Optical Internetworking Forum's 100G Activities

Future of Optical Networking
Lightwave e-conference
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ciena

OIF OPTICAL INTERNETWORKING FORUM

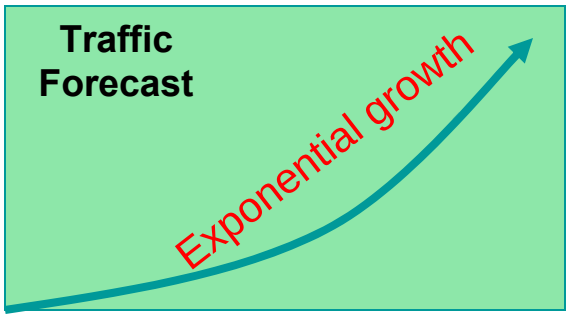
Agenda

- What is driving the next generation networks?
- The OIF's approach for 100G DWDM ULH
- Beyond 100G – How should it be approached?

Direction from the OIF Carrier Working Group

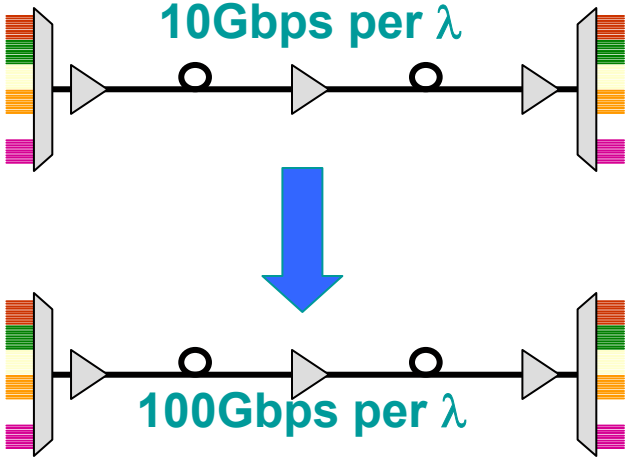
Traffic Challenges

- Exponential growth of backbone traffic
  - Trend expected to continue
  - Pricing per bit/λ/km is declining
- Transport native 100G signals
  - 100G links interconnecting routers, switches
  - 100G services



Network Requirements

- Capacity efficiency for LH (>1000km)
  - Continue using existing infrastructure
  - 100G channels in 50 GHz windows
- Lower CAPEX
  - Lower cost per bit than 10G and 40G
- Lower OPEX
  - Number of systems constant
  - Reduced space and power per bit



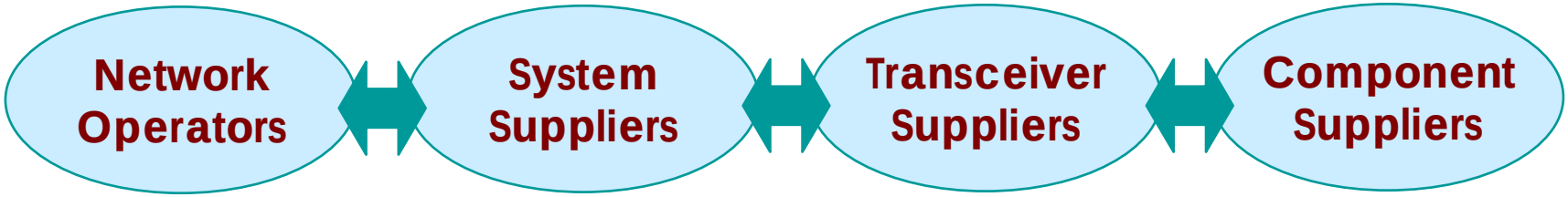
OIF's Role in 100G

Our Objective:

Foster an eco system to accelerate the availability of economically attractive 100G transmission solutions for ULH DWDM networks

Our Approach:

