zEnterprise
Long Distance Connectivity
Using WDM Technology

Uli Schlegel

ADVA Optical Networking SE

02/07/2012

Session # 12896

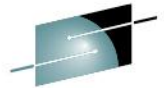www.LinkedIn.com/in/ulischlegel

Agenda

- WDM - what is it ?
  - Technology fundamentals
  - The WDM System
    - Protocols
    - Channel modules – general design
  - WDM optical layer
  - Protection options
- WDM design for datacenter environments
  - Network layout
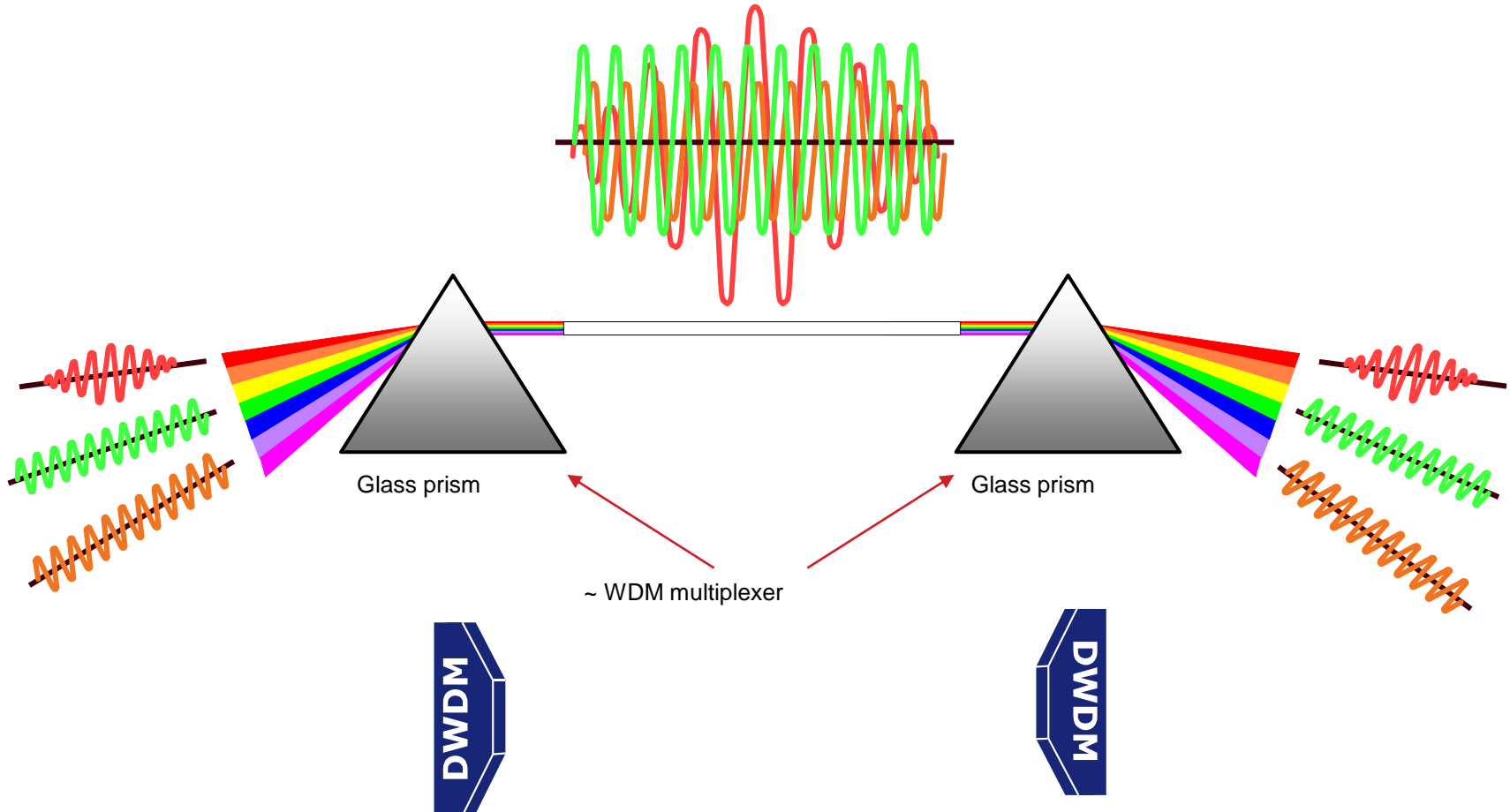- The near future of WDM

Agenda

- **WDM - what is it ?**
  - Technology fundamentals
  - The WDM System
    - Protocols
    - Channel modules – general design
  - WDM optical layer
  - Protection options
- WDM design for datacenter environments
  - Network layout
- The near future of WDM

WDM
FUNDAMENTAL CONCEPT

What is WDM ?

Glass prism

Glass prism

~ WDM multiplexer

DWDM

DWDM

Which flavors of WDM are available

- WDM means ***Wavelength Division Multiplexing***

  - Parallel transmission of number of wavelengths (λ) over a fiber

- Two flavors

  - **D**ense WDM (DWDM)

    - Narrow channel spacing - e.g. 0.4nm (50GHz grid) -> up to 160 λ

  - **C**oarse WDM (CWDM)

    - Wider channel spacing - 20nm (2.5THz grid) -> usually 8-16 λ
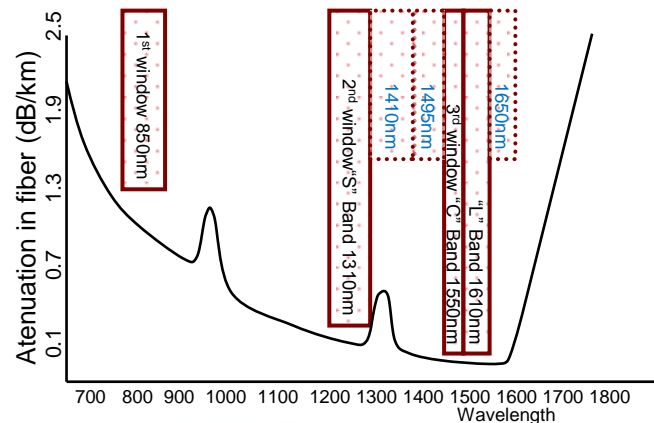
WDM optical networking
Passive versus active solutions

Passive
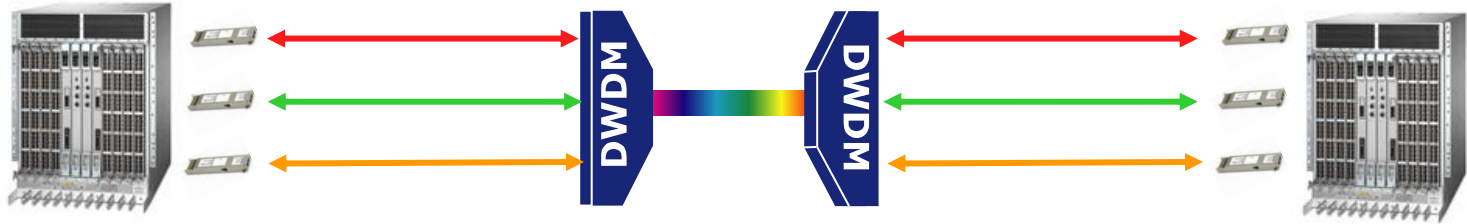
Active
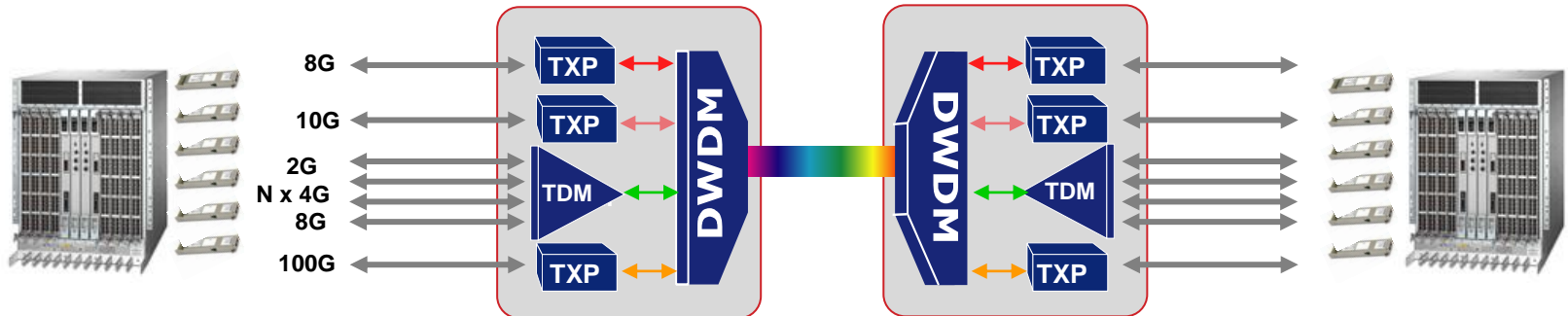
- Higher capacity per dark fiber

