IP + Optical in the Next Generation Network

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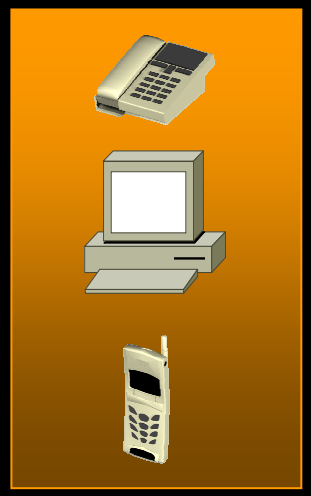
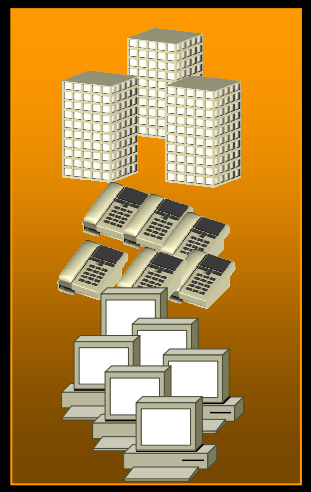
Networks in Transition
Today: Service Specific Networks





Narrowband Access Network

Broadband Access Network

Radio Access Network

SONET/SDH Access Network

High Speed (Ethernet) Access Network

Voice Network (Circuit)

TDM Network (Circuit)

FR/ATM Network (Packet)

Public IP Network (Packet)

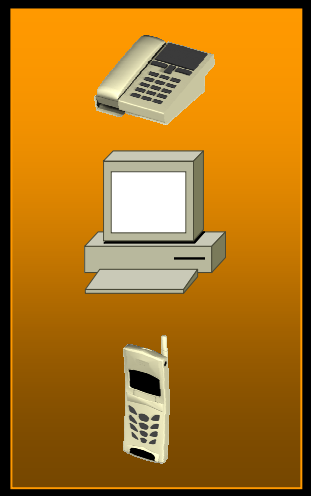
Private IP/MPLS Network (Packet)

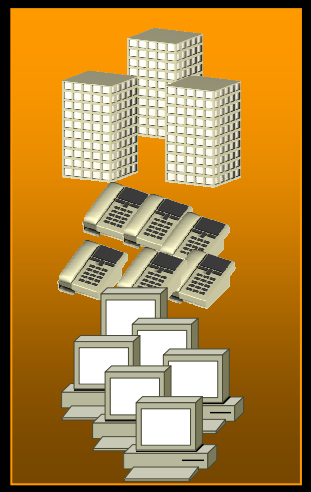
Optical Network (Circuit)

Challenges:

- Capex
- Opex
- Service Velocity

Networks in Transition
Future: One Network, Many Services





Broadband Access Network

Radio Access Network 2.5G/3G/4G/WLAN

SONET/SDH Access Network

High Speed (Ethernet) Access Network

TDM Network (Circuit)

