Zero touch photonics
Combining the flexibility of TDM networks with the cost efficiency of WDM

András Kalmár

Péter Barta

15. April, 2009 - Szeged

Outline

Drivers

Flexibility and transparency benefits

- Tunable ROADM (Reconfigurable Optical Add/Drop Multiplexer)

- N-Degree T-ROADMs (N-Directions)

- Optical resilience and restoration

System scalability

System automation

Alcatel·Lucent

Transformation Drivers for Photonic Networks

New services (and new players) are emerging, requesting huge bandwidth growth in photonic networks

- Fixed and mobile, personalized
- Increased popularity of new Video and Internet applications (> 6 x growth between 2004 and 2008)

Service providers are facing new challenges

- React faster, providing better time-to-service
  - □ Higher flexibility and capacity
- Control costs
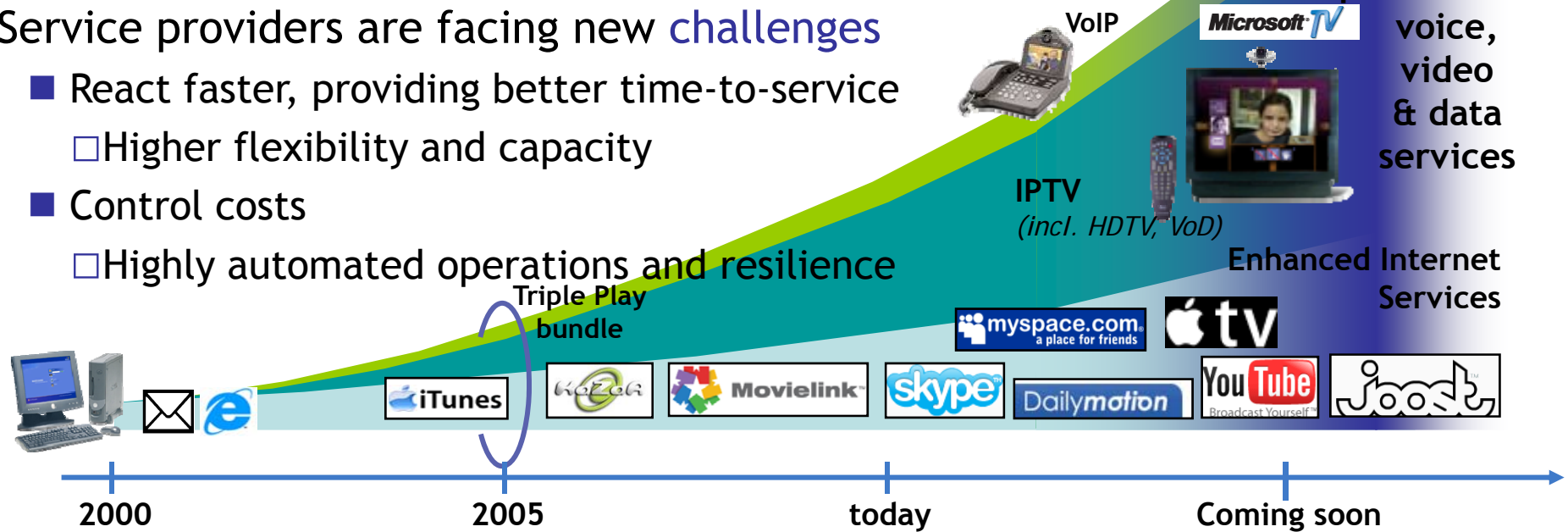 - □ Highly automated operations and resilience

More Bandwidth
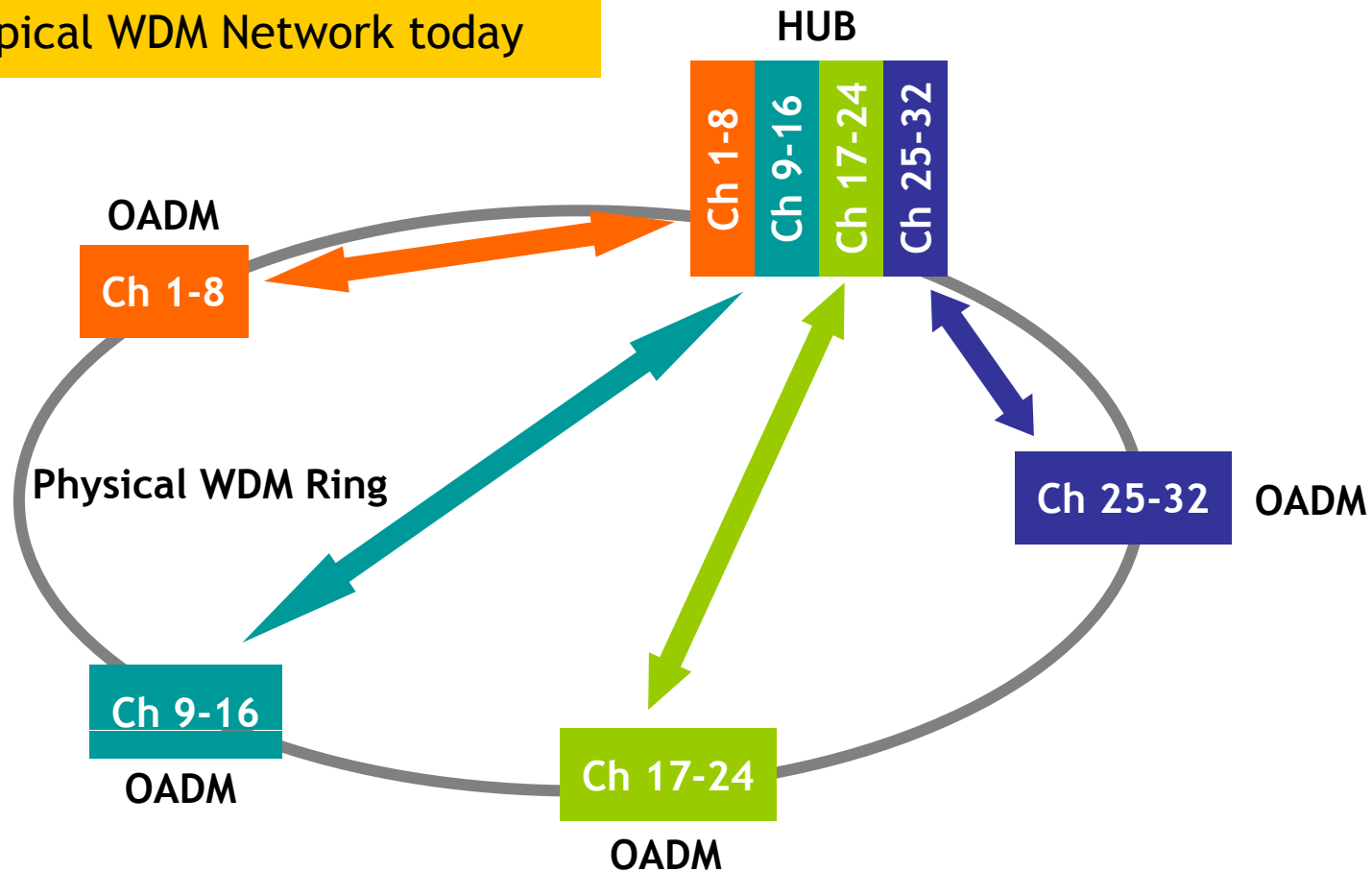
Blended, personalized voice, video & data services