- Higher aggregation bandwidth (100G per λ)

- Higher distance (up to 200km single span)

- Qualified solution available for zEnterprise

- More Features available (Encryption, failover, …)

What is TDM ?

Multilple clients signals feed into one network signal
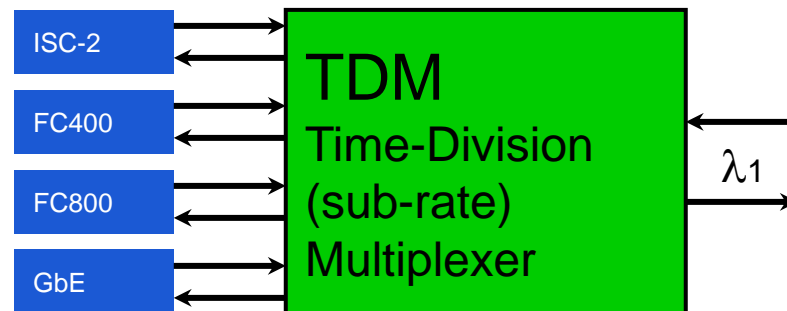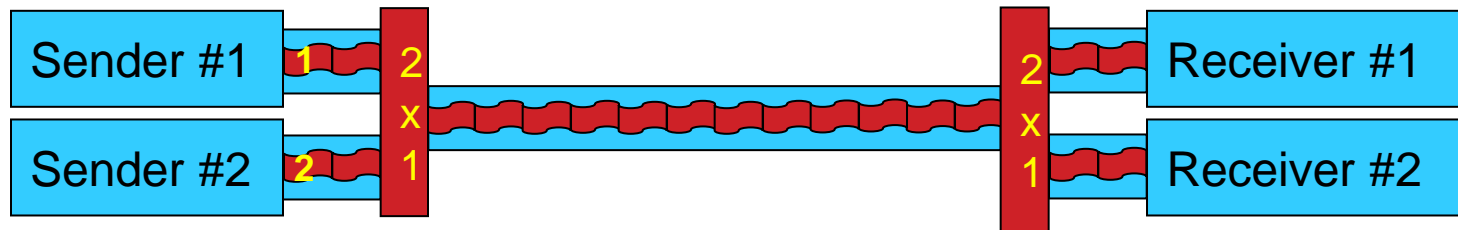
Bandwidth Allocation
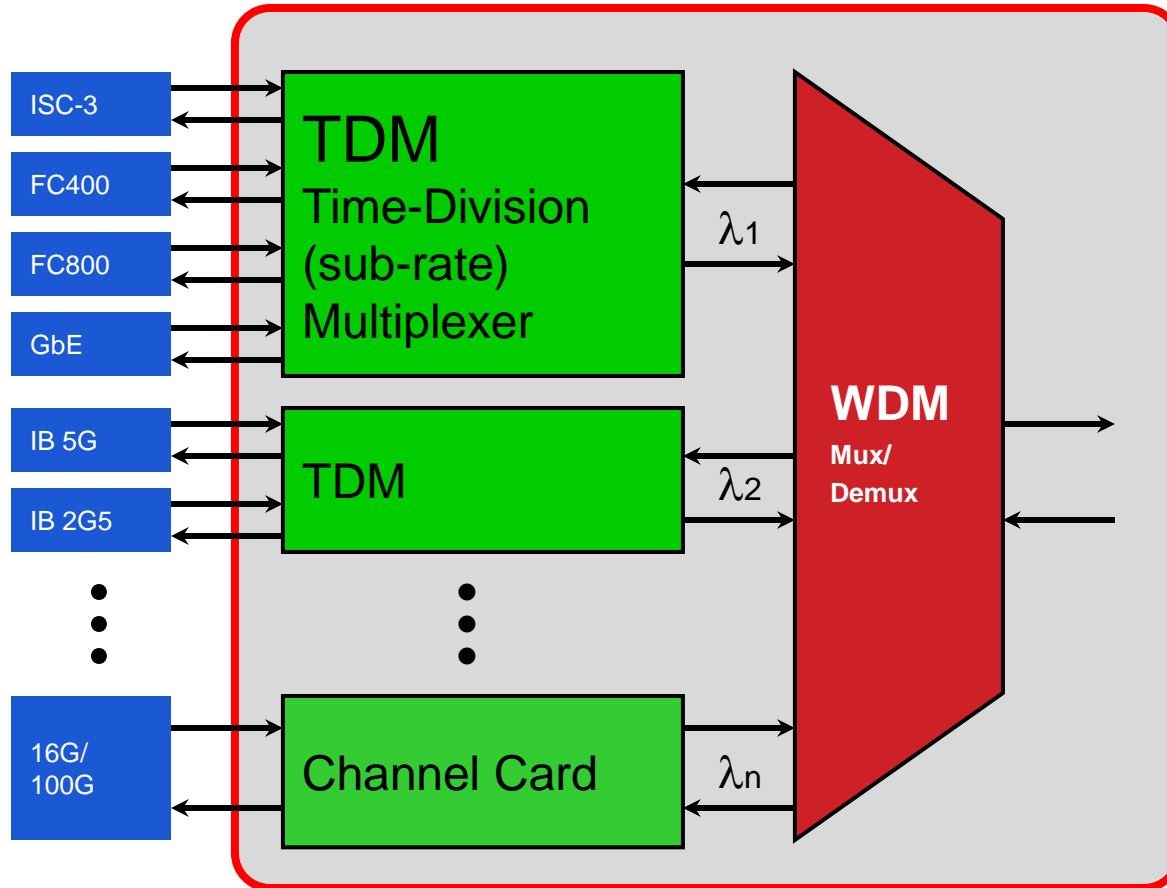
Relief of wavelengths for further services

OSI 7-Layer Model
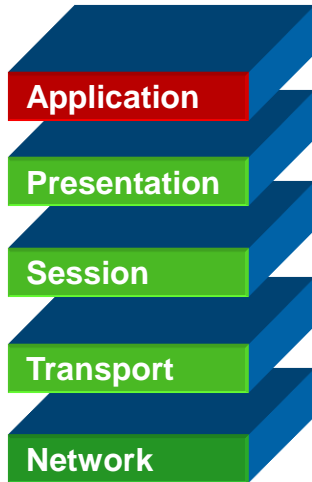
Application
File Transfer, Resource Sharing, Database Access,...
(e.g. Internet Protocols: Telnet, SMTP (eMail), FTP, HTTP,...)

Presentation
Data Encryption/Decryption, Compression, Syntax,...

Session
Establishing and Terminating logical Connections, Dialogue Control,...

Transport
End-to-End Data Reliability, Address Translation,...
(Transport Layer Protocols: TCP, UDP,...)

Network
Addressing, Routing, Switching, Sequencing, Flow Control,...
(Network Layer Protocols: X.25, IP, ATM, MPLS, SDH,...)