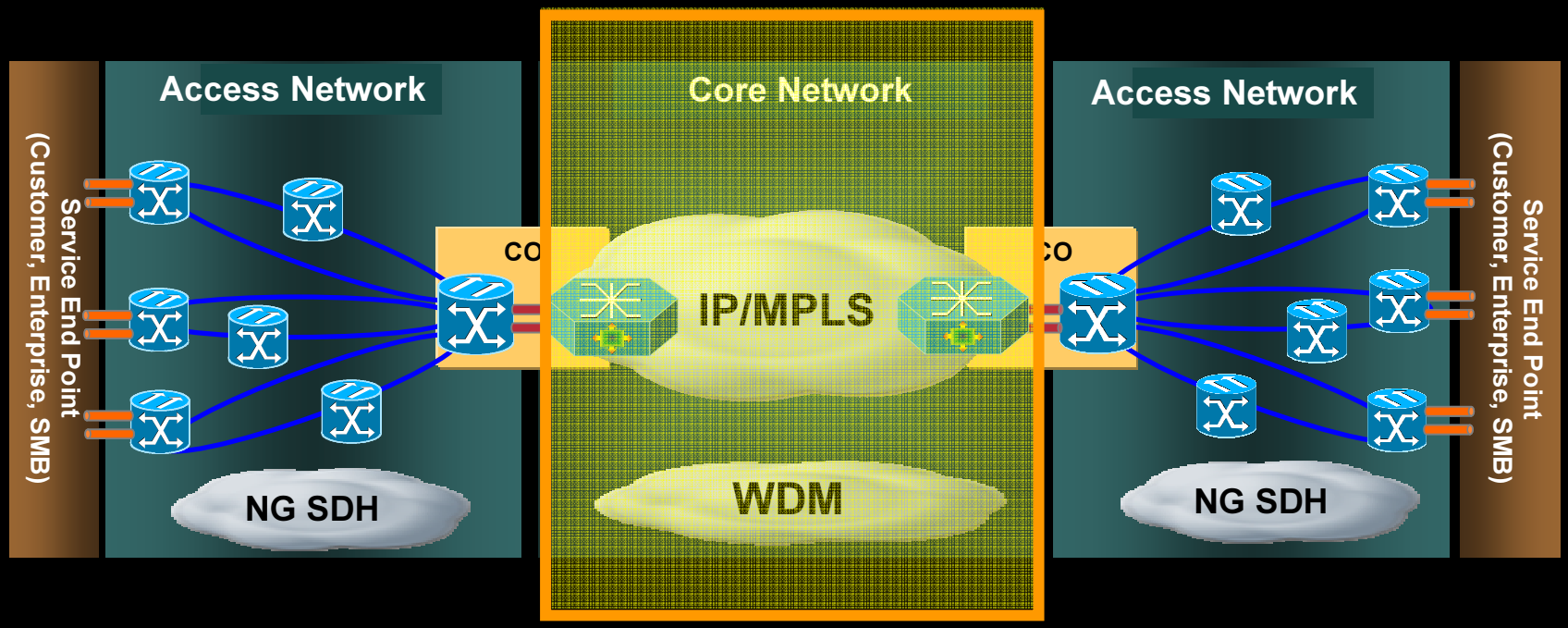
Public

IP/MPLS Network

Private

Optical Network

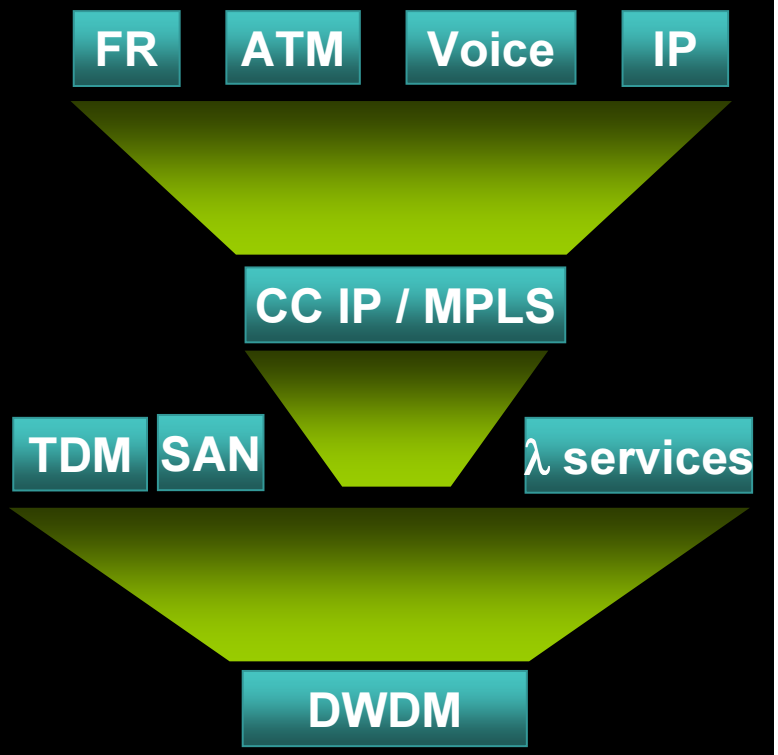
Access and core Networking:
End-End Data Delivery