VoIP

Microsoft·TV

IPTV *(incl. HDTV, VoD)*

Enhanced Internet Services

Triple Play bundle

myspace.com a place for friends

tv

iTunes

KaZaA

Movielink

skype

Dailymotion

You Tube Broadcast Yourself

Joost

2000   2005   today   Coming soon

Alcatel·Lucent

Static Networks
Based on fixed Wavelength filters

Typical WDM Network today

HUB

Ch 1-8 | Ch 9-16 | Ch 17-24 | Ch 25-32

OADM

Ch 1-8

Physical WDM Ring

Ch 25-32 OADM

Ch 9-16

OADM

Ch 17-24

OADM

Alcatel·Lucent

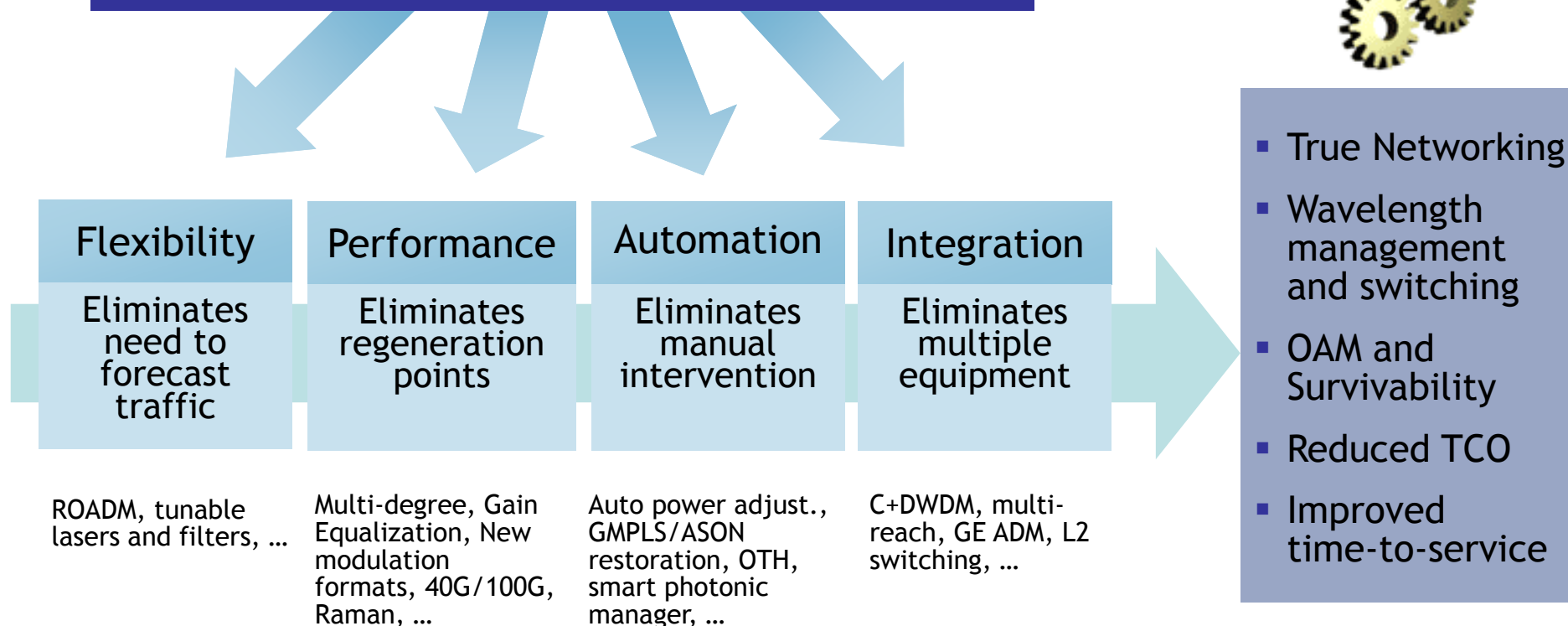# Static Networks
Based on fixed Wavelength filters

- Topology and capacity/node determined at time of network design
  - Traffic projection based upon best estimates at the time
  - Frequent changes even during design/bid/deployment
  - Not always cost effective to modify the system

- Can lead to premature system exhaust
  - Expected system life time: 5 – 10 years
  - No accurate traffic projections available for such a long period
  - Insufficient No. of wavelengths available to hot spots
  - Unlit wavelengths to cold spots cannot be utilized

- Topology is inconsistent for emerging applications
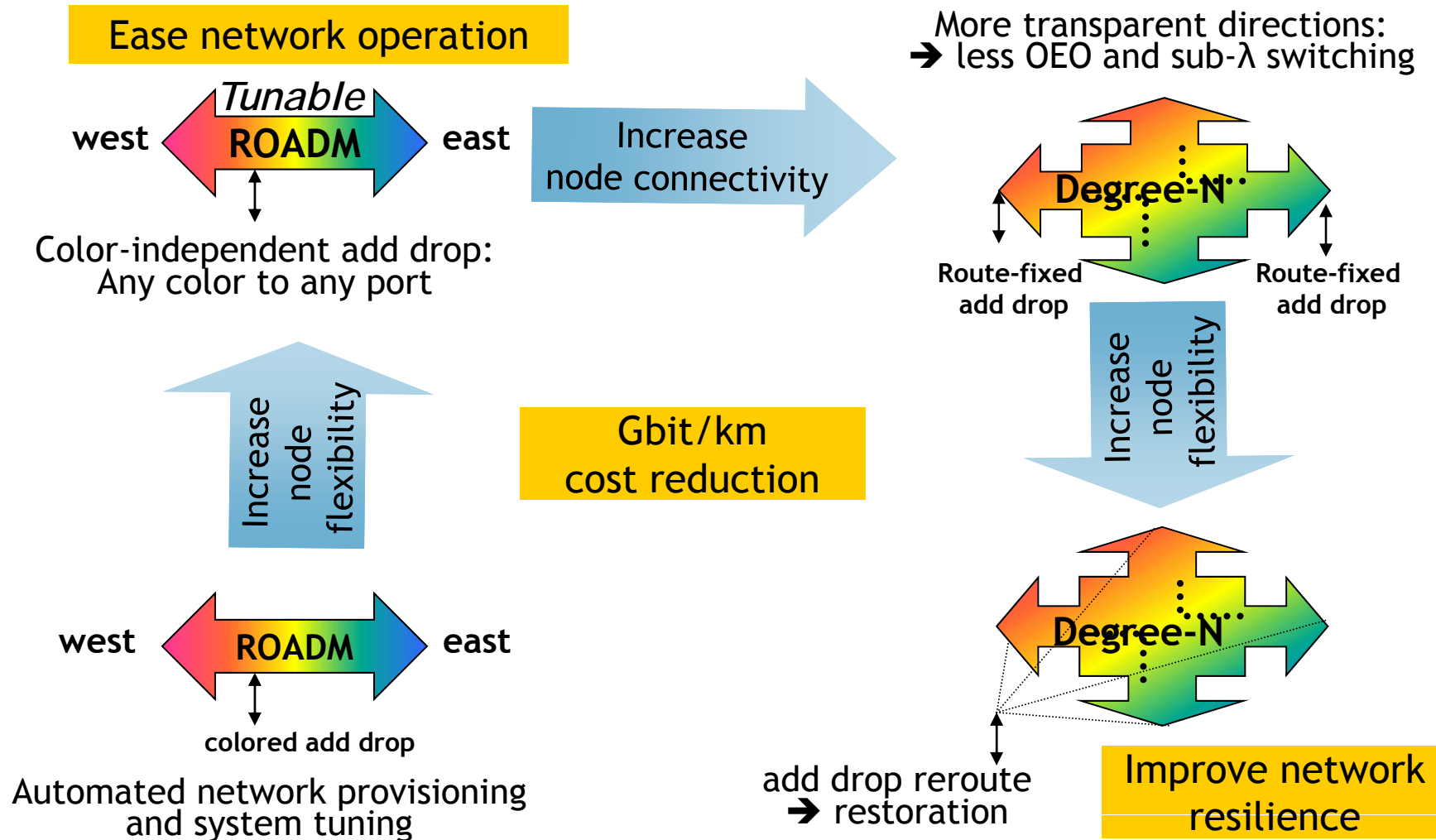 - Telephony, SAN, Enterprise, VoIP topologies looks different

