

Practical Options for 100G+ Development

Towards Terabits, Leveraging OIF IAs and Standards

Layer 123 Terabit Optical Networking

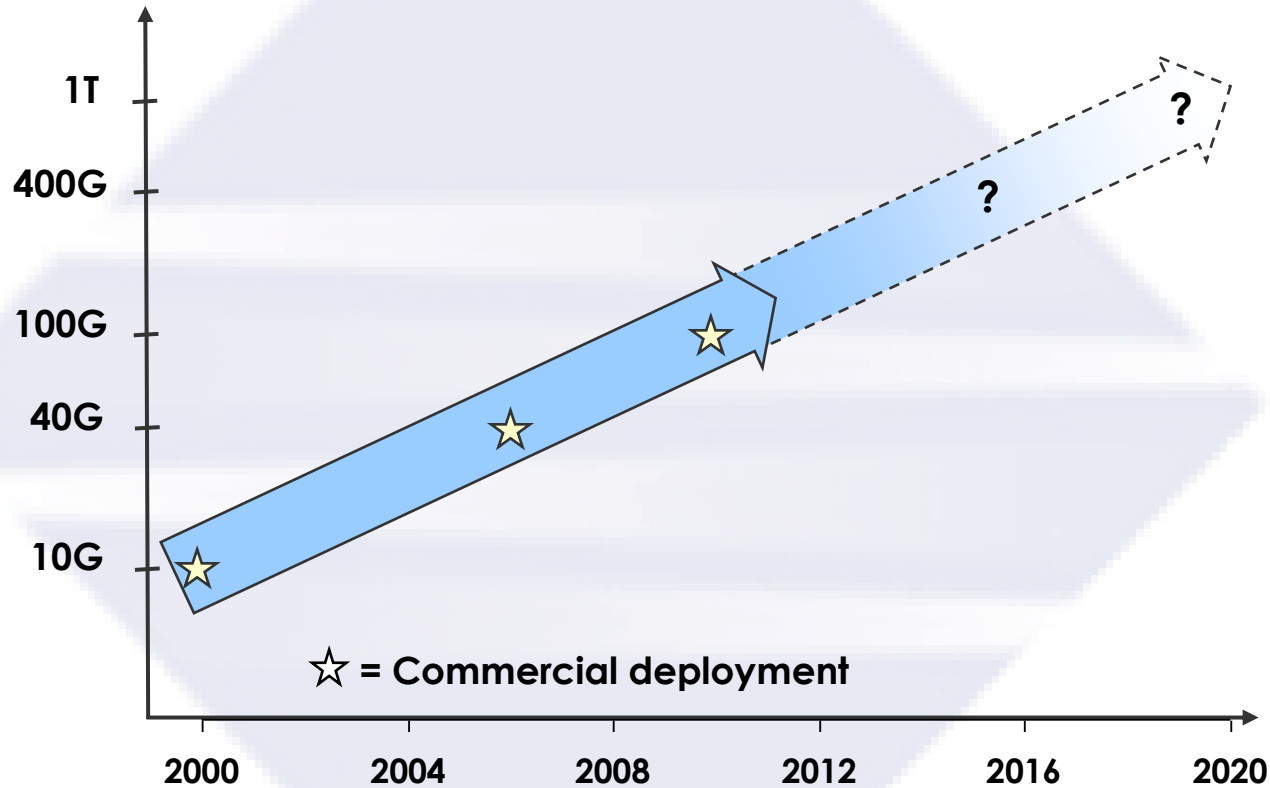
Jim Jones, Alcatel-Lucent
OIF President



Outline

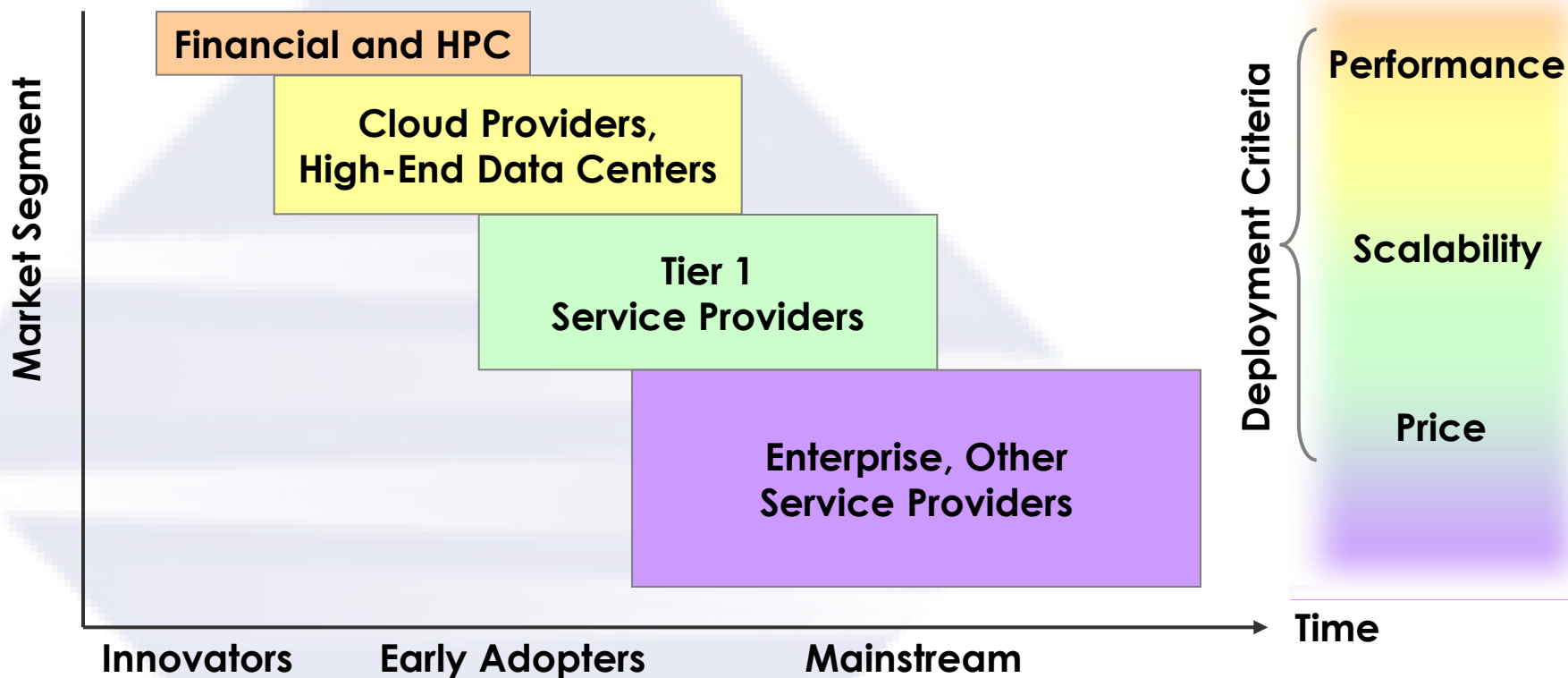
- ◆ **Perspective – Looking Back**
- ◆ **Deployment Strategies**
- ◆ **Anticipated Goals for 100G+**
- ◆ **Leveraging OIF Experience Toward 100G+**
- ◆ **The High-Speed Ecosystem**
- ◆ **Tools in the Toolbox**
- ◆ **Perspective – Looking Forward**

Perspective – Looking Back



Past performance is no guarantee of future returns...