Data Link
Defines Data Format including Framing, Error Control,...
(Data Link Protocols: HDLC, X.25, ATM, MPLS, Frame Relay, SDH,...)

Physical
Line Coding, Physical Link Control, Synchronization,...
(Interface Standards, V.24, X.21, G.703 (SDH), G.692 (DWDM),...)

ADVA Optical Networking

SHARE in San Francisco
2013

ACTIVE WDM SYSTEMS

Complete your sessions evaluation online at SHARE.org/SanFranciscoEval
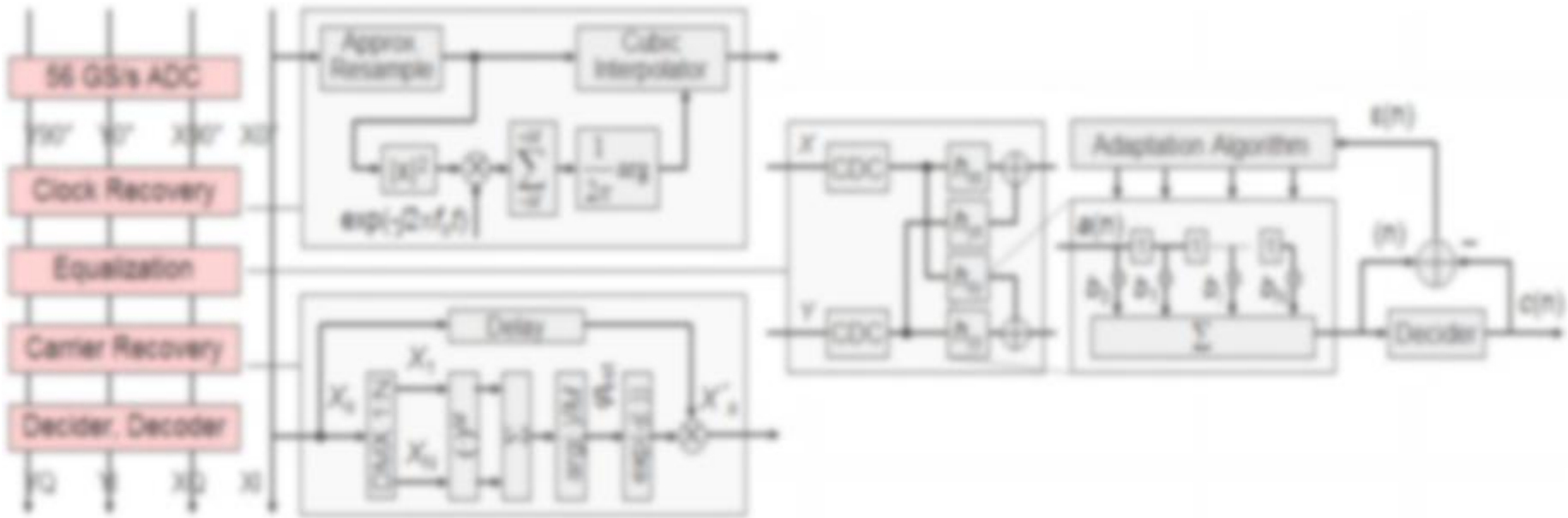
Basic working scheme of active WDM

Switch/Router Server/Disk Host

Mux-Transponders

Optical Layer Components

xPDR
xPDR
xPDR
xPDR
xPDR
xPDR

MUX

EDFA

"Grey" interface on WDM system

WDM MUX combines wavelengths onto fiber

Dark fiber

End device that connects to other side

WDM wavelength (up to 160)

Optical amplifier (optional)

Mux/Transponder card converts "Grey" to WDM wavelength
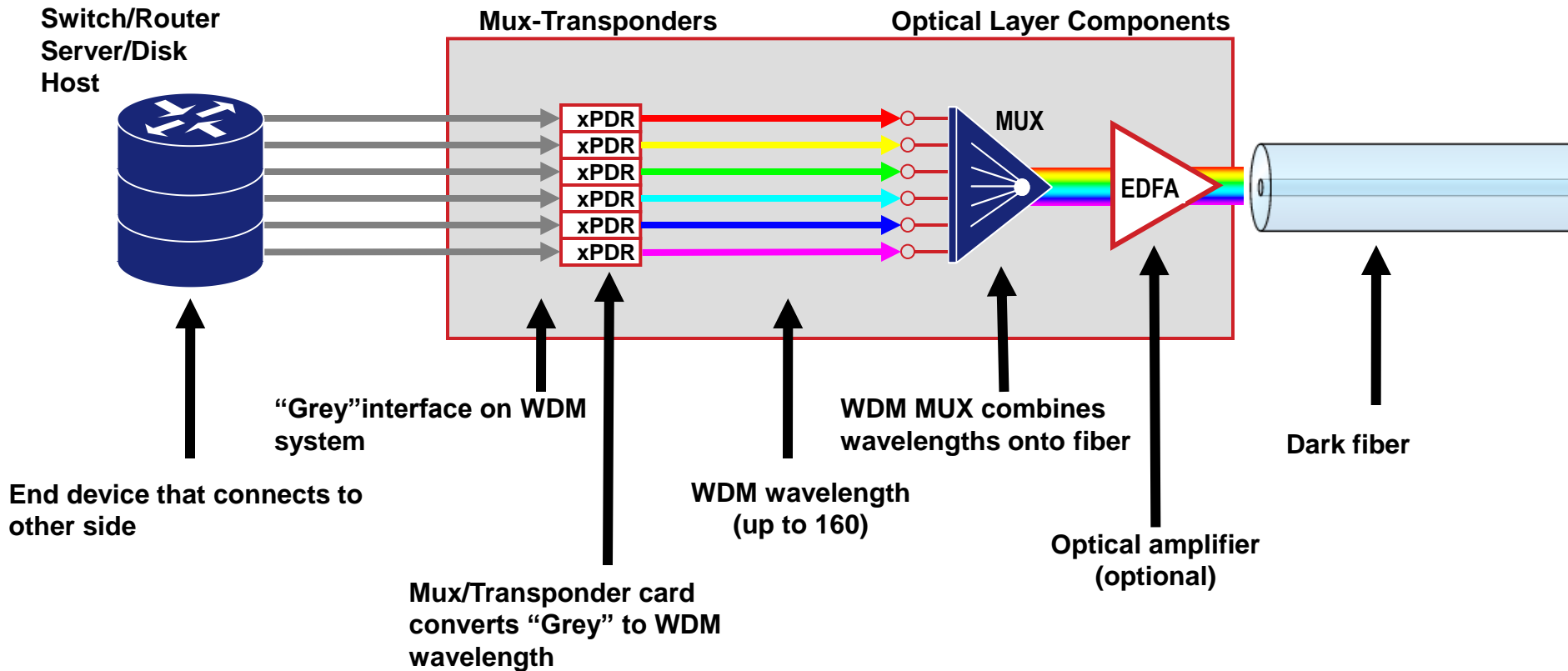
DWDM native service offerings

Mbit/s → Gbit/s

Speed values (along axis): 8...16 · 12,5 · 155,52 · 200 · 622,08 · 1.062,5 · 1.250 · 2.125 · 2.488 · 2.500 · 2.666 · 4.250 · 5.000 · 8.500 · 9.953 · 10.312 · 10.000 · 10.518 · 10.709 · 39.813 · 43.018

SDH/ATM
- STM-1 / OC-3
- STM-4 / OC-12
- STM-16 / OC-48
- STM-64 / OC-192
- STM-256 / OC-768

OTN
- OTU-1
- OTU-2 OTU-3

LAN/WAN
- Ethernet
- Fast Ethernet
- Gigabit Ethernet
- 10GbE WAN-PHY LAN-PHY
- 100 GbE