Transforming WDM Networks

Zero-Touch Transparent Photonic Networks

Flexibility	Performance	Automation	Integration
Eliminates need to forecast traffic	Eliminates regeneration points	Eliminates manual intervention	Eliminates multiple equipment

ROADM, tunable lasers and filters, …

Multi-degree, Gain Equalization, New modulation formats, 40G/100G, Raman, …

Auto power adjust., GMPLS/ASON restoration, OTH, smart photonic manager, …

C+DWDM, multi-reach, GE ADM, L2 switching, …

- True Networking
- Wavelength management and switching
- OAM and Survivability
- Reduced TCO
- Improved time-to-service

Zero-Touch Transparent Photonic Networks transform WDM into true transport networking for simplified and accelerated operations

Alcatel·Lucent

Flexibility: a key enabler

Ease network operation

Tunable

west ◀ **ROADM** ▶ east

Color-independent add drop:
Any color to any port

Increase node flexibility

Increase
node connectivity

More transparent directions:
➔ less OEO and sub-λ switching

Degree-N

Route-fixed
add drop

Route-fixed
add drop

Increase node flexibility

Gbit/km
cost reduction

west ◀ **ROADM** ▶ east

colored add drop

Automated network provisioning
and system tuning

Degree-N

add drop reroute
➔ restoration

Improve network
resilience

Alcatel·Lucent

T&R-OADM: value proposition

Benefits of the Tuneable add-drop functionality:

1. **Set-up or re-engineer a circuit within minutes**
   - ☐ Non-tuneable ROADMs avoids intervention at intermediate sites, but still require intervention at circuits endpoints
   - ☐ Tuneable architectures remove intervention at circuits endpoints (provided that transponders are available)

The need: re-engineering a circuit

Initial link set-up: existing circuits A-D and B-C
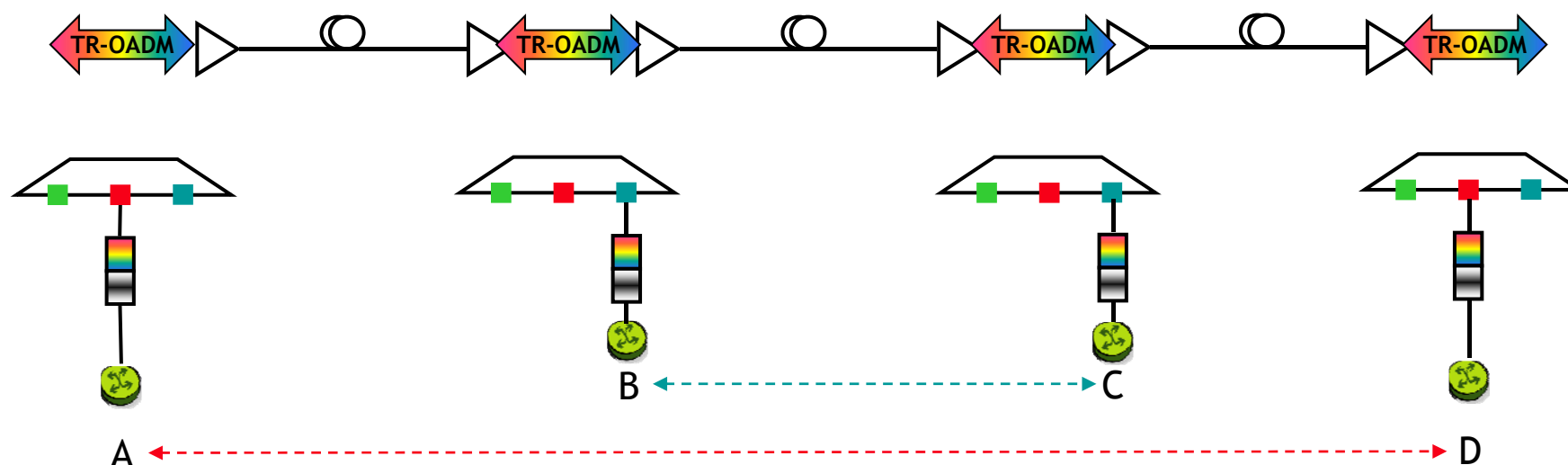
New need: change circuits to A-C, B-D

Standard approach:
non-tuneable ROADM
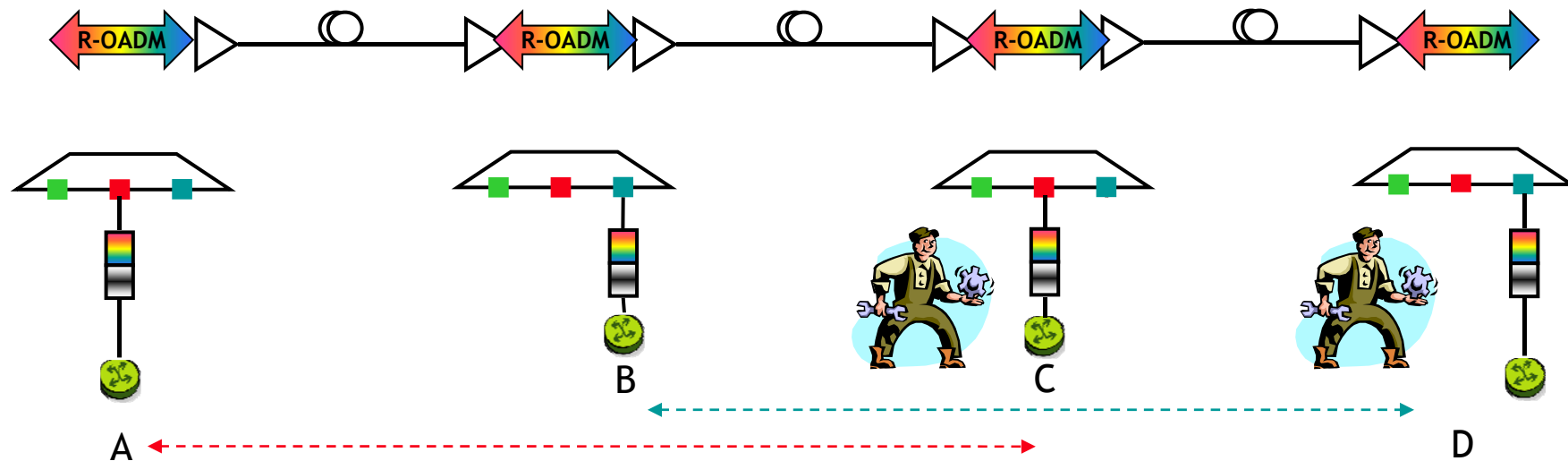
Non-Tuneable ROADM architecture:

