Small Form Factor Digital Coherent Optics for Mobile Network Applications

ECOC 2023 – MOPA, Optics for Wireless Networks (Su.B.2)

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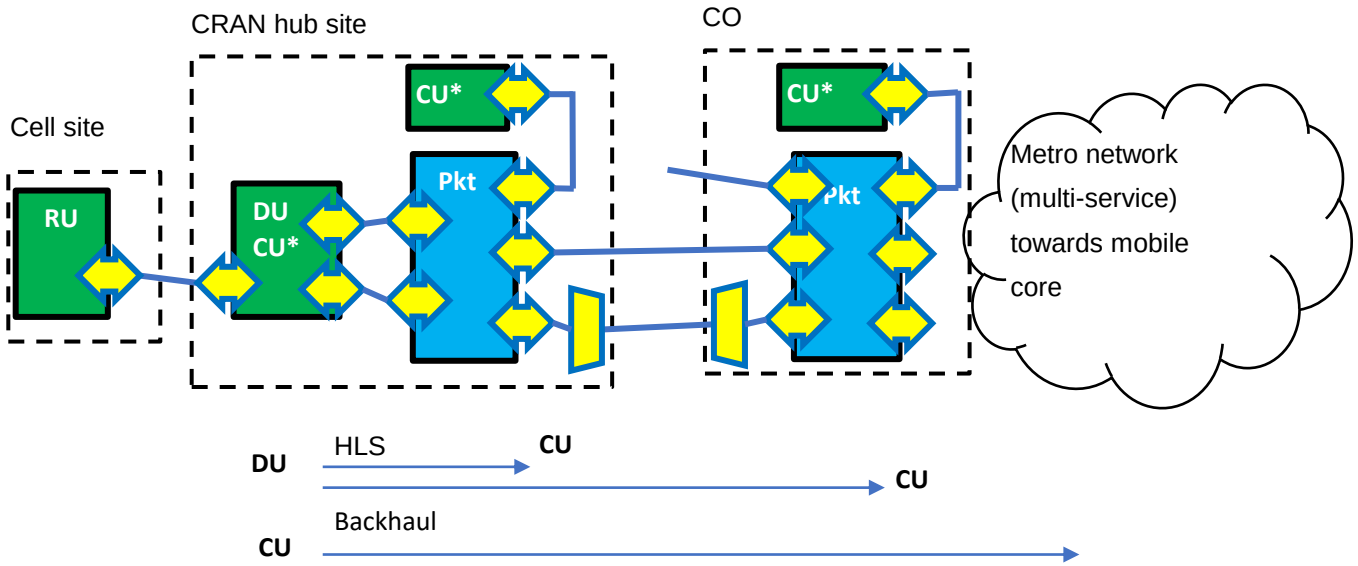
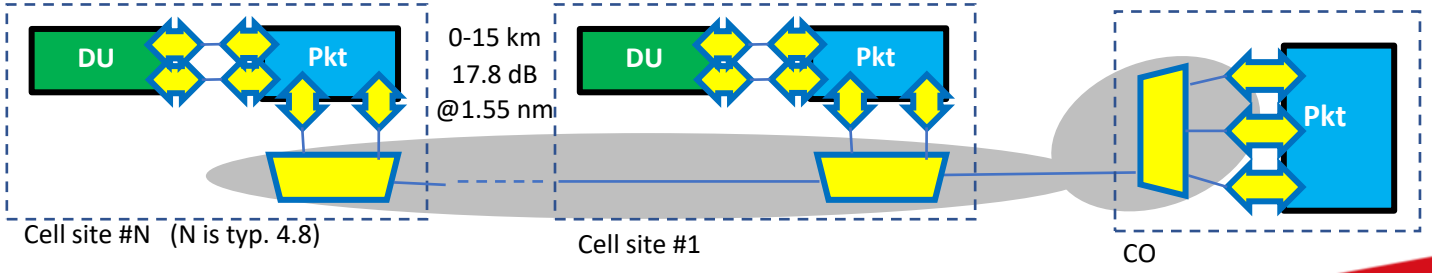
DWDM Optics for Mobile Backhaul