SAN
- ESCON
- FC/FICON
- 2G FC/FICON
- 4G FC/FICON
- 8G FC
- 10G FC
- 16G FC

HPC-Cluster
- Sysplex Timer ETR, CLO
- Coupling Link ISC-2
- ISC-3
- Infini Band 1xSDR
- Infini Band 1xDDR
- Infini Band 1xQDR

SHARE
in San Francisco
2013

Generic system Overview

- Shelf
  - AC or DC PSU (redundant)
  - Shelf controller
  - Node controller
  - Optical supervisory channel
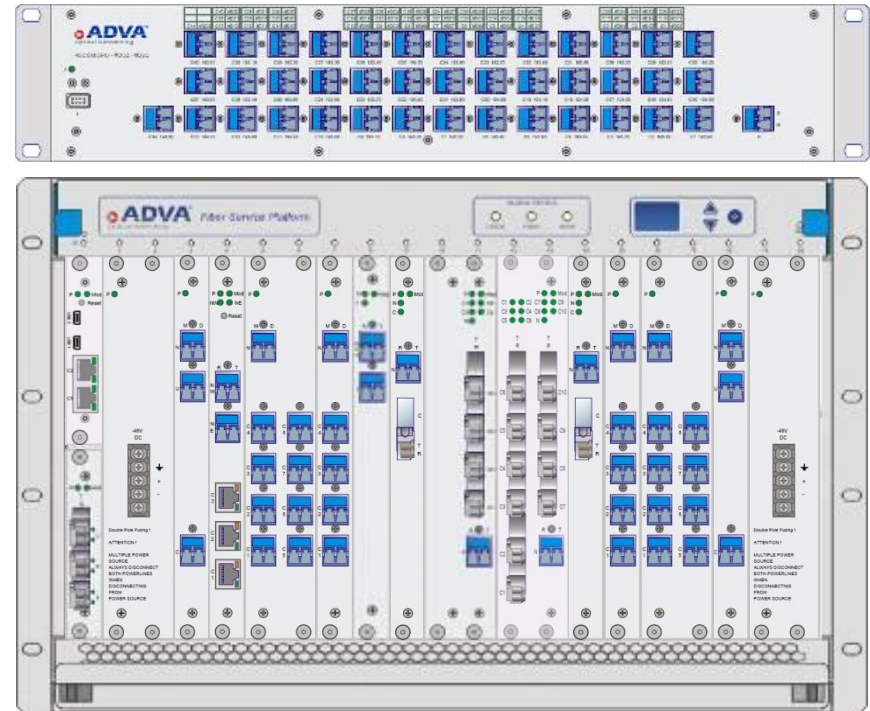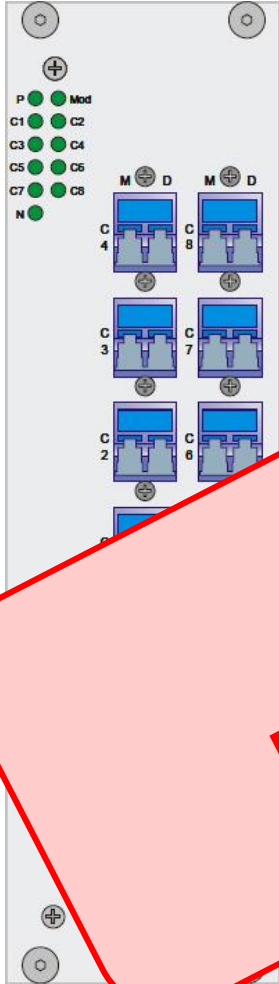 - Amplifier and dispersion comp.
  - WDM filters
  - Mux- and transponders

Note: Some systems has DC feed only, so rectifiers are needed too
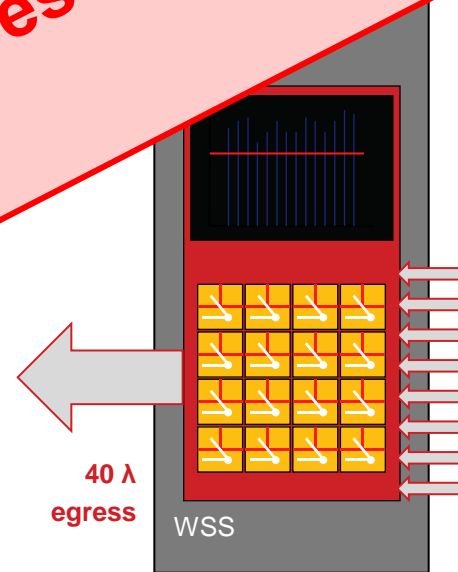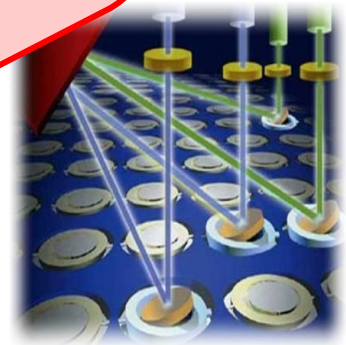
ROADM
40 λ WSS for 8 Directions

8ROADM-C40/0/OPM

- 8x1 WSS incl. 1x8 splitter
- Any input λ to any egress port
- WSS 9 ports: 1 ingress, 8 egress, 3 card
- Any input λ to any egress
- Switching, power mo
- Integrated OPM
- Fully passi
- Exter

40

@ 40 λ egress

8 ports @ 40 λ
ingress

40 λ
egress

WSS

**Meshed, Ring, ROADM…
Not covered in this presentation!**

WDM MODULE TYPES

Transponder design

Typical link delay: 5µs ≜ 1km of fiber

| Client I/F | SONET/SDH Mapping | G.709 Mapping w/ FEC | WDM Network I/F |
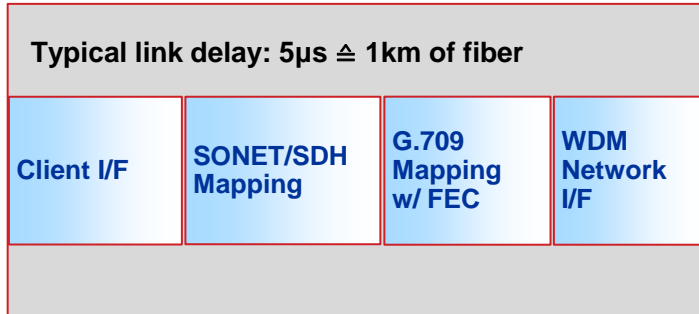
Telco/ISP Transponder design

- Full standard compliant network (WDM) Interface for Telco/ISP interaction
- Digital performance monitoring
- Up to 2000+km possible

Typical link delay : 50ns ≜ 10m of fiber

| Client I/F | signal regeneration | WDM Network I/F |

Simple Transponder design

- Proprietary network (WDM) interface
- Simple performance monitoring
- Up to 200km possible without regeneration
- Very fast and reliable (high MTBF)

Muxponder design (TDM)

Typical link delay: 30µs ≙ 6km of fiber

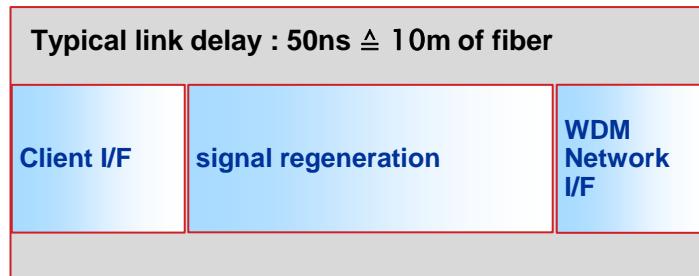| Client I/F | 8B/10B CODEC |
Client I/F	8B/10B CODEC
Client I/F	8B/10B CODEC
Client I/F	8B/10B CODEC

