Agile 400G-800G Optical Networking
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Factors influencing design of coherent optical solutions

- Equivalent 100G port capacity experiencing double digit growth YoY, no sign of slowing down
- Dependence on coherent technology innovations to drive cost / bit reductions

Ovum, Optical Networks Forecast: 2018 – 2023, Jan 2019

Representative cost of optical transport capacity over time and transponder generations based on historical average sales price (ASP) of DWDM line card data from Ovum.
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• Dependence on software and automation for successful network evolution
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- Client rates evolving from 100GbE to 400GbE

Expected introduction and growth of 400GbE LR8/RL4 clients

LightCounting Optical Components Market Forecast, April 2019
Two Types of Solutions Emerging for Transmission Cost Reduction

**PERFORMANCE - OPTIMIZED**
- Lowest $/bit per km
- Maximum fiber capacity using least # of modems
- Ability to maximize optical layer automation

**FOOTPRINT - OPTIMIZED**
- Designed to fit within specific power envelope
- Opportunity for packet-optical integration efficiencies
- Brings coherent to access applications

Most important element: DSP

But you also need high bandwidth E/O

Most important element: photonic integration

But you also need small footprint DSP
Design Choices

CMOS – Technology Node

- 7nm FinFET
- Maturity – full production
- **Benefits:**
  - Higher transistor density
  - Smaller die
  - More functions for less power
- **Considerations:**
  - Significant cost for mask tooling
  - Challenging high performance analog design

SiP or InP Photonic Integration

- **Silicon Photonics**
  - Volume # dies/wafer
  - Non-hermetic packaging
  - Cost reduction
- **Indium Phosphide**
  - Required for performance at high baud (>70Gbd)
  - Moving forward:
    - “Integration” of SiP and InP provide best of both material systems

System Requirements

- **Enabling SW Automation**
  - Variable capacity rate
  - Variable baud
  - Real-time link Monitoring
- **Encryption**
- **Low-latency FEC** for time-sensitive applications

Holistic design approach provides optimized system performance
Design choices - baud

• Baud Selection:
  • Based on throughput objective and achievable distance for throughput based on representative network characteristics
  • Throughput selected based on expected client rates
    • Ex. 90-100Gbd for 100GE/400GE rates
    • 800G at 100km, 400G at >1,500km

• Considerations:
  • High-speed DAC/ADC operating at appropriate sampling rate
  • High-bandwidth electro-optics
  • FEC algorithm and coding will dictate spectral efficiency, performance
  • Time to market will depend on control over all aspects of the solution

• System implications:
  • At single wave 400G and above, >50GHz spectrum is required → flex grid WSS
  • Higher baud → more channel spectrum
  • Appropriate software applications for spectral assignment / routing critical moving forward

• Example of networking benefits:

![NA Backbone Analysis](image)

- Ave ch. (G)
- Ave S.E. (b/s/Hz)
Network benefits example of next generation coherent technology
Based on Analysis of existing Network

- Analysis completed to determine networking benefits by evolving from 100G fixed grid network to new coherent modem technologies

- Pan Euro network:
  - A: London – Amsterdam (450km)
  - B: Dublin – Amsterdam (1400km)

- Higher baud
  - Fewer wavelengths to deploy/manage
  - Reduced cost/bit

- More fiber capacity – extending life of existing asset
## Summary

### Key Takeaways

1. Upcoming advancements in both DSP and electro-optics will continue to drive down cost/bit: 7nm FinFET, miniaturization of electro-optics with SiP and InP promise significant benefits.

2. Increasing baud reduces networking costs; design and time-to-market dependent on high speed converters and high bandwidth electro-optics.

3. At single wave 400G and above, flexible grid network required. Moving forward, software applications for simple spectral assignment and routing are essential.

4. Co-design of both DSP and electro-optics provides advantages in both system performance and time-to-market.
Thank You