Who Will Buy 100G or 100G+

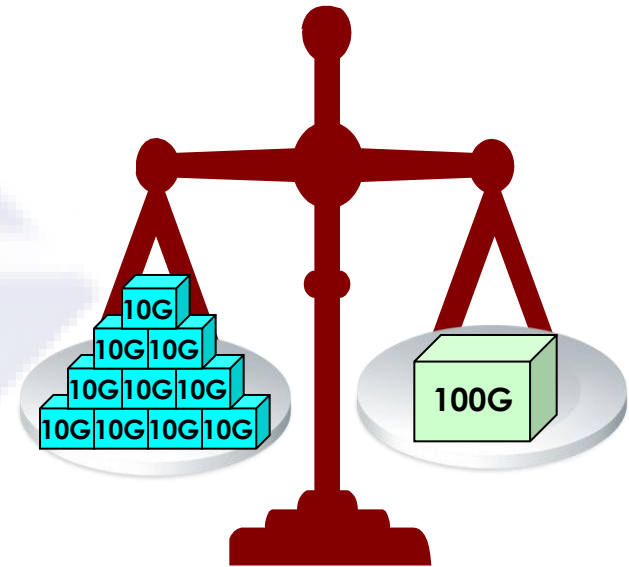


“Get me my 1T pipe please... I would rather have 1T in three years than 400G in two years.”
- Head of Network Services at international stock exchange

“Carriers will buy 100G because they want to, Google will buy 100G because they need to.”
- Michael Howard, Infonetics

Deployment Strategies

- ◆ Many service providers base their 100G plans on port prices (is port price/bit cheaper with 100G than 10G?)
 - **Price parity is a moving target**
- ◆ Total Cost of Ownership (TCO) is more meaningful than port price – it accounts for limitations of parallel 10G systems
 - **To get 100G of usable BW on Nx10G LAG takes $N > 10$**
 - **100G improves Opex and traffic engineering**
- ◆ Availability of 100GbE router interfaces
 - **Seamless router-transport interworking**



Anticipated Goals for 100G+

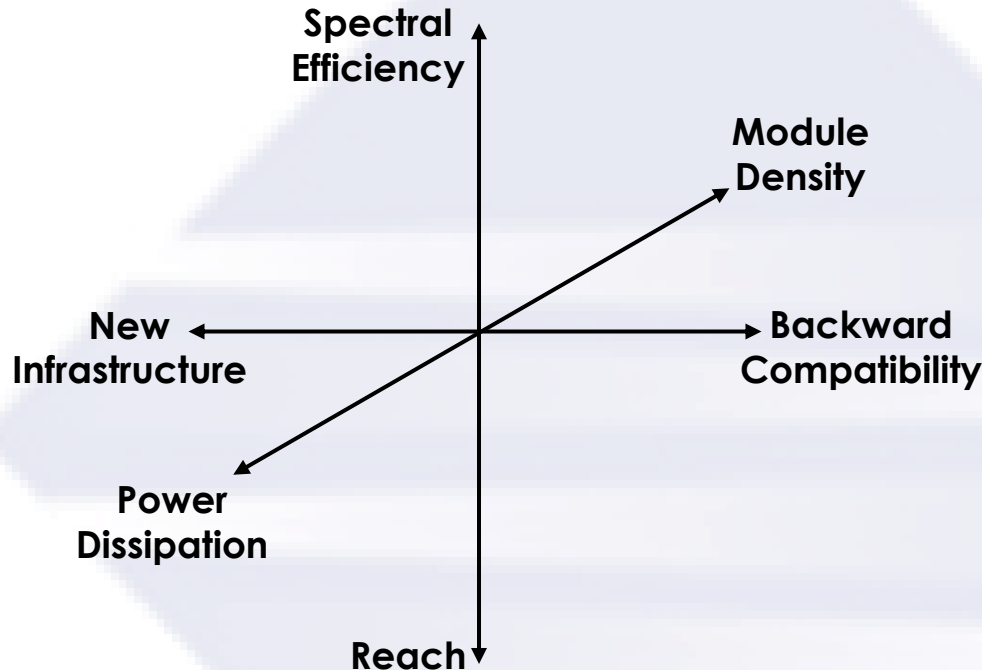
Client Side (LAN)