Standard Framing (e.g GFP) → G.709 Mapping w/ FEC → WDM Network I/F

Telco/ISP Muxponder design
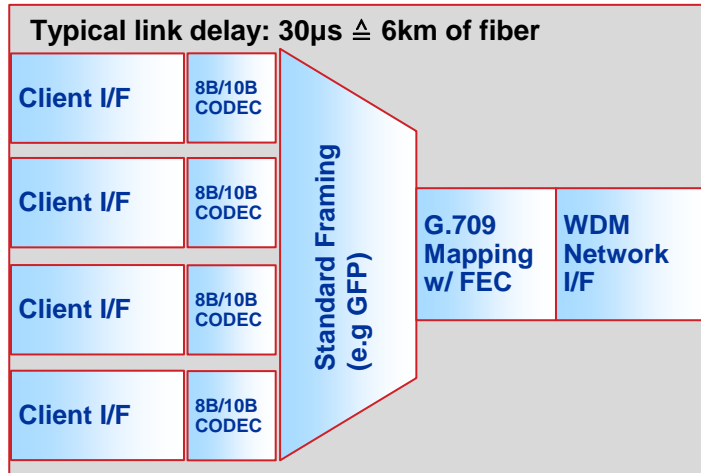
- Full standard compliant network (WDM) Interface for Telco/ISP interaction
- Digital performance monitoring
- Up to 2000+km possible
- High and unstable delay

Typical link delay: 5µs ≙ 1km of fiber

Client I/F	8B/10B CODEC
Client I/F	8B/10B CODEC
Client I/F	8B/10B CODEC
Client I/F	8B/10B CODEC

Proprietary High Speed framing → WDM Network I/F
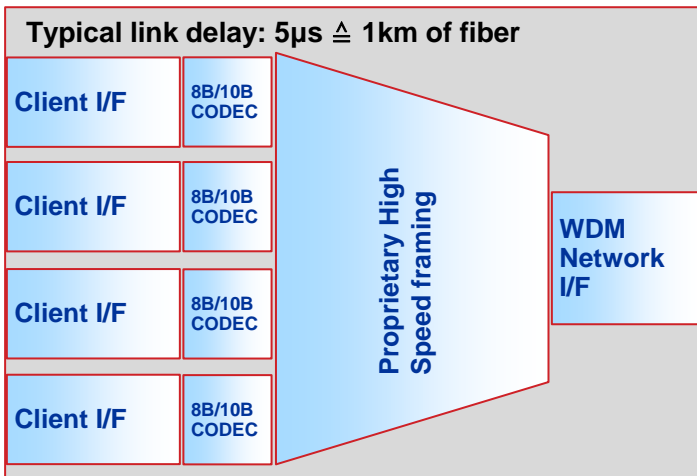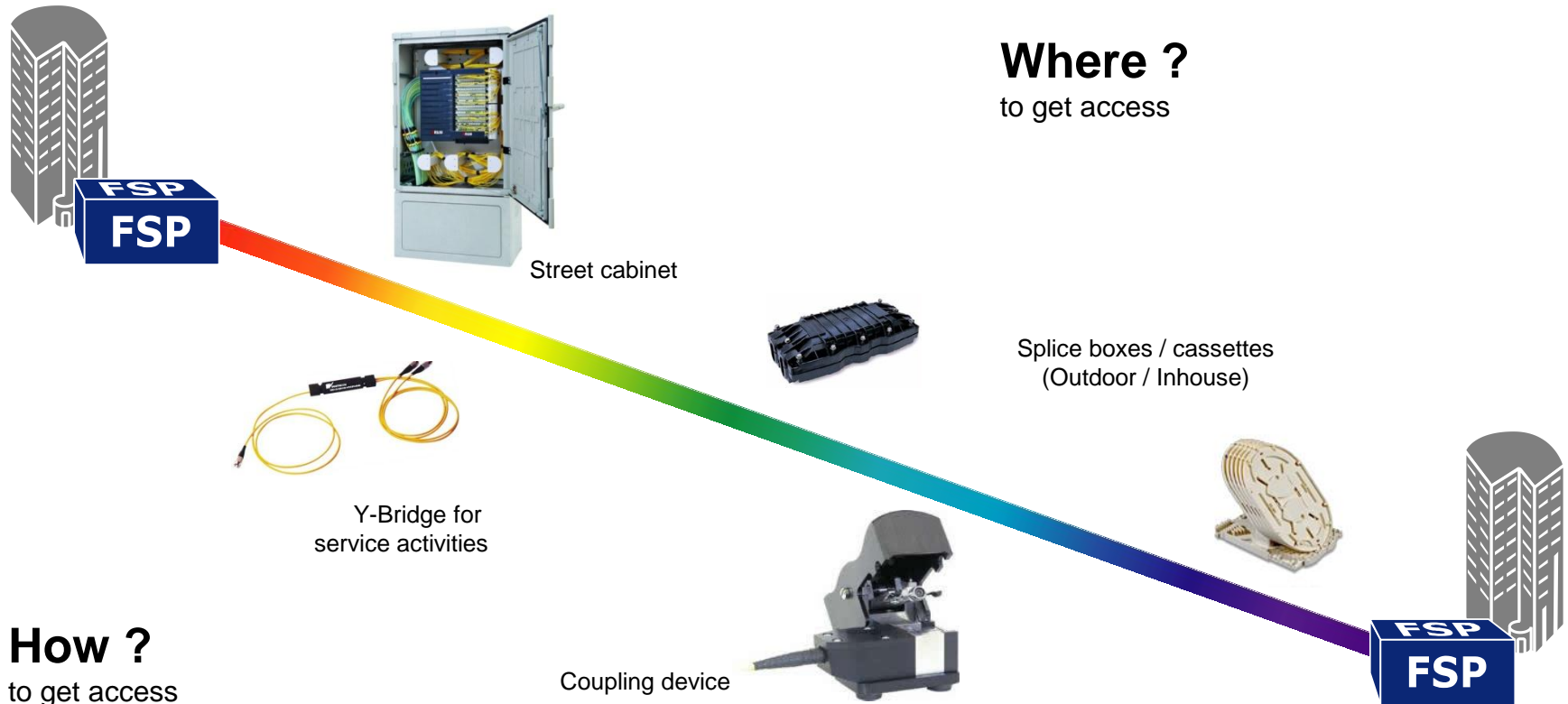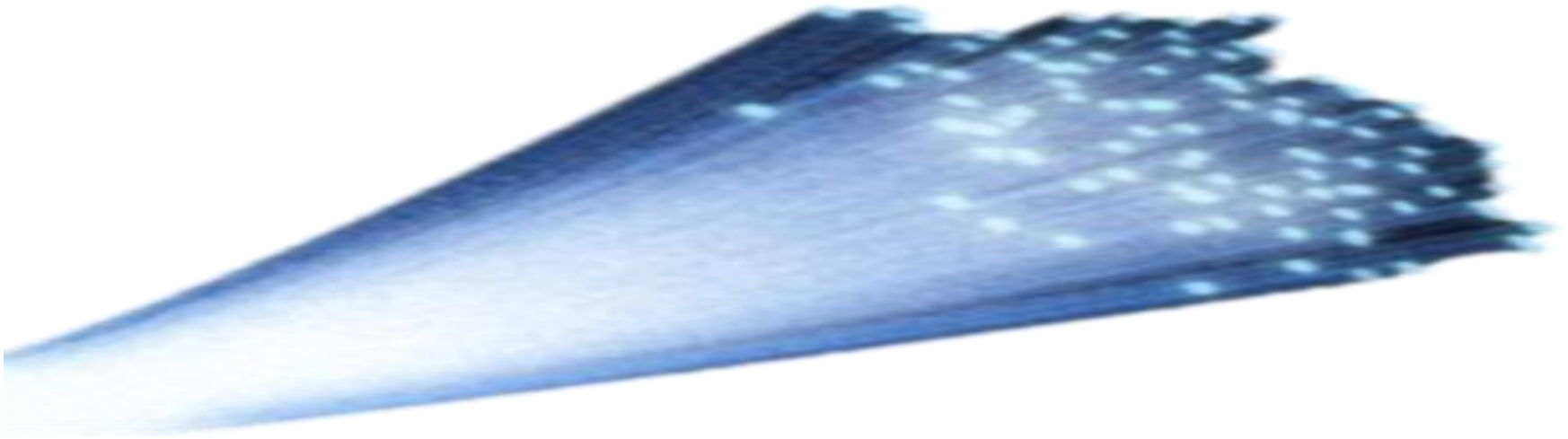
Simple Muxponder design

- Proprietary network (WDM) interface
- Simple performance monitoring
- Up to 200km possible without regeneration
- Very fast and reliable (high MTBF)
- Transparent also for 'non standard' signals like ISC-3, Infiniband, ….