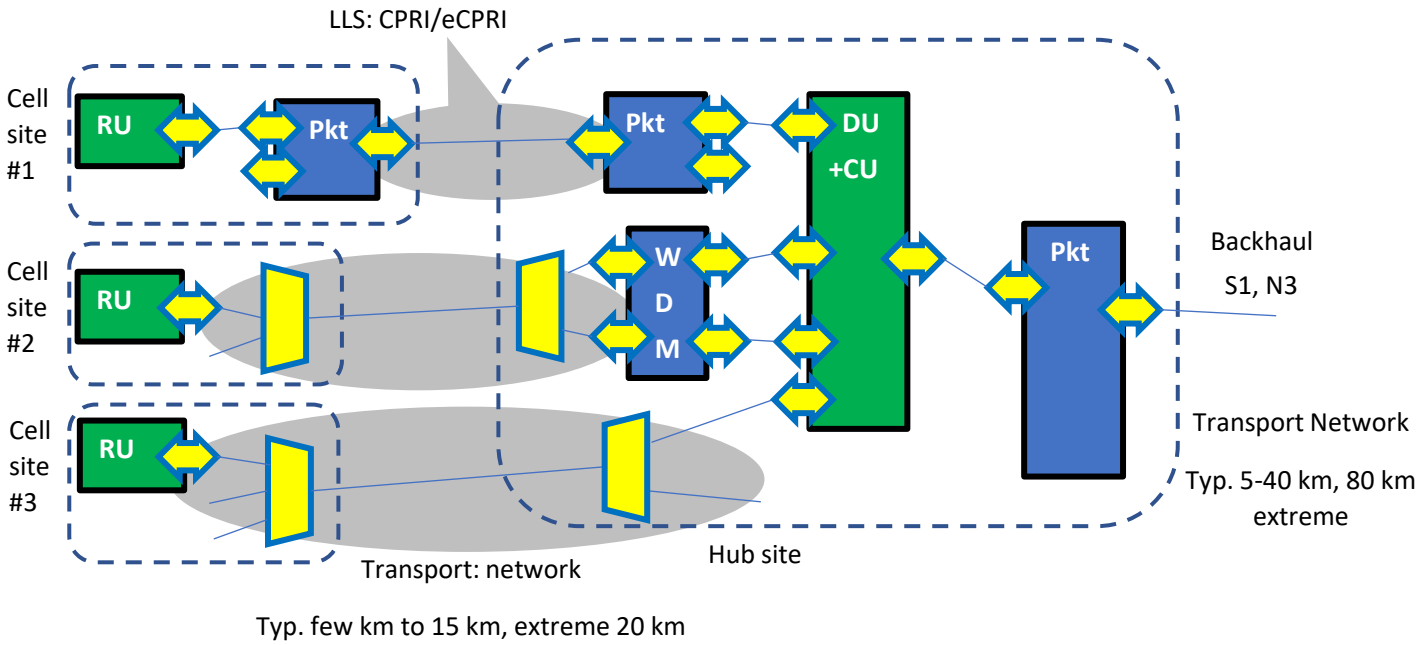


- DWDM transmission is used in scenarios where capacity requirements are high and fiber resources are scarce
- This occured first in mobile backhaul, where data from many cell sites is aggregated and distances are longer

Example: DRAN backhaul, passive DWDM bus

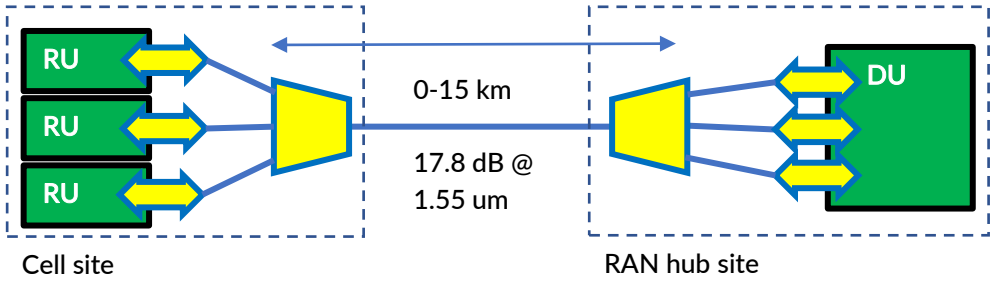


DWDM Optics for Centralized RAN



- As mobile networks migrate to CRAN architectures with centralization of DUs in a common location, capacity requirements and distances increase also in fronthaul