- Go to site D, and change transponder cabling
- Go to site C, and change transponder cabling
- Activate new service

Alcatel·Lucent

Tuneable ROADM:
re-engineering a circuit within minutes
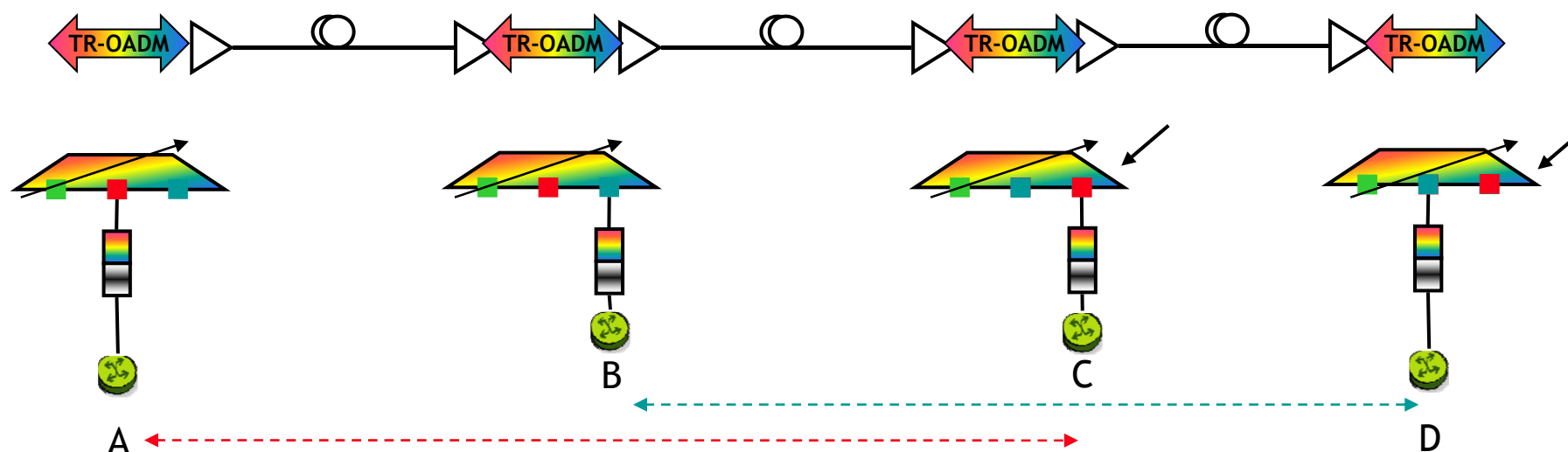
Tuneable ROADM architecture:

- Just re-program your DEMUX ports, no site intervention needed!

Alcatel·Lucent

T&R-OADM: value proposition

Benefits

1. **Set-up or re-engineer a circuit within minutes**
   - ☐ Non tuneable architectures avoid intervention at intermediate sites, but require still intervention at circuits endpoints
   - ☐ Tuneable architectures allow to avoid intervention at circuits endpoints (provided that transponders are available)

2. **Make channel planning unnecessary**
   - ☐ All items are "colorless", i.e. not associated to a specific wavelength

Alcatel·Lucent

T&R-OADM value proposition:
Make channel planning unnecessary

Initial traffic plan:

- Dual homed traffic matrix with minimum frequency usage
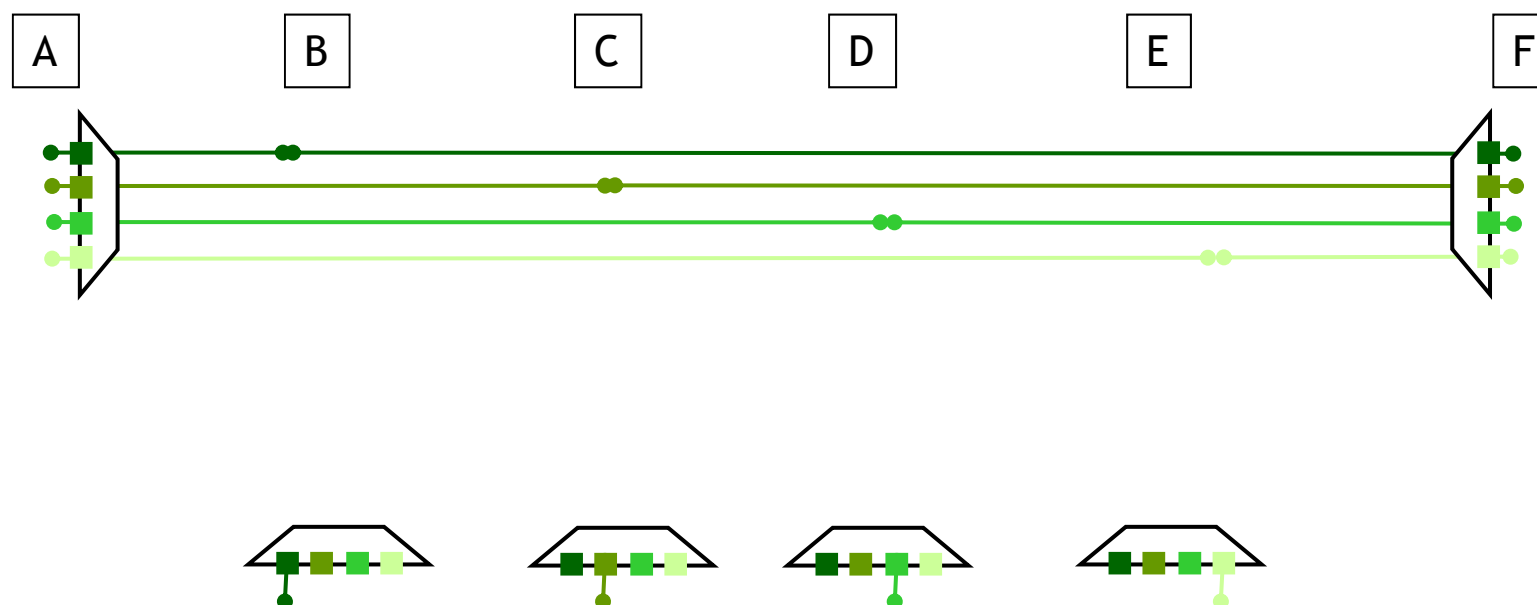
New need:

- Install a new service A-B and B-F, A-C and C-F...