Fibre optics networks security concerns

Where ?
to get access

Street cabinet

Splice boxes / cassettes
(Outdoor / Inhouse)

Y-Bridge for
service activities

How ?
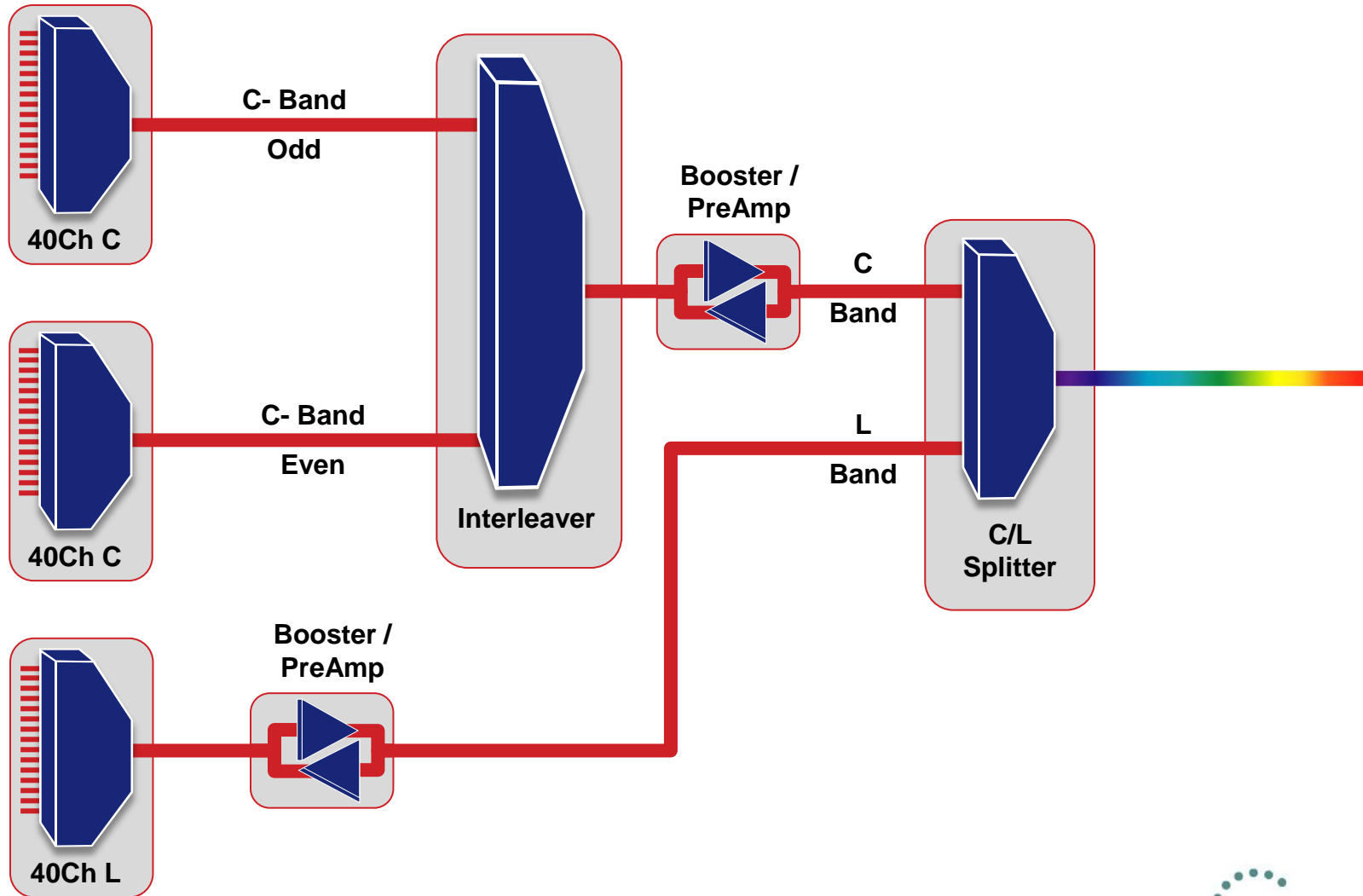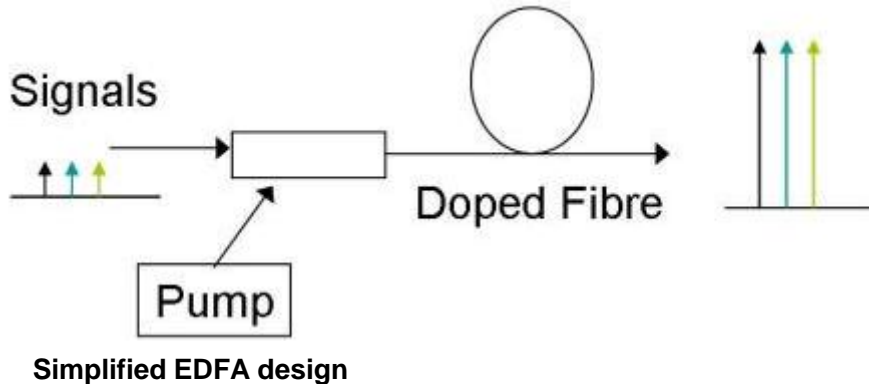to get access

Coupling device

FSP

FSP

There are multiple ways to access fiber

WDM OPTICAL LAYER

120 lambda WDM system

# Amplification and dispersion compensation

Simplified EDFA design

- Erbium doped fiber for light amplification without a optical-electrical-optical conversion
- Amplifies up to 80 lambdas at once
- Low latency design

Signal distortion due to chromatic dispersion
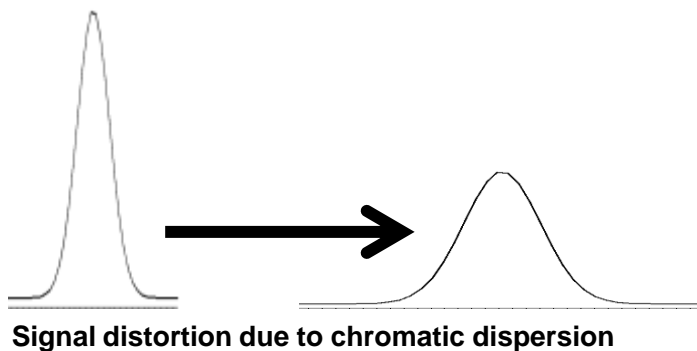
- Dispersion compensation might be needed from 50kms onwards
- Fiber based compensation (spool based)
  - High latency
- Bragg grating based compensation
  - Very low latency
  - But more complicated and expensive
  - Better suitable for datacenters

