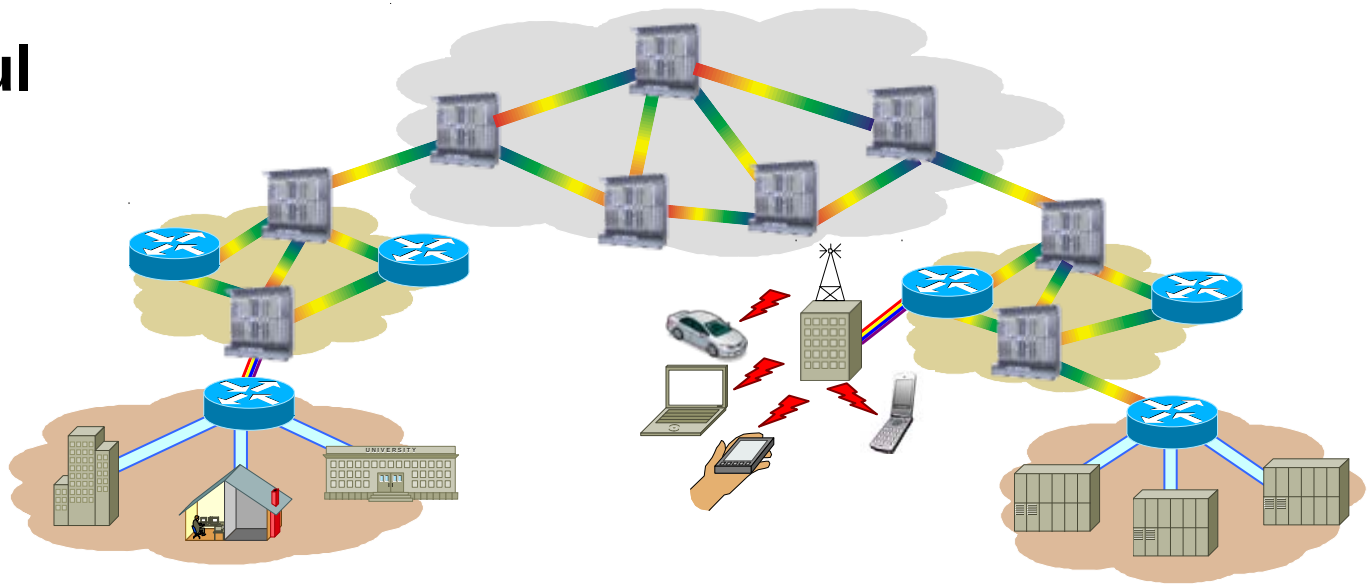
Summary

- Digital signal processing to be introduced at all network levels

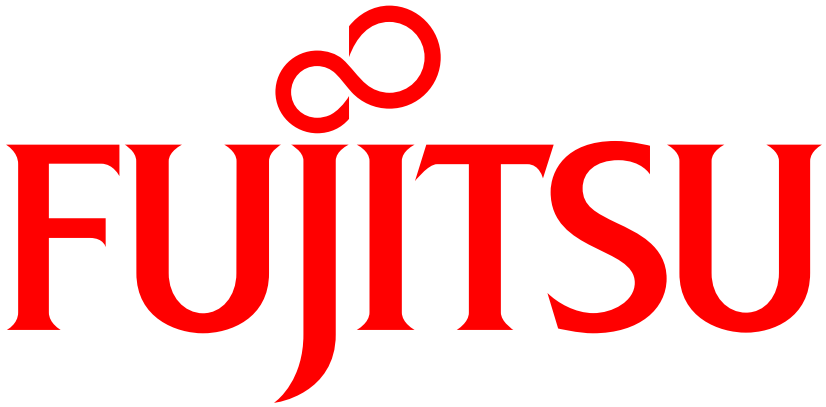
Long-haul

Metro

Access



- Long-haul: Digital optical coherent
- “Shorter” reach (Metro, Access): Digital, but not optical coherent
- Long-haul → Metro → Access: More and more cost sensitive
- Broad market introduction to leverage from economy of scale
  - Technology development (ADC/DAC DSP, Silicon Photonics, Packaging)
  - Standardization



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