For speeds lower than 100G the innovations could be tackled separately

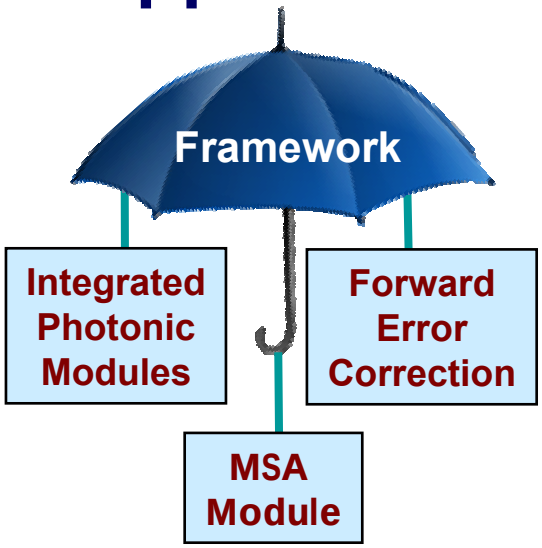


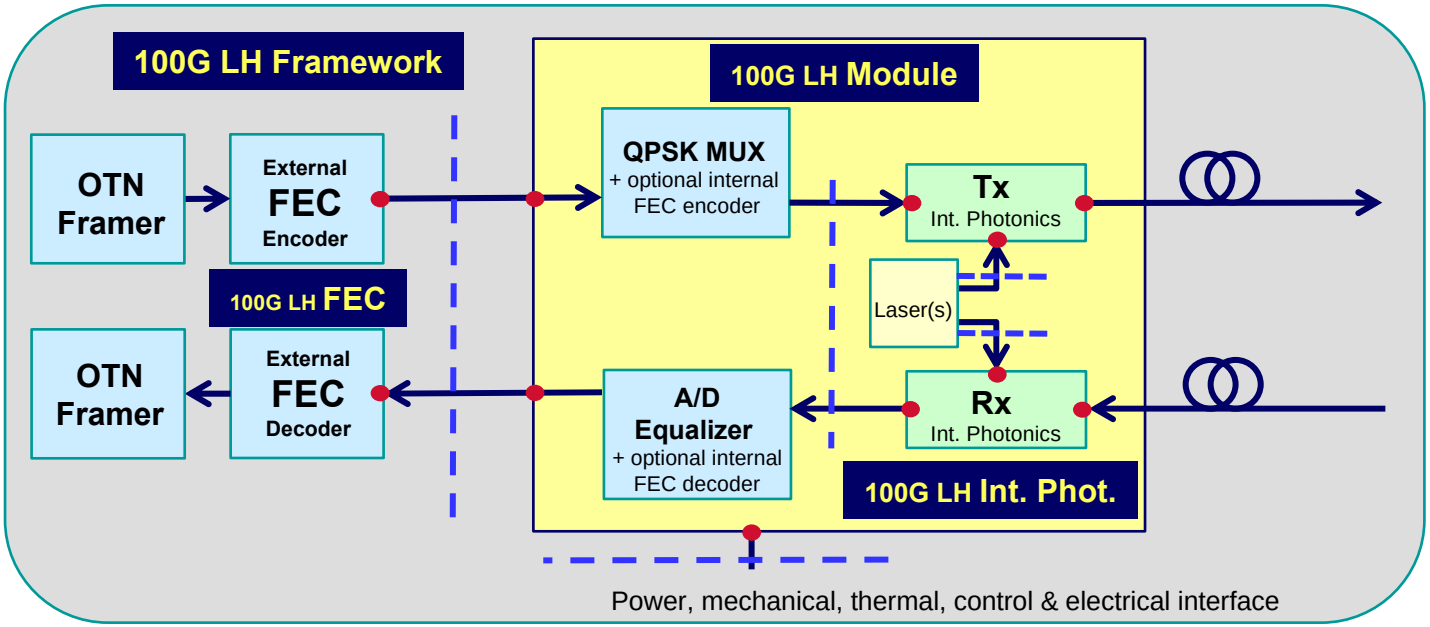
But at 100G, the innovations required coupling from all levels of the eco system to arrive at a viable solution

OIF's 100G DWDM Project Approach

Our Approach

- Select an application target – Core backbone networks
- Build upon IEEE and ITU-T standards
- Agree on modulation format
- Identify key technology building blocks and interfaces
- Develop IAs among building blocks
- Develop Implementation Agreements (IA) for MSA transceiver module and integrated photonics module
- Note that "Line side" DWDM system interoperability is not a current objective

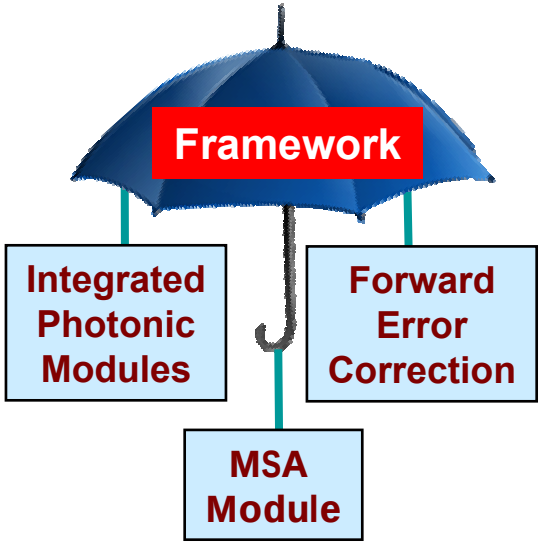


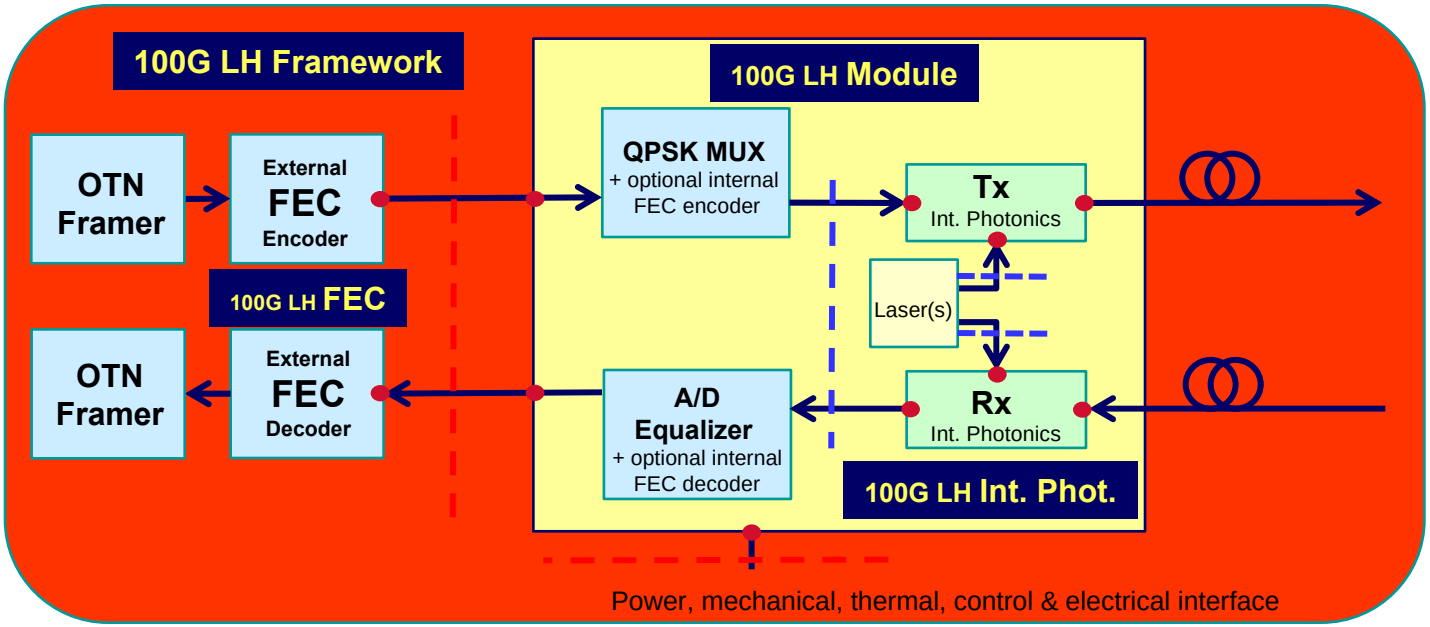


OIF's 100G DWDM Framework

Framework

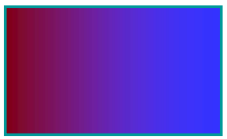
- Starts with carrier requirements
- Creates consistent interfaces between blocks
- Provides:
  - An application description
  - A high level transceiver architecture
  - A transceiver modular decomposition