- ◆ Short reach for data centers, medium reach for metro
- ◆ High module density
- ◆ Available same time as transport I/F

DWDM Side (WAN)

- ◆ Comparable reach/amplifier spacing as 100G
- ◆ Spectral efficiency improvement of at least 2x over 100G
- ◆ Compatible with current infrastructure (fiber, amps, 40/100G)

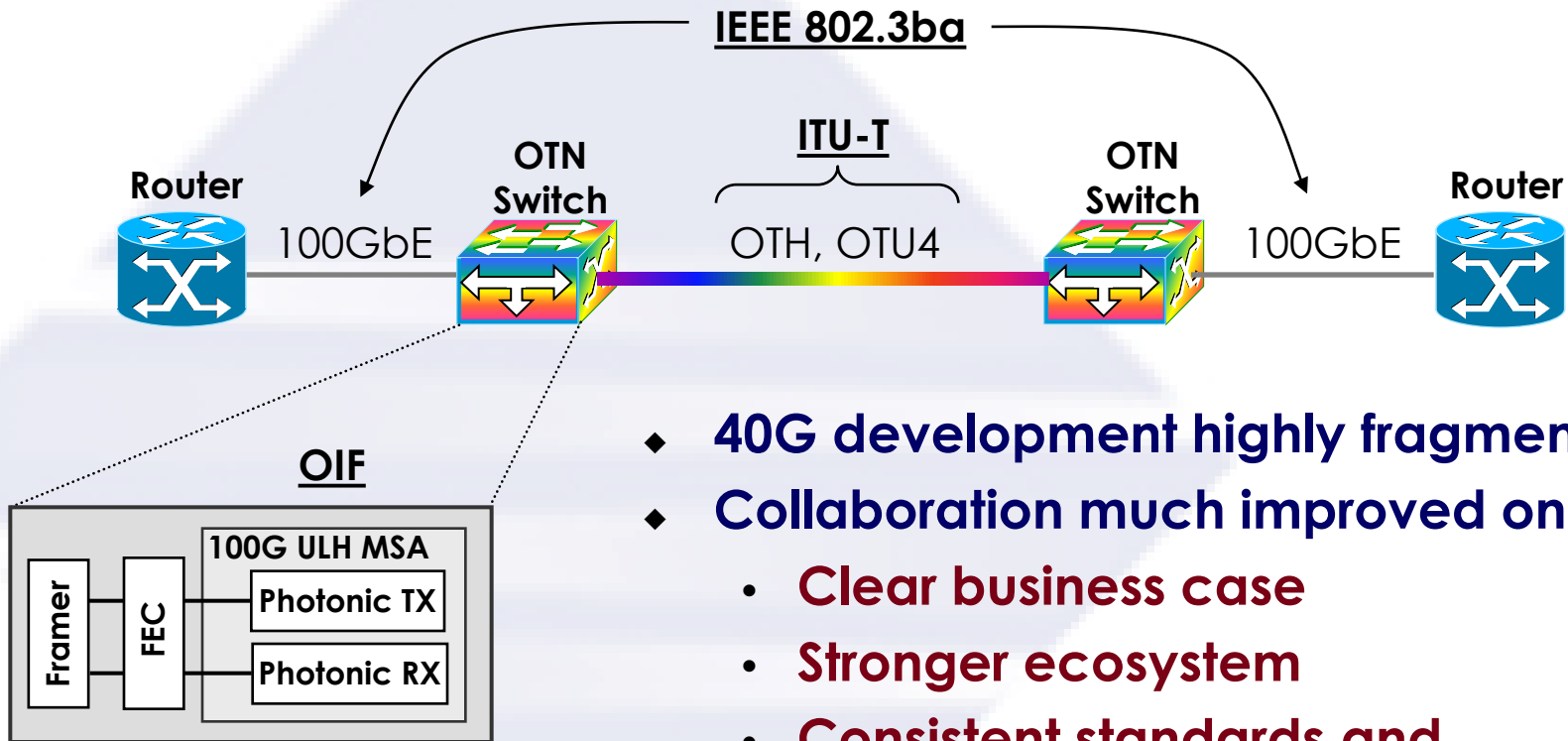
Meeting 100G+ Goals



- ◆ **400G/1T requires much higher noise tolerance**
 - **Or shorter propagation distances than 100G**
- ◆ **We used many of our best tools at 100G**
 - **Some incremental improvements possible**
- ◆ **We need to expand our search for solutions**