Alcatel·Lucent

T&R-OADM value proposition:
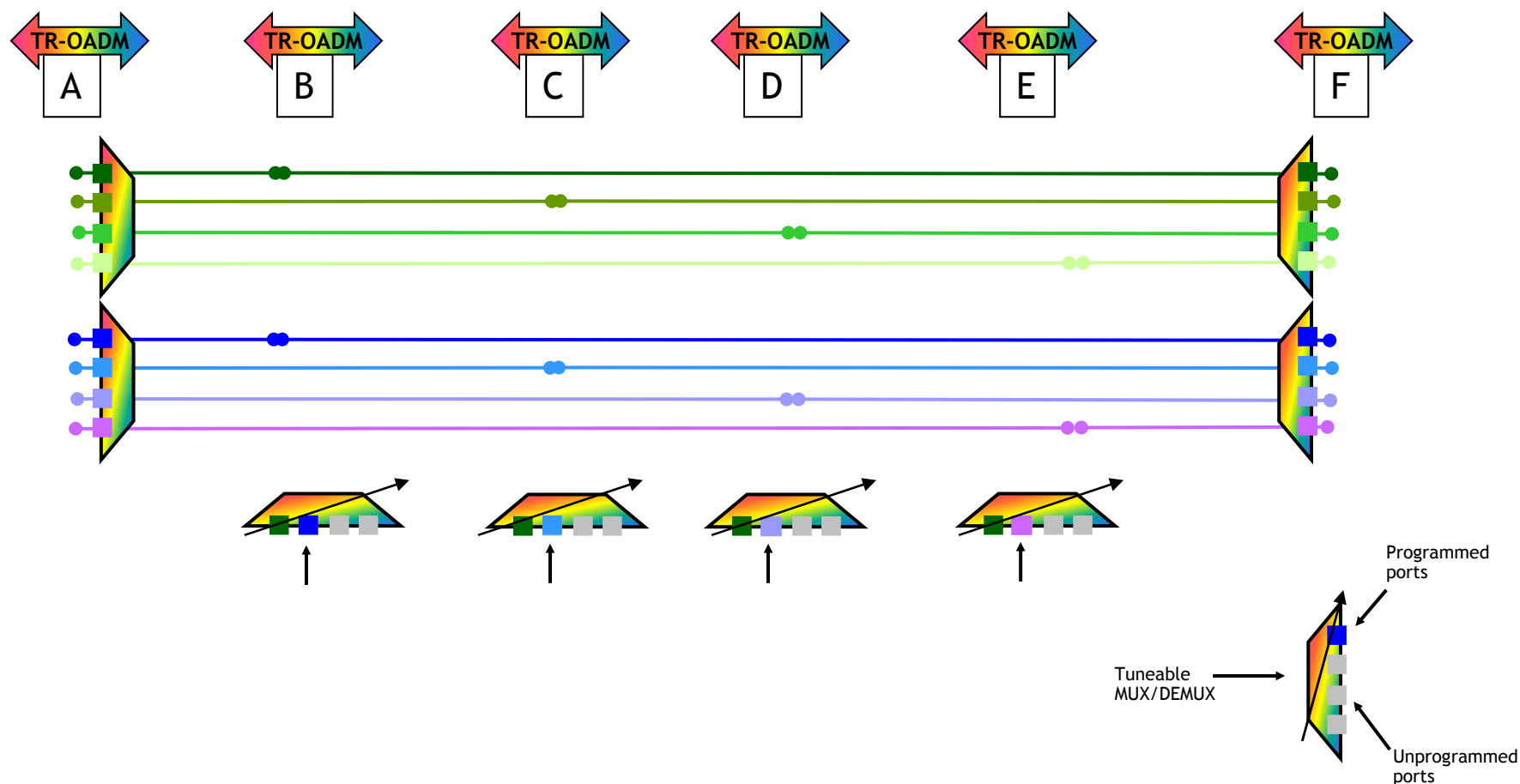# Make channel planning unnecessary

Non-tuneable ROADM:

■ Deploy new set of MUX/DEMUX, as the green MUX-DEMUX channels are fully used

Fixed-color add/drop ports

NON-tuneable MUX/DEMUX

Alcatel·Lucent
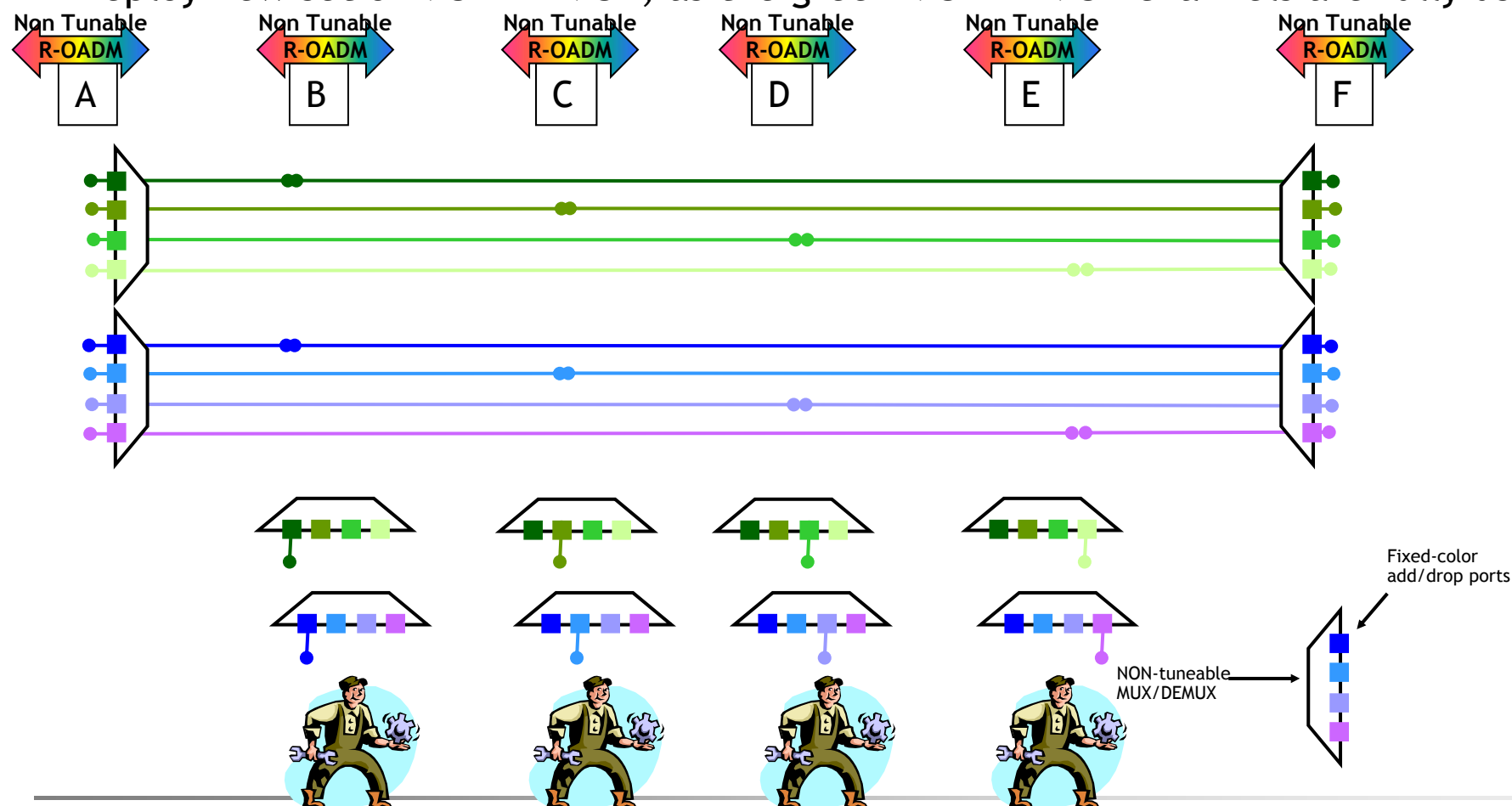
T&R-OADM value proposition:
Make channel planning unnecessary