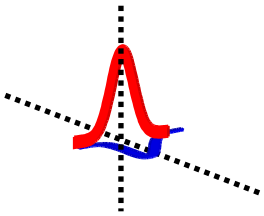


100G Modulation Format

Dual Polarization

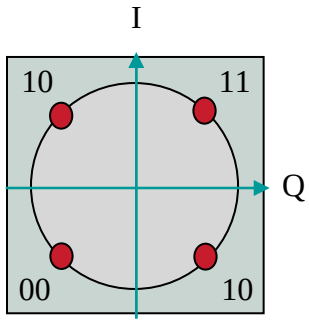


Filter Width
200 GHz
~ 2 Tb/s per system



Quadrature Phase Shift Keying

Filter Width
100 GHz
~ 4 Tb/s per system



Filter Width
50 GHz
~ 8 Tb/s per system

1 X 100 G

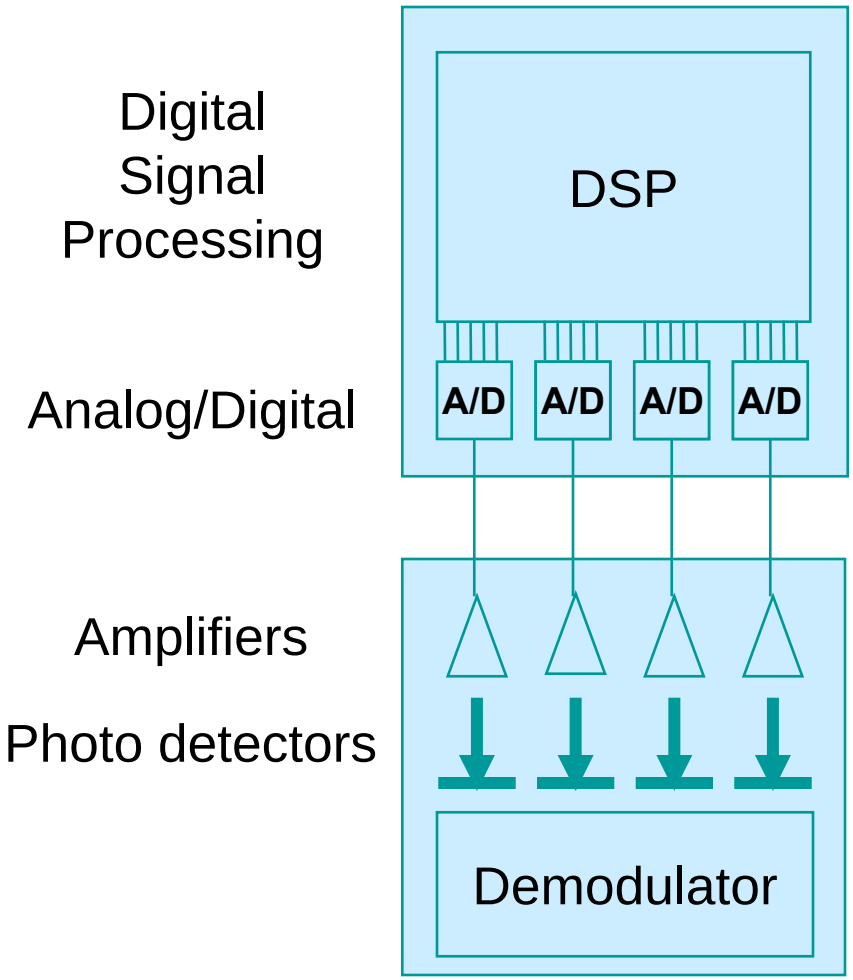
2 X 50 G

4 X 25 G

Trade speed for parallelism, then attack parallel complexity with photonic integration

- **Two independent polarizations**
  - **Same optical frequency**
  - **Halves the data rate**
  - **Halves the spectral width**
  - **Doubles components**
- **Data encoded into 4 phase states**
  - **Phase symbol – 2 bits of data**
  - **Halves the symbol rate**
  - **Halves the spectral width**
  - **Doubles components**

Coherent Receiver



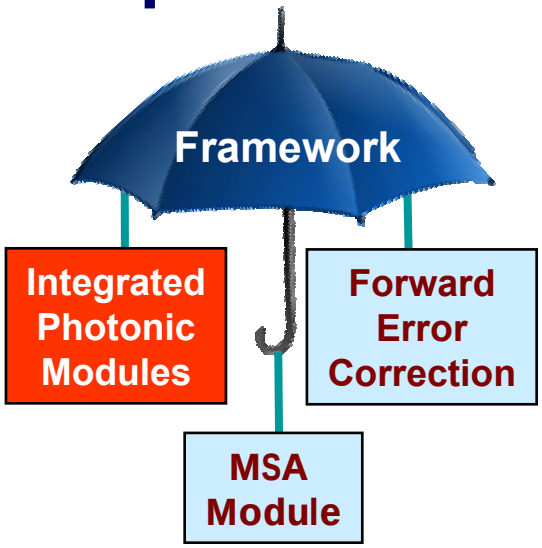
- **Improved signal/noise ratio**
- **Preserves optical phase info**
- **Electronic solution for**
  - **polarization separation**
  - **phase resolution**
  - **chromatic dispersion**
  - **polarization mode dispersion (PMD)**
- **Silicon economics**