Protection – overview
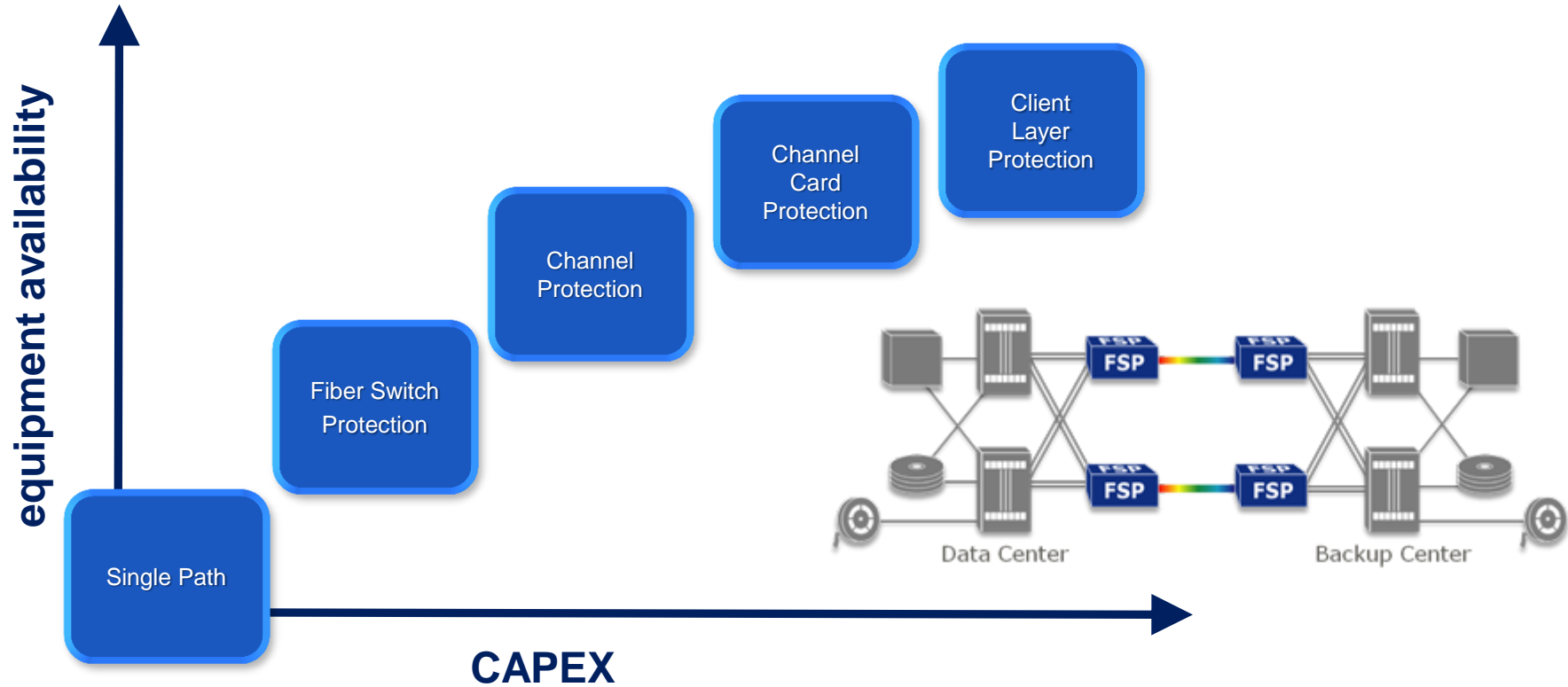
- Protection could offer huge leverage over equipment cost
- Wide variety of protection options allows exact match of required availability to necessary CapEx

Protection cost versus availability

Scenario	Category	Cost Index[1]	Availability [%][2]
unprotected		1,00	99,94
line protection (RSM)		1,10	99,99
line protection (VSM)		1,10	99,99
Channel protection (NPCUP)		1,38	99,994
Card protection		2,13	99,996
Client layer protection (CL)		2,00	99,99997

[1] Based on a 16Ch System with 4xGbE, 4x10GbE, 6x2G FC; 50km G652, HW Cost only

[2] Based on a fiber availibility of 99,95% and a MTTR of 4h

SHARE
in San Francisco
2013

Agenda

- WDM - what is it ?
  - Technology fundamentals
  - The WDM System
    - Protocols
    - Channel modules – general design
  - WDM optical layer
  - Protection options
- WDM design for datacenter environments
  - Network layout
- The near future of WDM

WDM NETWORK DESIGN

Complete your sessions evaluation online at SHARE.org/SanFranciscoEval

Network design goals #1

- Fiber routes
  - Must be independent and non crossing
  - As short as possible
  - New fiber preferred for latest protocols

- Protection
  - Shall be based on client devices (SAN/Ethernet Switch /MF) (client based protection)
 - Additional protection may be provided by the WDM system

Network design goals #2

- WDM system
  - Lowest latency possible
  - Qualified by major datacenter vendors (IBM, EMC, HP, Brocade, Cisco)
  - Should behave like a cable rather than like an additional system
- Concept
  - WDM system should be seen as part of the SAN network
  - Proof of concept should be accomplished as part of the theology evaluation
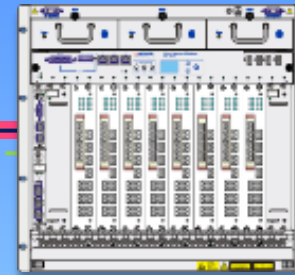
Especially coupling links and sync mirroring links are extremely latency sensitive -> short fiber and low latency devices

SHARE
in San Francisco
2013

WDM based dark fiber network

Client Side 1
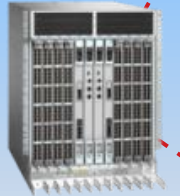
Client Side 2

Primary #1

Primary #2
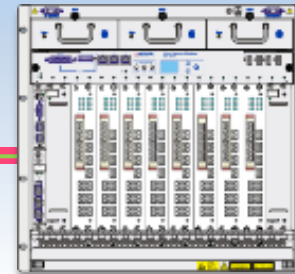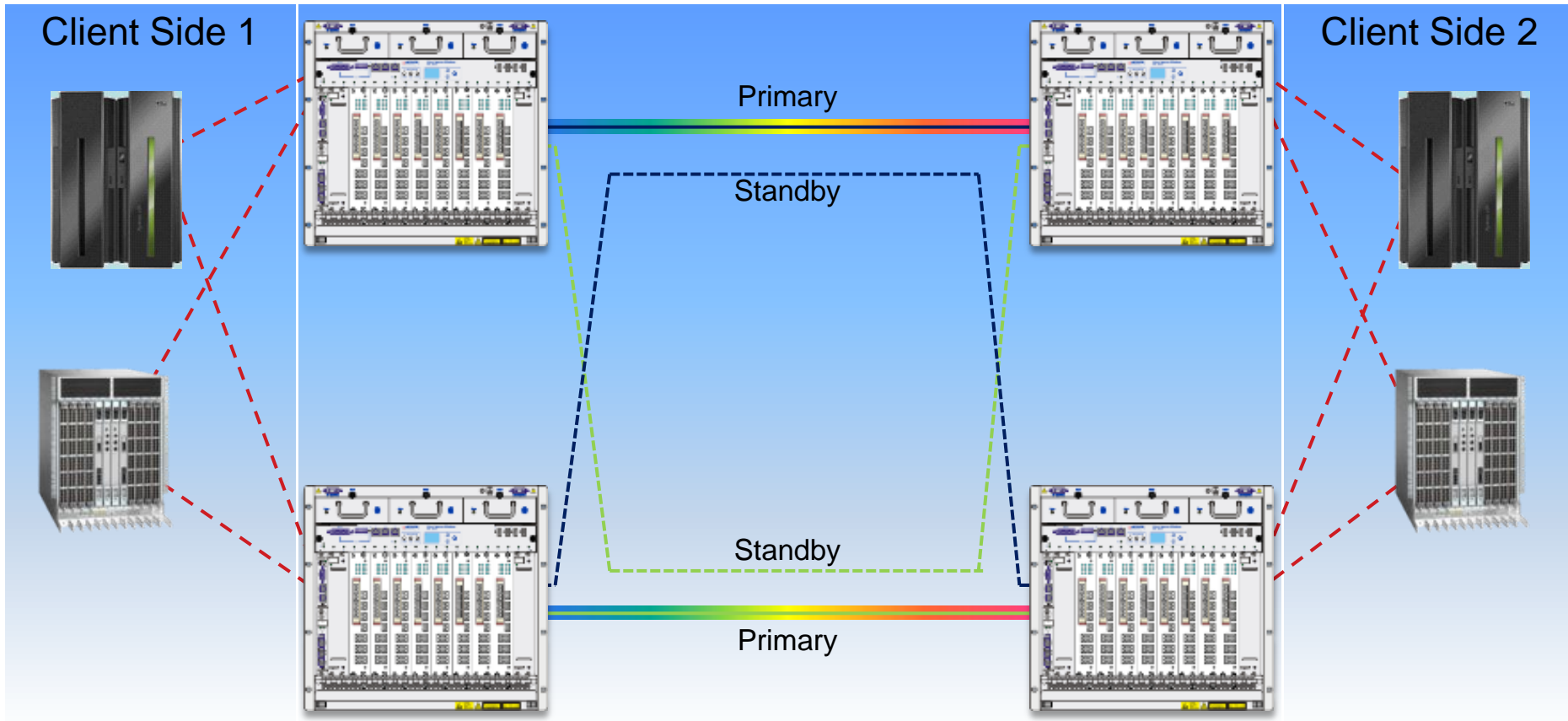
- Up to 100km for sync applications
  - Up to 200km per span
- Up to 2000km for async applications