Tuneable ROADM:

- Just re-program the tuneable MUX ports to any color in the C+ band

Programmed ports

Tuneable MUX/DEMUX

Unprogrammed ports

Alcatel·Lucent

T&R-OADM value proposition:
Make channel planning unnecessary

Simulation:

- Ring network
- Any-to-any traffic:
  Random traffic evolution,
  from 1 to max capacity,
- New channel assignment
  decided at each step
  without any knowledge of
  the future demands

Graph:

- X-axis: # of nodes in the ring
- Y-axis: MUX port utilization
  in %, at full-channel loading
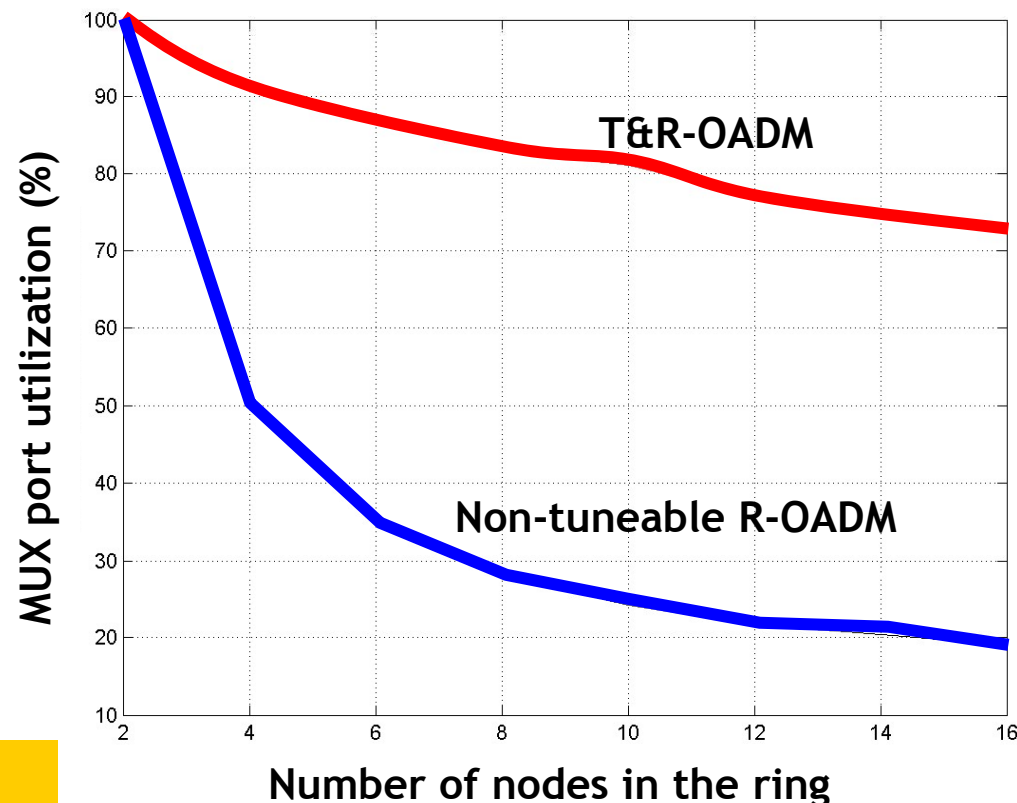
T&R-OADM up to 3.5 times more efficient than non-tuneable R-OADM !

Alcatel·Lucent

T&R-OADM: value proposition

Benefits

1. **Set-up or re-engineer a circuit within minutes**
   - ☐ Non tuneable architectures avoid intervention at intermediate sites, but require still intervention at circuits endpoints
   - ☐ Tuneable architectures allow to avoid intervention at circuits endpoints (provided that transponders are available)
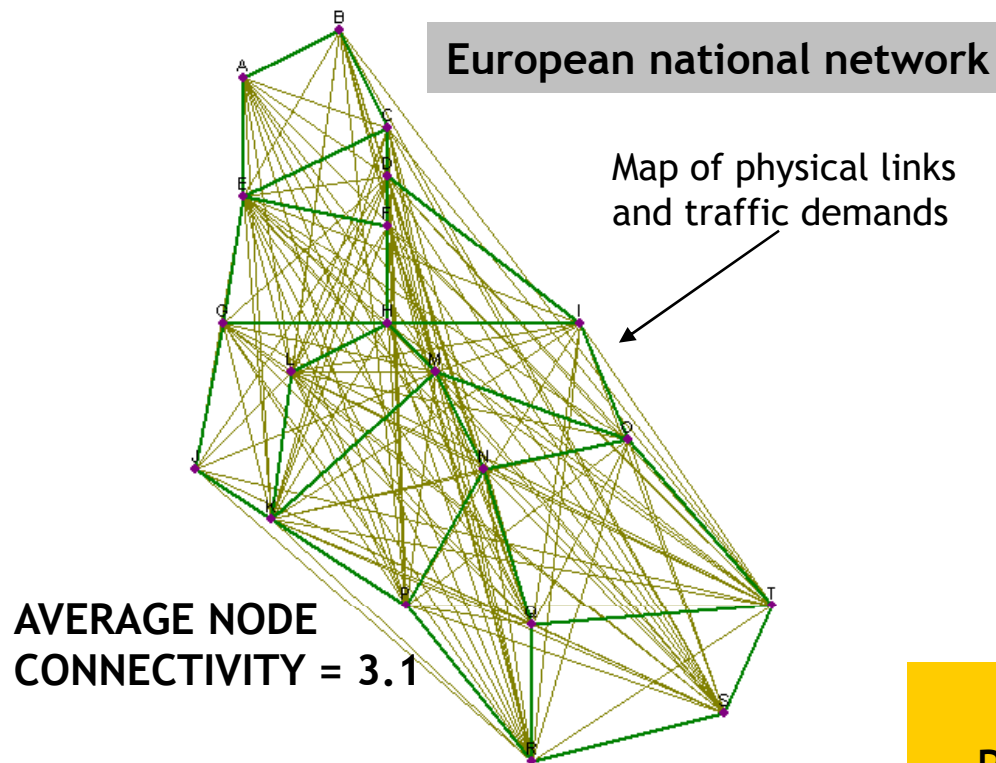
2. **Make channel planning unnecessary**
   - ☐ All items are "colorless", i.e. not associated to a specific wavelength
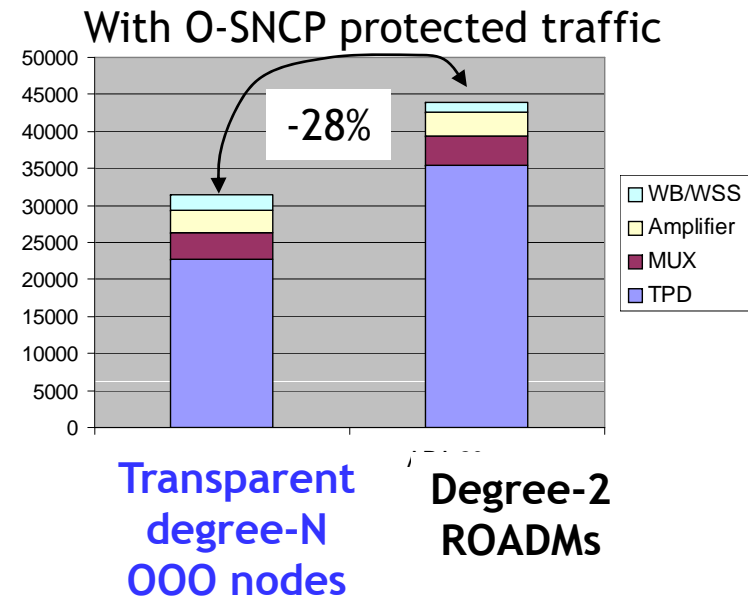
3. **Dramatically simplify logistics**
   - ☐ Reduce the lead-time to define an order (no longer any need to check the installed base)
   - ☐ Eliminate possibilities of errors when ordering new items (wrong transponders and MUX colors is a typical cause of errors)
   - ☐ Simplify and optimize spares management