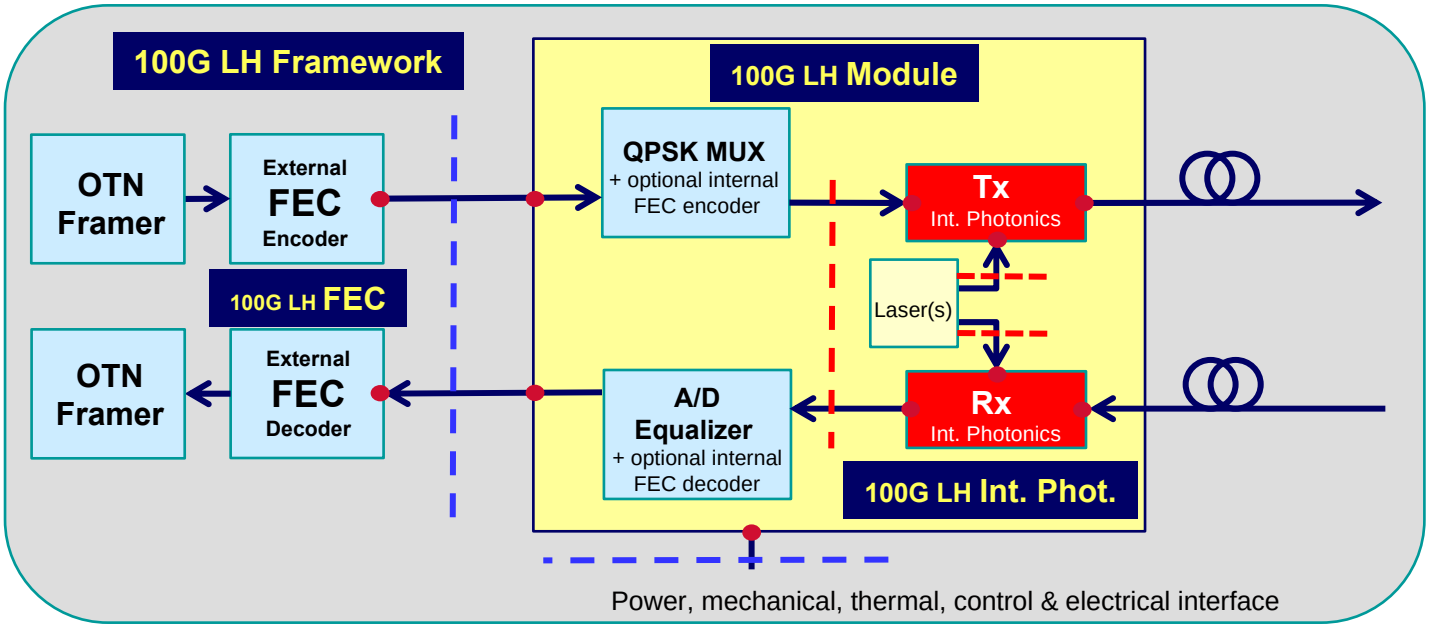
OIF's 100G DWDM Photonic Components

Framework

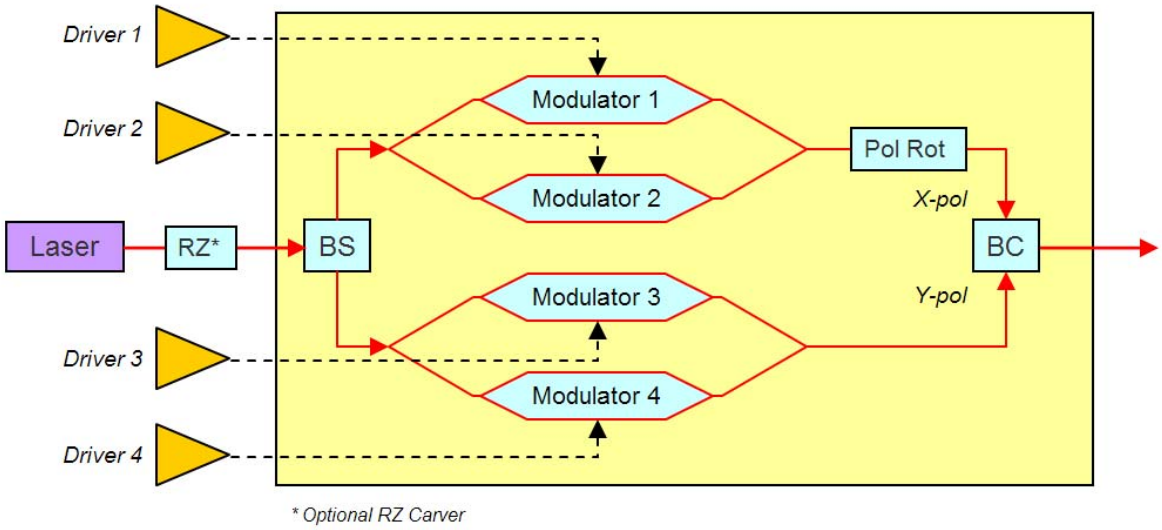
Integrated Photonic Modules

- Define the blocks and their key interfaces
  - Transmitter Module IA
  - Receiver module IA