Example: CRAN RU-DU, passive DWDM



Limitations of DWDM IM-DD Transceivers

- Current DWDM solutions for mobile networks use Intensity-Modulated Direct-Detection (IM-DD) transceivers
- As data rates increase, use of IM-DD becomes challenging
  - Rx sensitivity degrades inversely proportional to the symbol rate
  - Chromatic dispersion (CD) tolerance scales inversely proportional to the square of the symbol rate (80km for 10G NRZ → 15km for 25G NRZ)
  - Inserting tunable chromatic dispersion compensation, either in the transceiver or in the link, adds significant cost and complexity, and leads to increased optical losses
  - More complex IM-DD modulation formats like PAM4 can partially alleviate the CD limitations, but result in further degradation of Rx sensitivity and loss budget

See Mobile Optical Pluggables Alliance (MOPA) Technical Paper, Version 2.2 (October 1, 2023), Section 11.2 “Cost effective high-capacity transceivers”

Digital Coherent Optics (DCO) Transceivers for Mobile Network Applications

- Coherent transmission addresses limitations of IM-DD solutions:
  - Rx signal is mixed with light from local oscillator (LO) laser, resulting in enhanced Rx sensitivity and improved Rx OSNR tolerance
  - Detection of not only amplitude, but also phase and polarization information allows for advanced compensation schemes in a digital signal processor (DSP), virtually removing any penalty due to chromatic dispersion (CD) and other link impairments
- Coherent transmission was first employed in long-haul networks
- Advances in technology have successively reduced size, power dissipation, and cost of digital coherent optics (DCO) transceivers
  - 100G DCO transceivers are now becoming available in the same form factor (QSFP28) and with similar power dissipation (5W) as 100G IM-DD solutions
- Multiple standards have been developed to ensure multi-vendor interoperability, e.g.
  - ITU-T G.709.2 / G.698.2 DW50U-8A2(C)F
  - IEEE Std. 802.3-2022 100GBASE-ZR
  - CableLabs P2PCO-SP-PHYv1.0-I03-200501

100G ZR QSFP28-DCO

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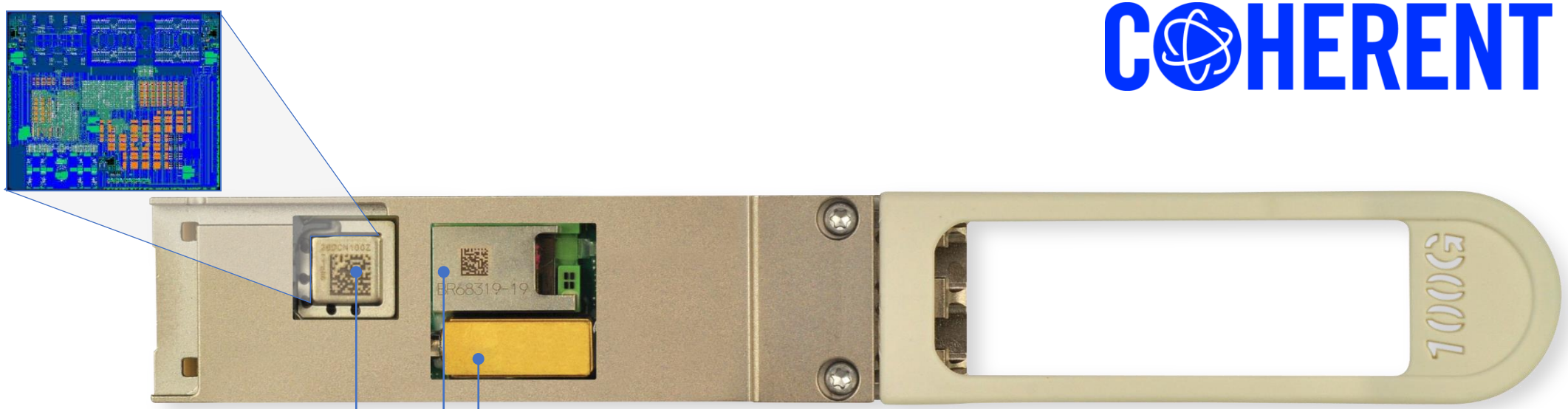