WDM dark fiber network with protection

Client Side 1

Client Side 2

Primary

Standby

Standby

Primary

Agenda

- WDM - what is it ?
  - Technology fundamentals
  - The WDM System
    - Protocols
    - Channel modules – general design
  - WDM optical layer
  - Protection options
- WDM design for datacenter environments
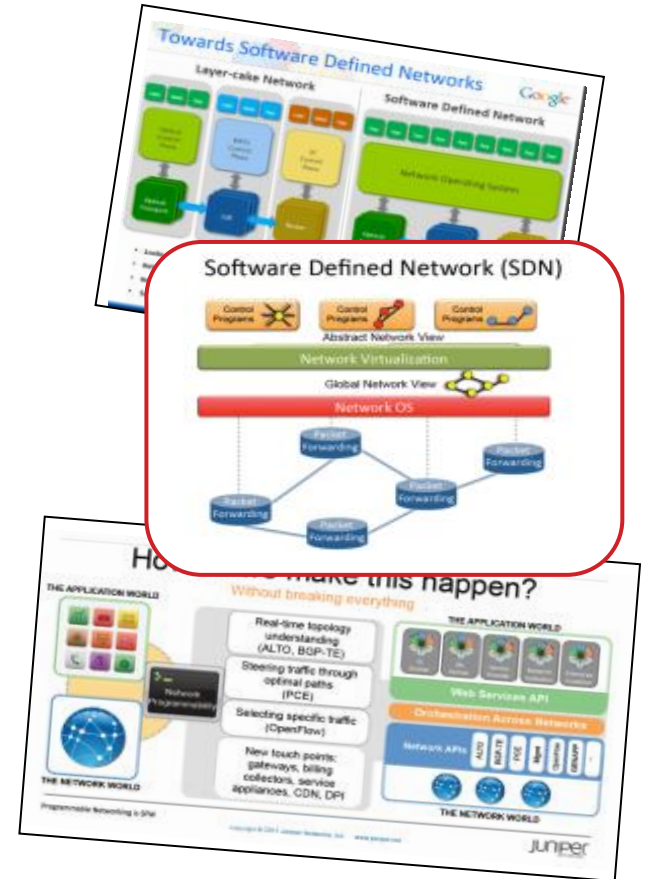 - Network layout
- The near future of WDM

WDM – FUTURE

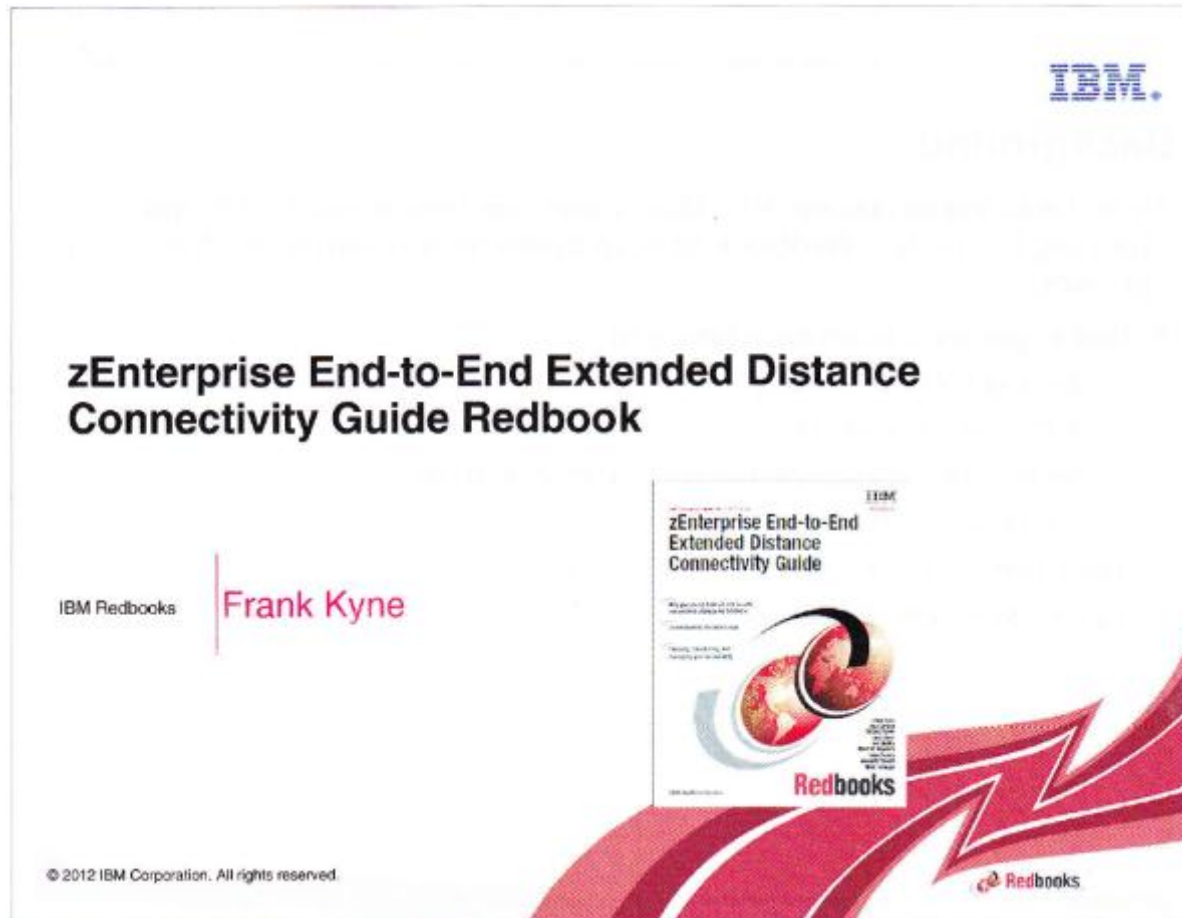Complete your sessions evaluation online at SHARE.org/SanFranciscoEval

What's next in WDM ?

- 100G per lambda as a standard protocol with encryption
- SDN for the optical layer
  - Virtualization of the optical layer
  - Full flexible networks with on demand connectivity
  - Openflow based integration
- WDM enabled end devices
  - Switches/Routers could take over the role of a WDM system
  - Highly integrated and standardized interfaces

Complete your sessions evaluation online at SHARE.org/SanFranciscoEval

Extended Distance Redbook

zEnterprise End-to-End Extended Distance
Connectivity Guide Redbook

IBM Redbooks | Frank Kyne

© 2012 IBM Corporation. All rights reserved.

Please check the IBM Redbook homepage for availability

QUESTIONS ?

zEnterprise
Long Distance Connectivity
Using WDM Technology

Uli Schlegel

ADVA Optical Networking SE

02/07/2012

Session # 12896

www.LinkedIn.com/in/ulischlegel

SHARE
in San Francisco
2013