Increasing beyond 100G requires more performance tradeoffs – and potentially disruptive technology

How OIF accelerated 100G



- ◆ **40G development highly fragmented**
- ◆ **Collaboration much improved on 100G**
 - **Clear business case**
 - **Stronger ecosystem**
 - **Consistent standards and Implementation Agreements**

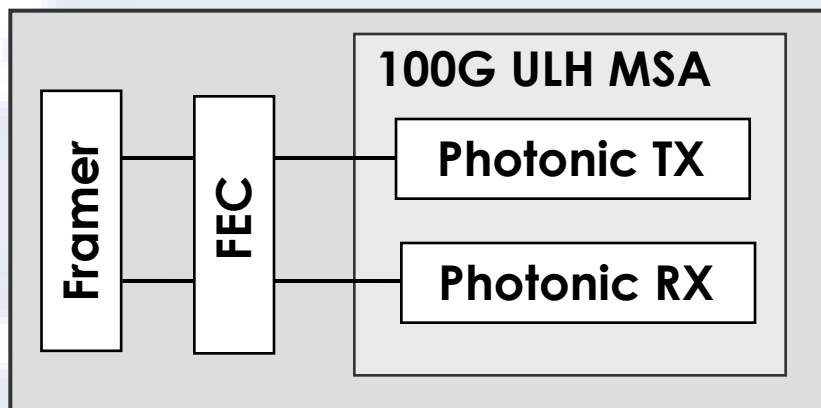
“The point of the OIF framework ...is to keep costs down by pointing vendors in the same direction.”

- Craig Matsumoto, Light Reading

Leveraging OIF Experience Toward 100G+

Common electrical I/O (CEI)

- 25-28G interconnect
- LR, SR, VSR



Forward Error Correction (FEC)

- Soft Decision FEC (SD-FEC)
- Overhead/BER tradeoffs

Module MSA

- Mechanical, power, control

Tx/Rx modules

- Optical parallelism
- High density photonics

System Level Contributions

Service provider requirements

- Traffic levels/business case

Interoperability demos

- Vendor interworking

Thermal management

- Heat dissipation

Tools in the 100G+ Toolbox

Photonic

100G

DP-QPSK modulation
Polarization multiplexing
Coherent transceivers

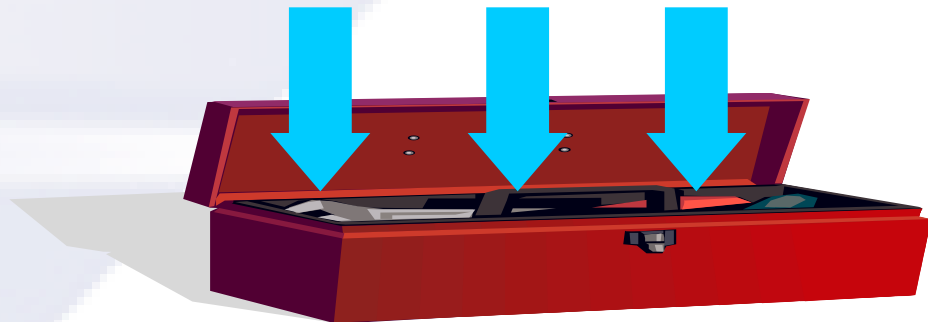
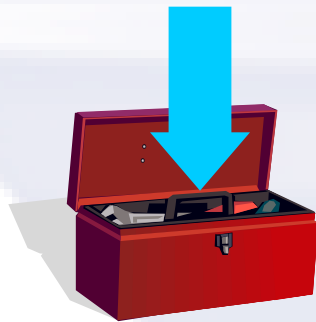
Beyond 100G