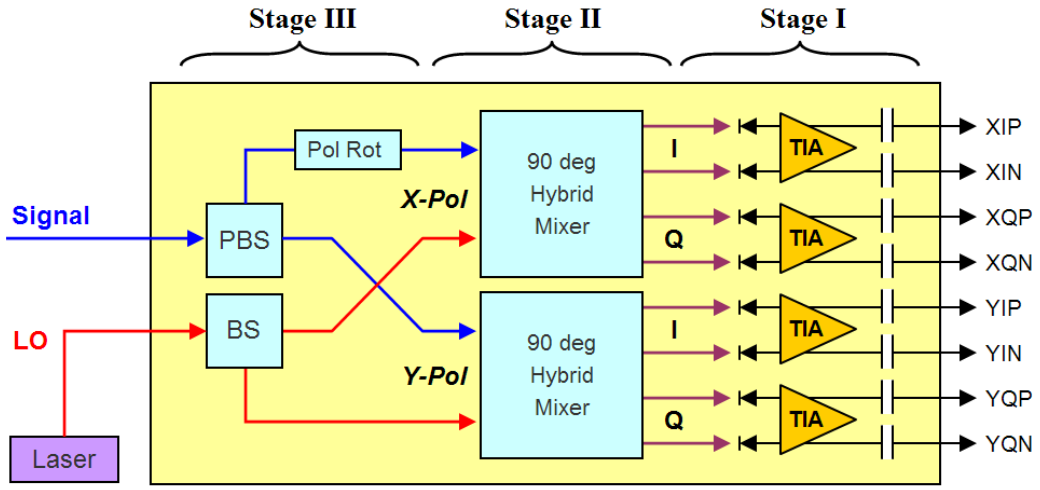
Integrated Photonic Modulator



- **Current photonic transmitter module composition**
  - **Modulators and other optical components integrated**
  - **Integrated drivers on separate module(s)**
  - **Transmit laser using OIF ITLA***
- **Future possibility of further integration**

*Integratable Tunable Laser Assembly Implementation Agreement

Integrated Photonic Demodulator/Receiver

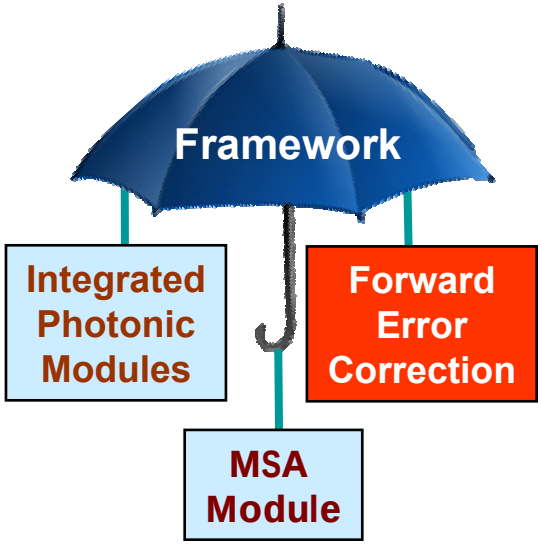


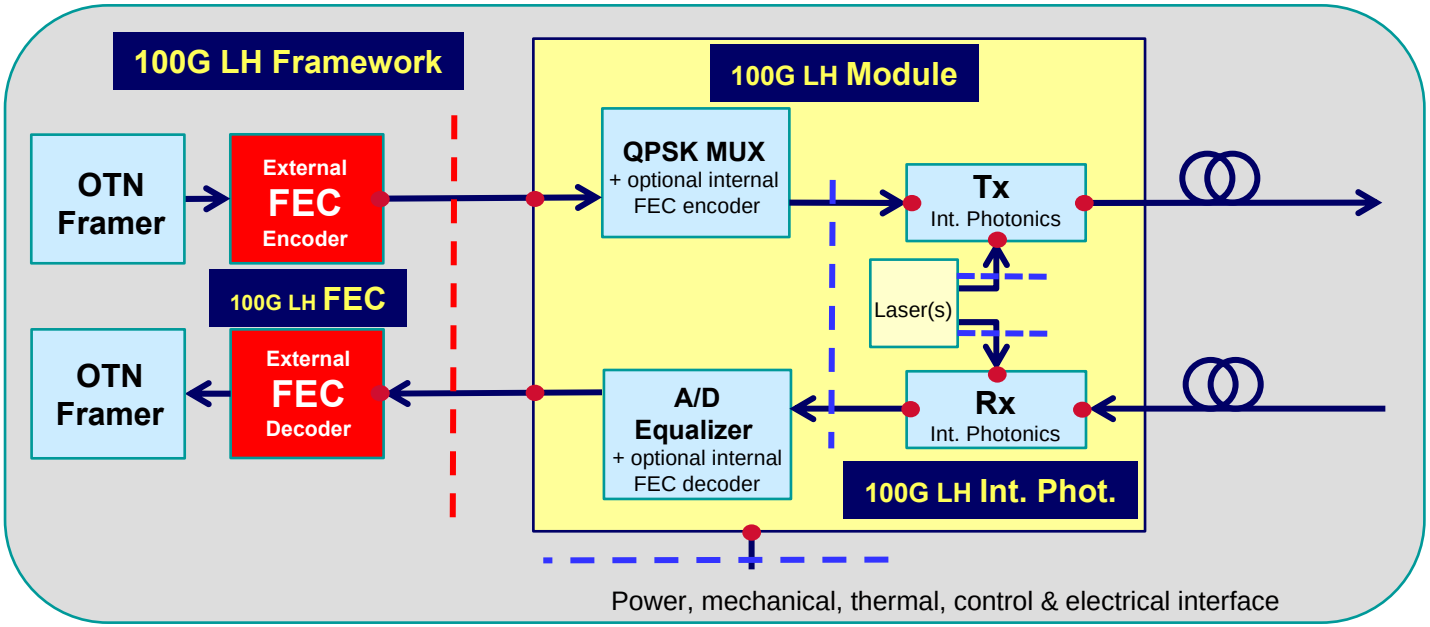
- **Current photonic receiver module composition**
  - **Beam splitters, hybrids, photodetectors and TIAs**
  - **Separate local oscillator based on OIF ITLA**