Alcatel·Lucent

CAPEX benefits:
Degree-N transparency

Network studies show ~30% CAPEX savings with Transparent OOO nodes

European national network

Map of physical links and traffic demands

AVERAGE NODE CONNECTIVITY = 3.1

Source: Alcatel-Lucent study

With O-SNCP protected traffic

-28%

Legend:
- WB/WSS
- Amplifier
- MUX
- TPD

Transparent degree-N OOO nodes

Degree-2 ROADMs

Remove external nodes (e.g. SDH, Routers,..) for Ring Interconnections

Alcatel·Lucent

Scalability
Future-Proof Photonics Networks

Flexible photonic networks must support

- Upgrade to **higher bit rate** per channel

e.g. 100GHz spacing

- Upgrade to **higher channel count**
  - □ Add more 10G channels in the remaining spectrum
  - □ Improve spectral efficiency, save fiber back-up capacity

100➜50GHz spacing

- Upgrade with **broader channels**
  - □ Variety of modulation formats for reach diversity
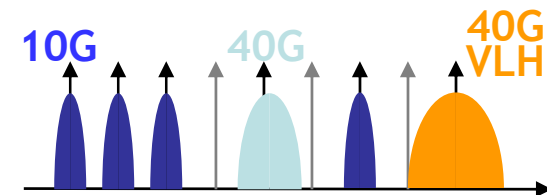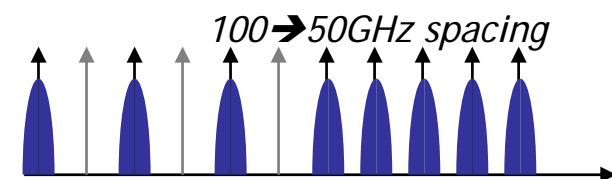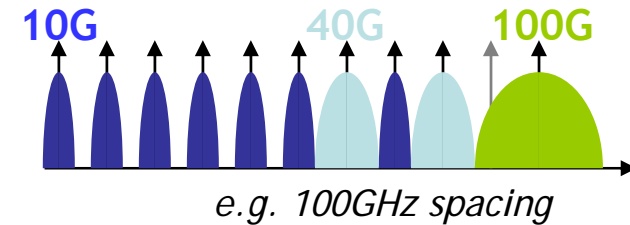
WSS technologies supporting variable channel bandwidth and spacing are key for the evolution path of photonic networks

Alcatel·Lucent

Scalability:
100 Gigabit Ethernet transport

Moving to 100GE is to increase capacity, so

➔ Link capacity needs to be increased accordingly*

➔ In core networks, scalability of fiber links clearly advocate for higher spectrum efficiency and single wavelength solution with sophisticated modulation format.

- Historically at 2.5G, typ. 32ch: 0.025 b/s/Hz (100 GHz)
- Typ. now at 10G: 0.2 b/s/Hz (50 GHz grid)
- Typ. now at 40G: 0.8 b/s/Hz (50 GHz grid)

*Reminder: today's typical link capacity is ~1 Tbit/s (100x10G)

- **<u>Target for 100G</u>: spectral efficiency at least comparable:**
  - **1b/s/Hz on 100GHz grid = 40 channels = 4 Tbit/s link capacity**

<u>Status:</u>
- **Substantial market interest for 100G**
- **Alcatel-Lucent Technology leadership including standards development**

Alcatel·Lucent

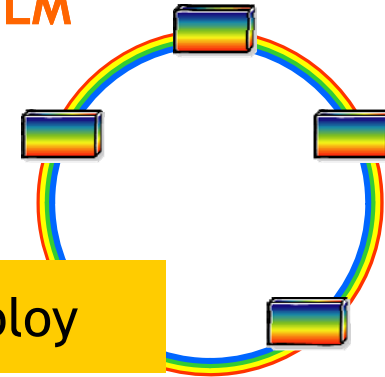# Integrated Alcatel Solution: Greater intelligence, Accelerated deployments

Link Planning Tool
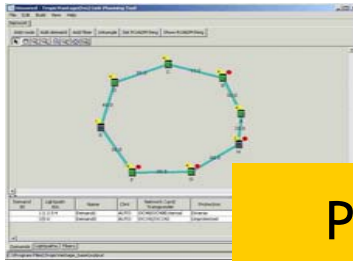
SPLM

- Equipment configuration automatically generated
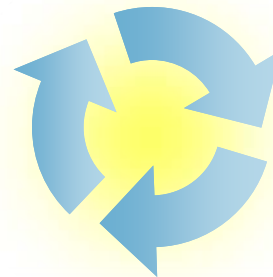- User-friendly interface with graphical views of the network

Plan

Deploy

- Current configuration is imported to LPT to support upgrade of existing design

- Validated network design exported to NMS

Manage

NMS 1354RM

Alcatel·Lucent

The next step:
Wavelength rerouting to increase the overall network reliability with T&ROADM:

Local OTS Port:
Towards photonic transparent networks

The local OTS ports represents the ultimate flexibility:

• local add/drop traffic is not dependent on any specific direction

• Paths can be provisioned in the photonic domain

• **The enabler for photonic restoration !**

Direction 1

Direction 2

Direction 3
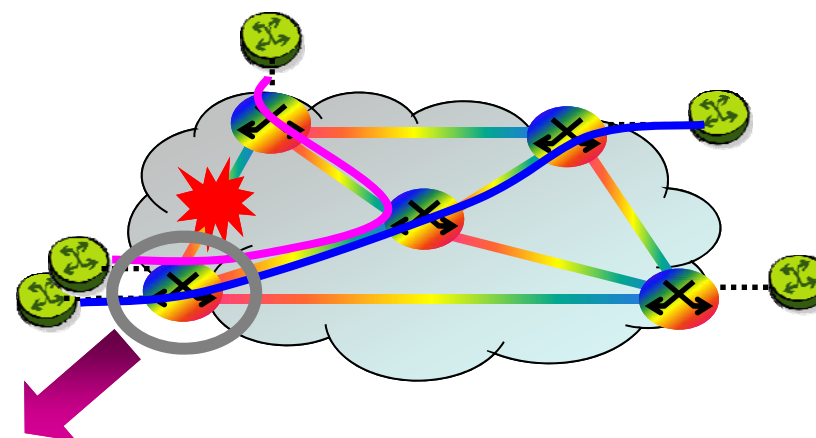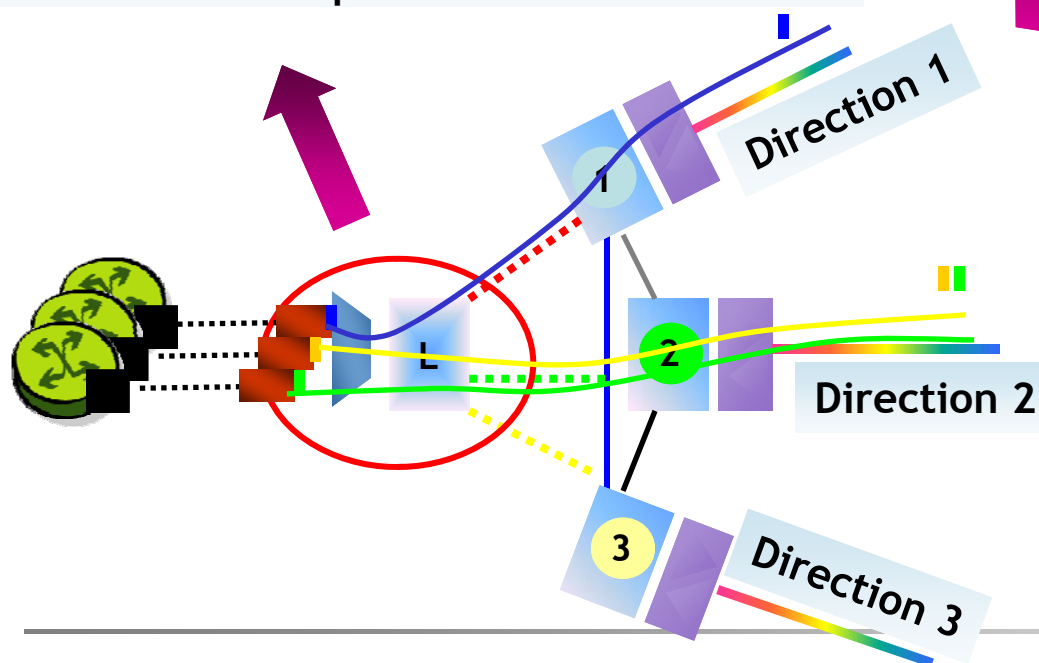
pool of regenerator on local OTS port can be accessed dynamically for new connections

Alcatel·Lucent

Automated photonic layer:
GMPLS for fast service setup (BW-on-Demand), restoration...

Switched Connection restoration supporting multiple failures

Source-based restoration mode : photonic routing engine for optical route choice

Automatic check Optical Path (direct or regen)

RSVP-TE

UNI

UNI

GMPLS

UNI

UNI

RSVP-TE

OOO Transparent Domain

GMPLS benefits:
- Faster service setup
- Automatic restoration
- High level of resilience
- Good resources usage
- Automated discovery

IP/MPLS router

Multi-Service XC

degree-N node

Alcatel·Lucent
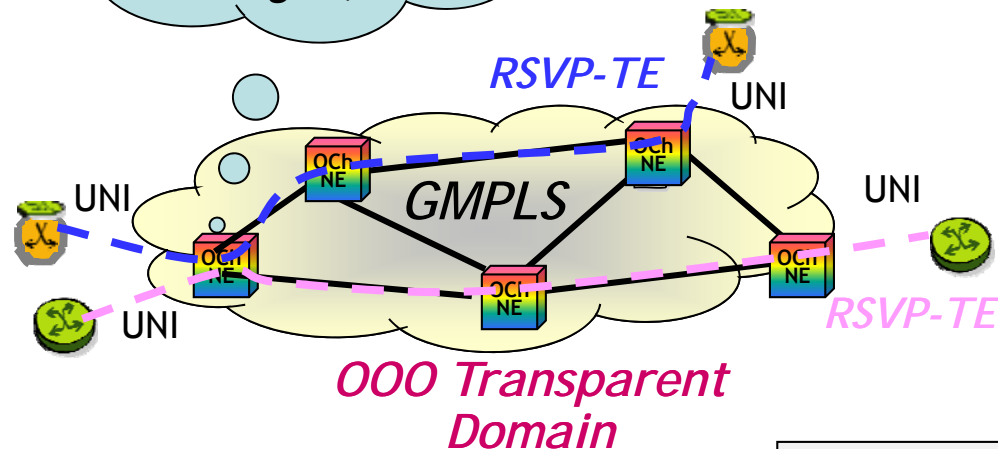
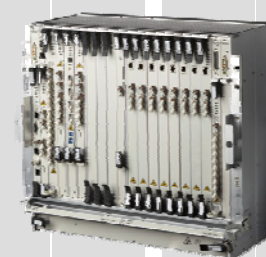# Products for Tunable ROADM

2007

2008

1696 R-OADM 5.0
- 1-4 Degree T-OADM
- 42 λ 2,5G & 10G
- SDH & GbE TDM
- λ Management
- Transponder less operation (40G)

1850TSS-320 2.0
- 1-8 Degree T-OADM
- 44 λ 2,5G, 10G
- TDM/WDM/Packet Machine
- 10xANY (SDH, GbE)
- OTU-2 (λ tunable)

1626 LM 5.0
- 1-4 Degree T-OADM
- 72 λ 2,5G, 10G & 40G
- Multi Range Platform
- 40G (PBST & DPSK)
- GbE-ADM (L2-PM)

Alcatel·Lucent

Conclusion

Zero-Touch Transparent Photonic Networks help service providers to:

- Ease operations
  - Tunable ROADM, to ease commissioning
  - Flexible nodes, to provision/reconfigure and tune remotely
- Reduce costs
  - Cost-effective scalable Multi-degree ROADMs enable transparent transits
- Improve network resilience
  - Photonic restoration
  - Supporting multiple failures in addition to fast electrical/client protection
- Cap existing, future-proof investments
  - Photonic switching to support variable grid and channel bandwidth
  - Future-compatible (40G/100G ready) and backward-compatible

Alcatel·Lucent

www.alcatel-lucent.com