Steelerton™ DSP purpose-built for small size and low power consumption

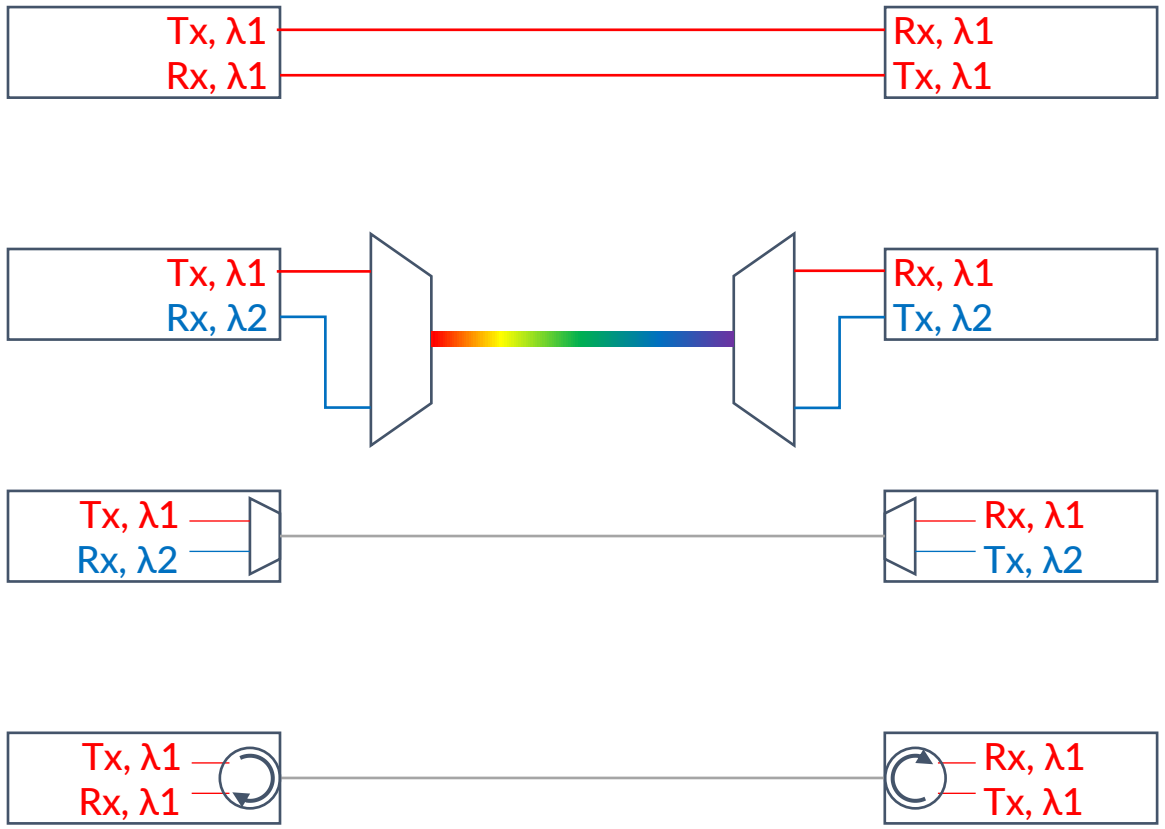
Purpose-built power-optimized tunable laser

Highly integrated silicon photonics PIC

2023 LIGHTWAVE 5.0 INNOVATION REVIEWS

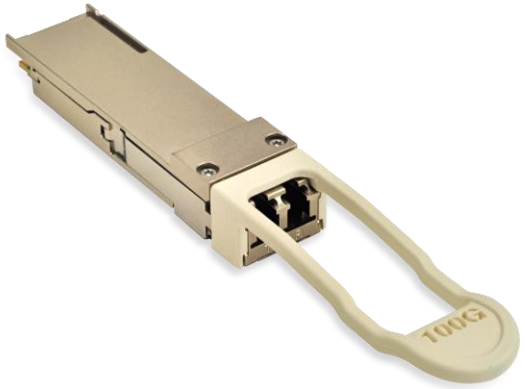
Areas for Further Study within MOPA

- **Bi-directional transmission over single fiber**
  - Typical DCO transceivers use shared laser for Tx and Rx, so upstream and downstream signals use same wavelength
  - Separating lasers for Tx and Rx allows upstream and downstream signals to be combined onto a single fiber using a wavelength mux/demux (either internally or externally to the transceiver), but increases power consumption and cost
  - Using a circulator to combine/separate upstream and downstream signals adds little cost, but increases sensitivity to multi-path interference
- **Transceiver latency requirements for time synchronization using IEEE 1588 PTP**
  - Many DSPs add significant uncertainty to Tx and Rx propagation delays
  - Minimizing this uncertainty requires careful DSP design



Conclusion

Advances in small form factor Digital Coherent Optics (DCO) transceivers will ensure capacity and reach increases for fiber scarce mobile backhaul and centralized RAN networks can be supported for many years to come



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Come see our live demo at the ECOC Exhibition in booth # 406!