OIF's 100G DWDM Forward Error Correction

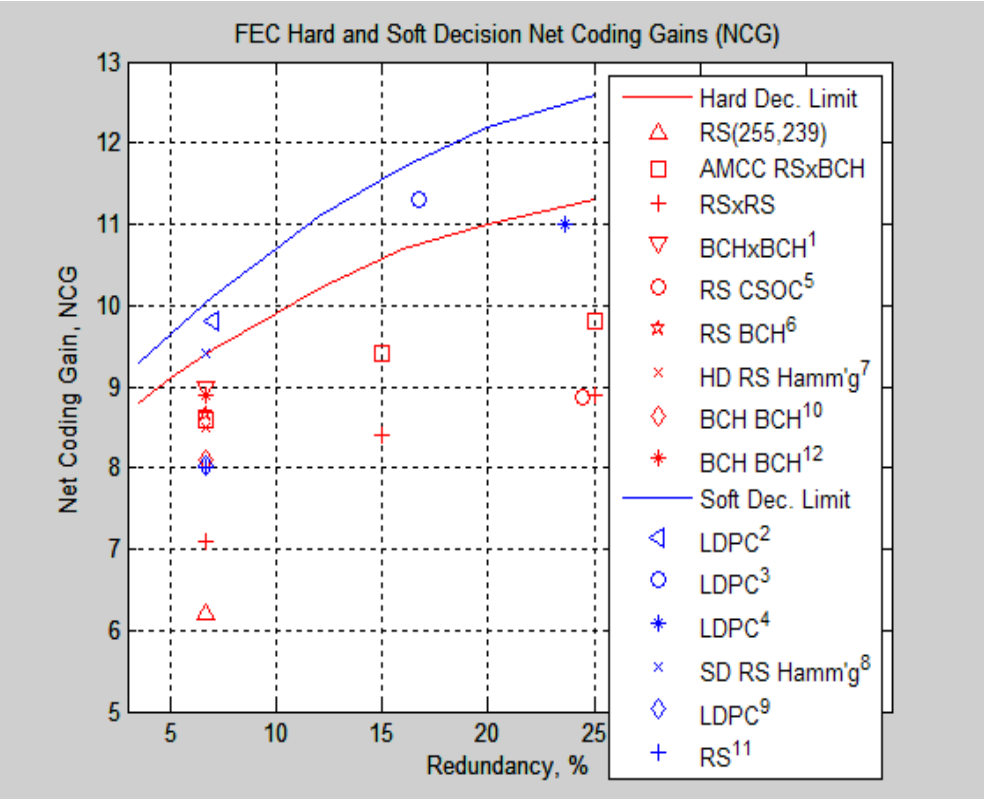
Framework
Integrated Photonic Modules
Forward Error Correction

- Determine the needs for FEC in the LH link
- Develop a channel model to answer key questions
- Study coding approaches
- Develop performance estimates





Forward Error Correction for 100G



- **ITU standard FEC (G.975)**
  - Not mandatory
  - Basis for interoperability
  - Coding gain about 6db
  - ~ 7% overhead
- **Enhanced FEC codes**
  - Widely used at 10G and 40G
  - Many solutions available
  - Coding gain 8-9 db (7% OH)
- **OIF 100G FEC studies**
  - Higher overhead rates
  - Impact of 50 GHz optical filters
  - Soft decision* vs. hard decision decoding

***Soft decision error correction decoding operates on more detailed signal level information than does hard decision decoding, in which an information symbol is either a "0" or "1"**