Enhanced modulation/spectrum
Photonic integration
Advanced amplifiers/fiber

Electronic

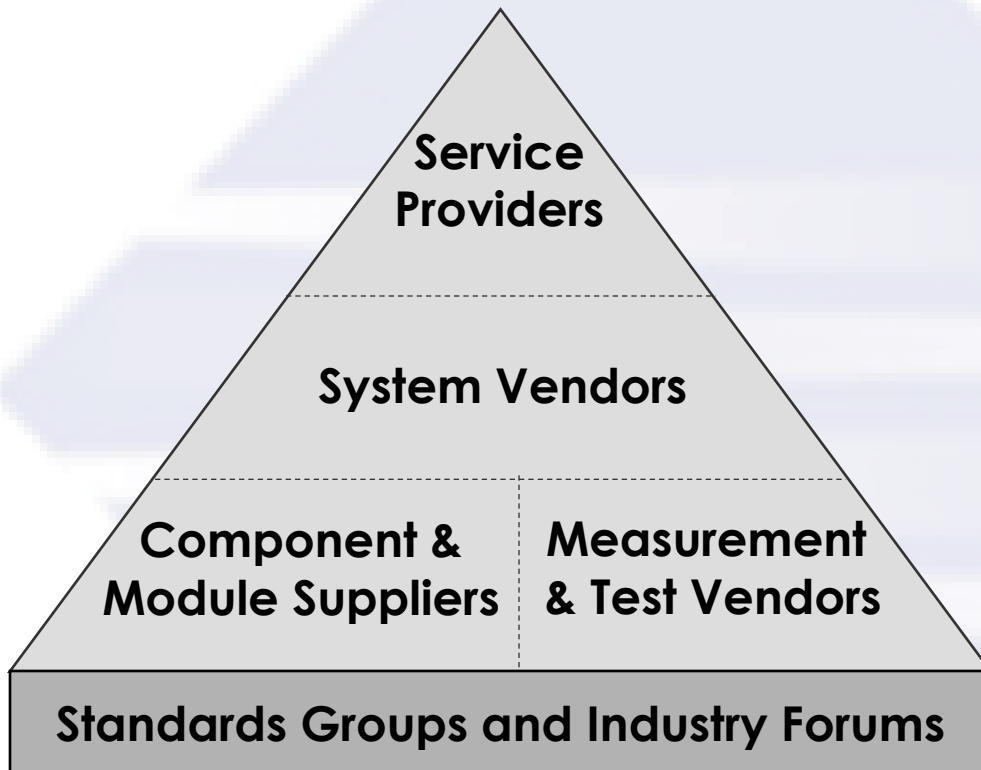
High-speed A/D converters
DSP-based coherent detection
Common electrical interface
Enhanced FEC

Improved thermal management
Further advances in ADC, DSP, CEI
Soft-decision FEC



**400G/1T toolbox will use and extend all the 100G tools –
and require development of new ones**

The High-Speed Ecosystem



- ◆ **What brings the ecosystem together?**
 - **Cohesive technical approach**
 - **Clear business case**
- ◆ **What motivates each player to move forward?**
 - **Operational necessity**
 - **Ability to differentiate**
- ◆ **What do standards groups and forums contribute?**
 - **Market-driven feasible standards**
 - **Interoperability**

Perspective – Looking Forward

Service Provider
Requirements

Business
Case

Ecosystem
Convergence

Technology
Assessment

Standards
Definition

Development and
Deployments

Hero
Experiments

40G/100G
Lessons

Standards-based
Products

We are already well along the journey to 100G+



OIF OPTICAL
INTERNETWORKING
FORUM