OIF's 100G DWDM MSA Module

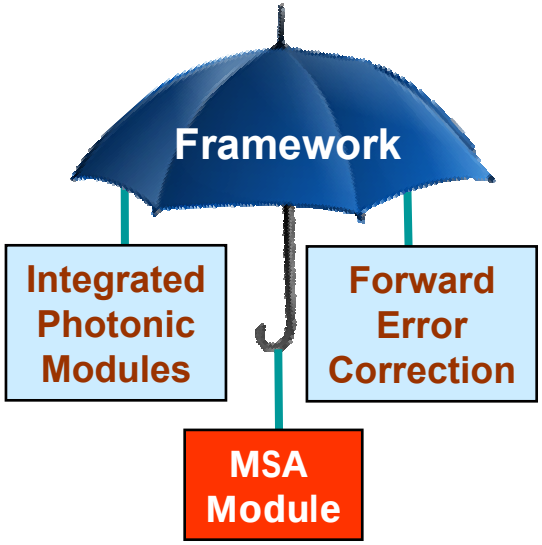
Framework

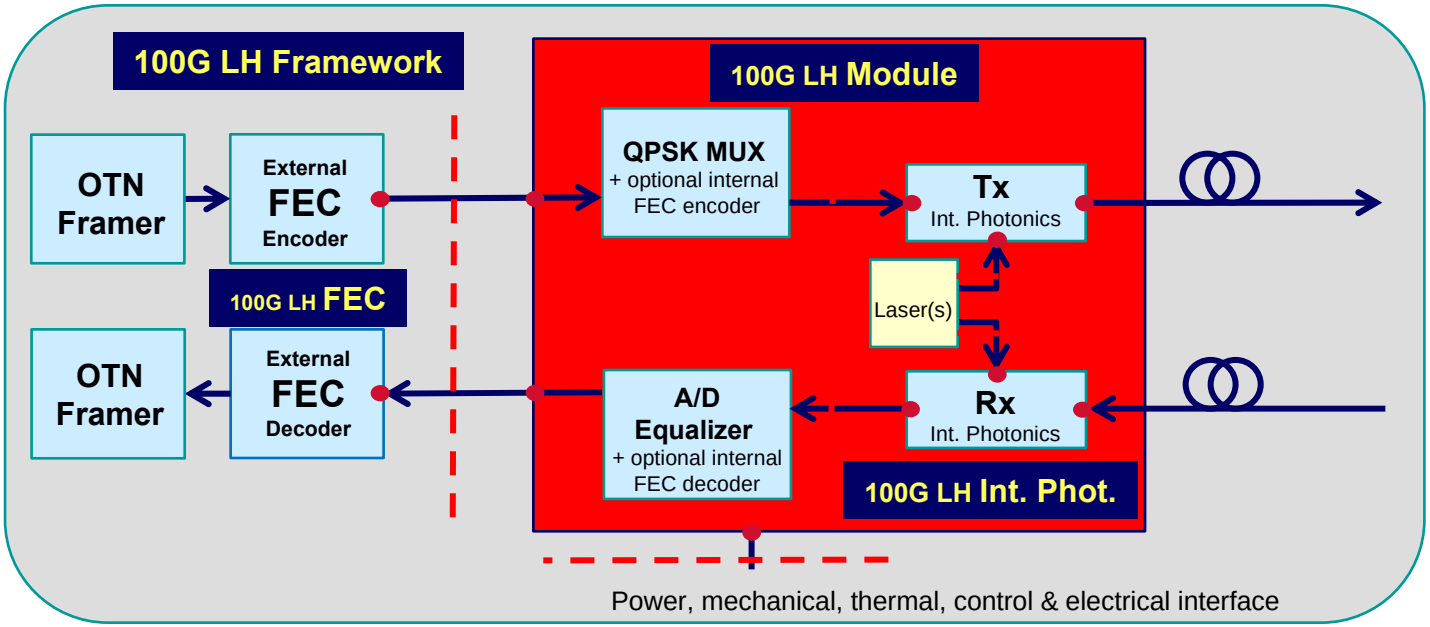
Integrated Photonic Modules

MSA Module

Define a modulation independent module

- Mechanical dimensions, electrical connector
- Max power consumption
- High speed data & management interfaces

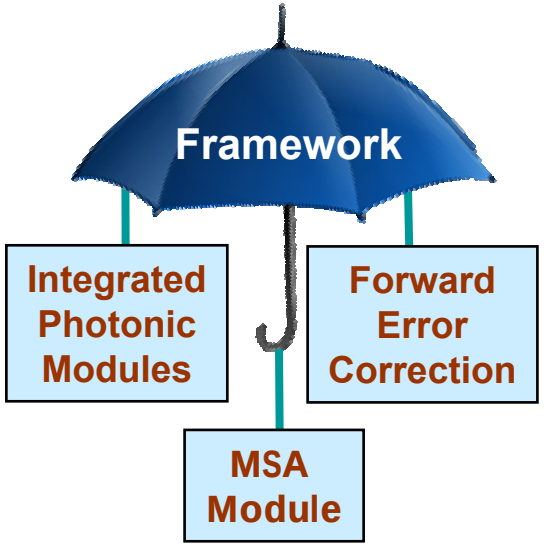


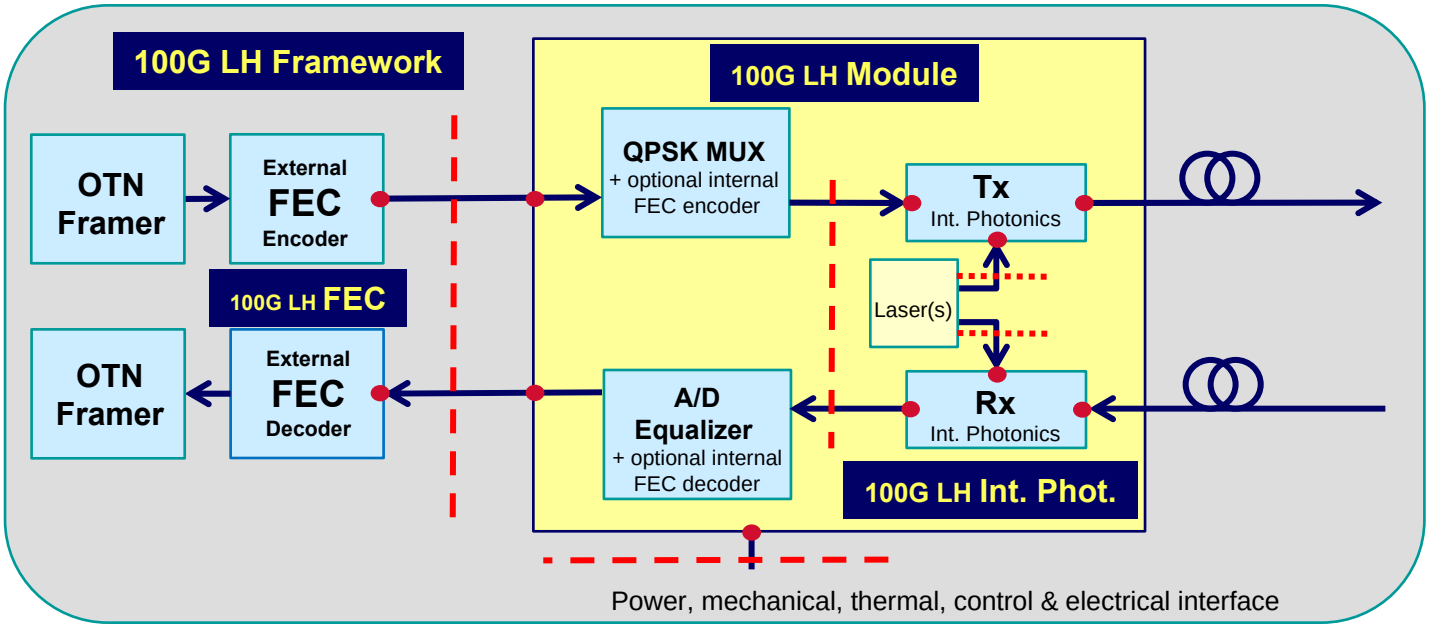


Summary : OIF 100G Project Structure

Result

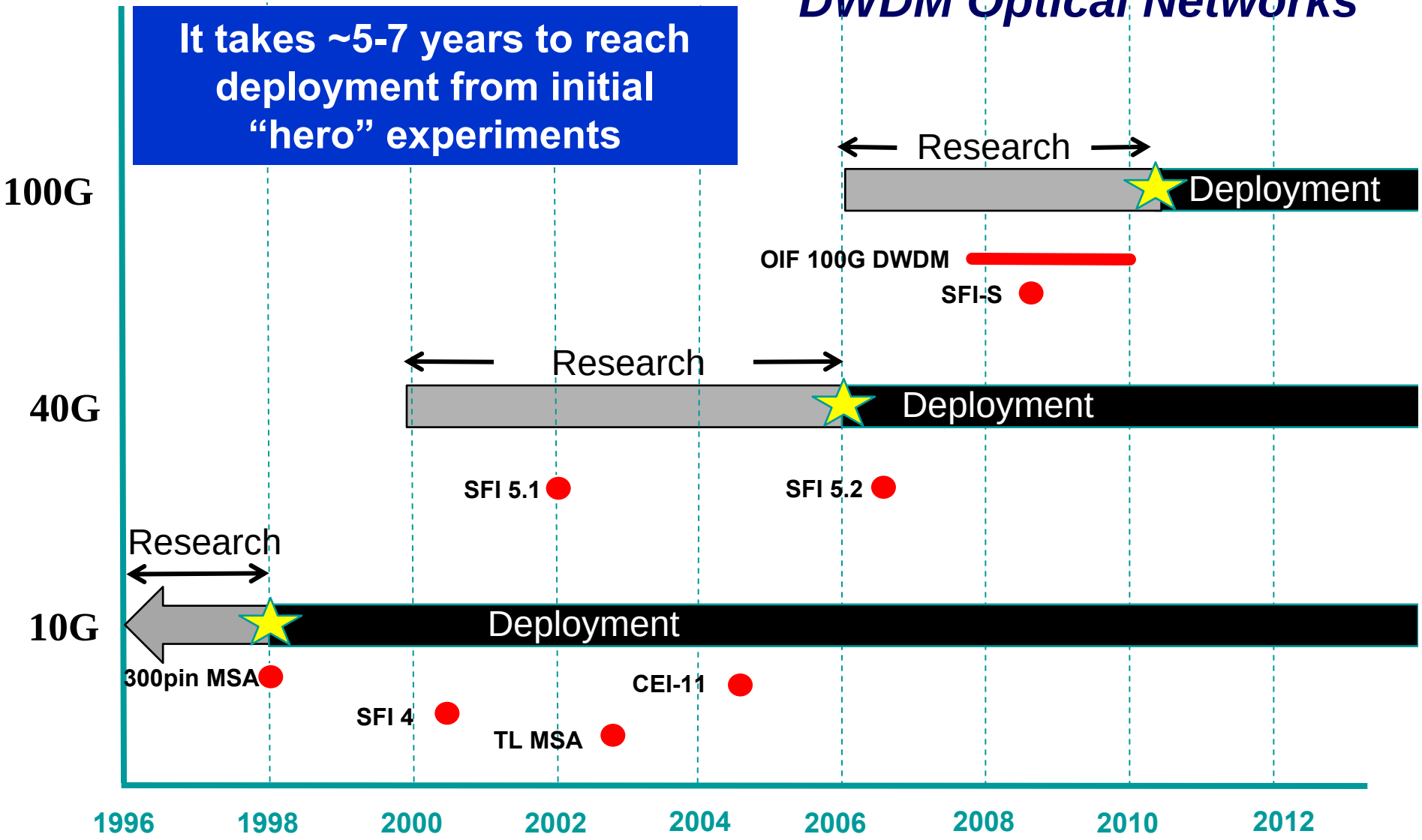
A closely coupled set of projects which enables an eco system to provide products which meet the carriers' needs for 100G LH DWDM transport





Historical Perspective: Research to Deployment

DWDM Optical Networks



Challenges beyond 100G DWDM are even more difficult

- Moving from 40G to 100G LH with the existing infrastructure, resulted in a -4dB OSNR deficit
  - The OIF's solution compensates for this deficit through the application of higher gain FEC, advanced DSP technologies, and advanced modulation techniques
- Moving beyond 100G LH to increase the capacity results in additional OSNR deficits when using the same infrastructure
  - It appears that there is very little room left for innovations in FEC, DSP, and advanced modulation techniques to compensate
  - Additionally, the narrow 50GHz link pass bands further complicate the picture
  - In fact, it isn't even clear what innovations might be targeted to make required improvements
- Given the 5-7 year delay between hero experiments and product availability, the time to start working on research to find solutions is now

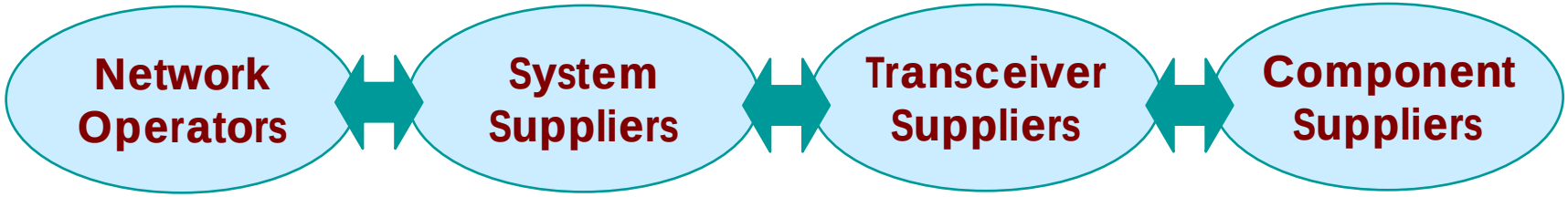
Beyond 100G

What approach should be taken for beyond 100G?

- For speeds below 100G, the innovations could largely be tackled separately
- At 100G, given the carrier requirement of increased capacity using existing infrastructure, many of the innovations (modulation format, FEC, coherent receiver, electronic compensation) have already been employed
- For capacities beyond 100G, it isn't clear to us what tradeoffs or innovations will be required to achieve an economically viable solution. Will it require e.g. new fiber or shorter amplifier spacing?
- But certainly, initiating research and early discussions on performance tradeoffs across the eco system are key

Beyond 100G

The OIF is a great place to collaborate on these challenges because of its membership at all levels of the eco system!



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