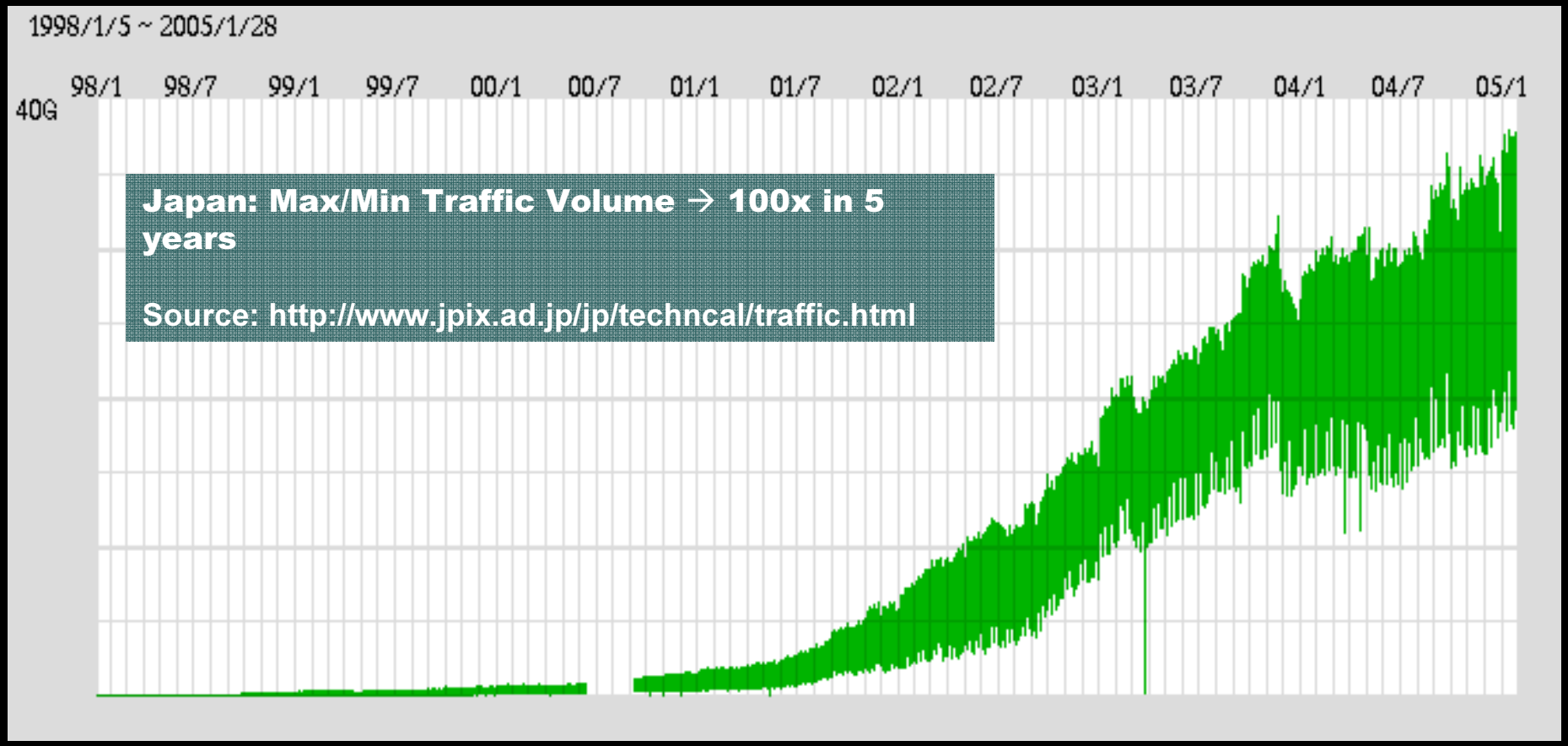
- Core networks: IP+WDM
- Access Networks: NG SDH with packet integration
- Boundaries between packet and optical blurring
- Integration of management and control planes

IP+Optical Integration in the Core

- Packet layer convergence to IP/MPLS is starting to deliver CAPEX and OPEX savings in core networks
- Significant additional CAPEX/OPEX saving can be had by converging the IP layer and the optical layer



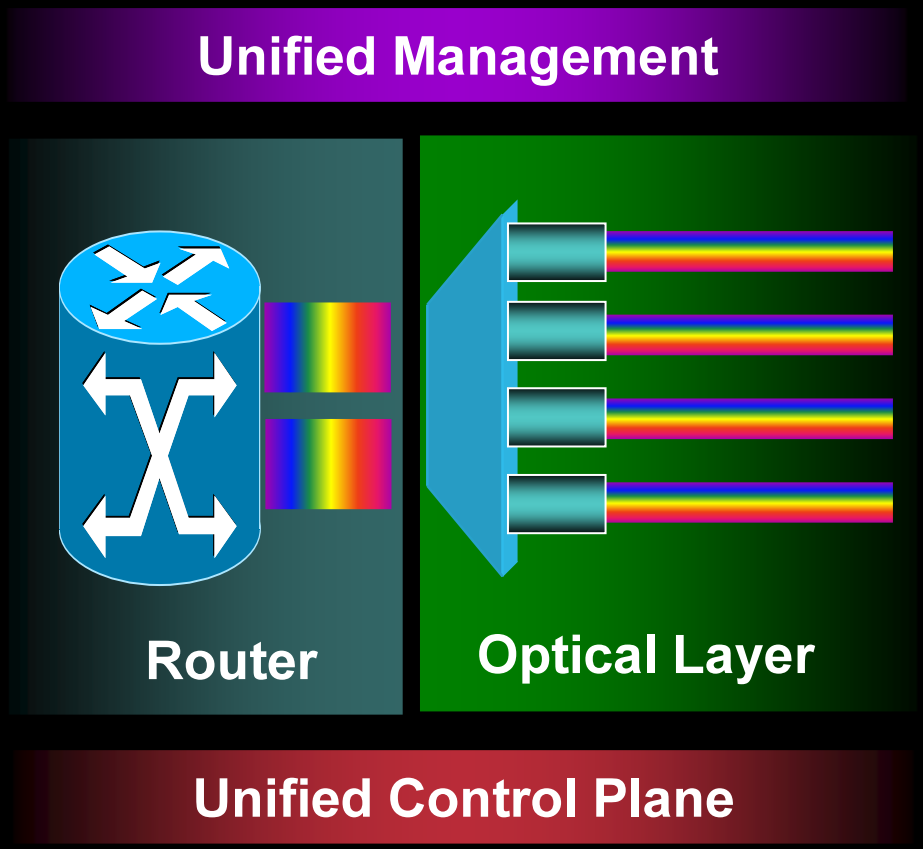
Why Converge Over a True Optical Layer



- **Only a true optical layer can accommodate such traffic growth!!!**

IP+Optical Building blocks

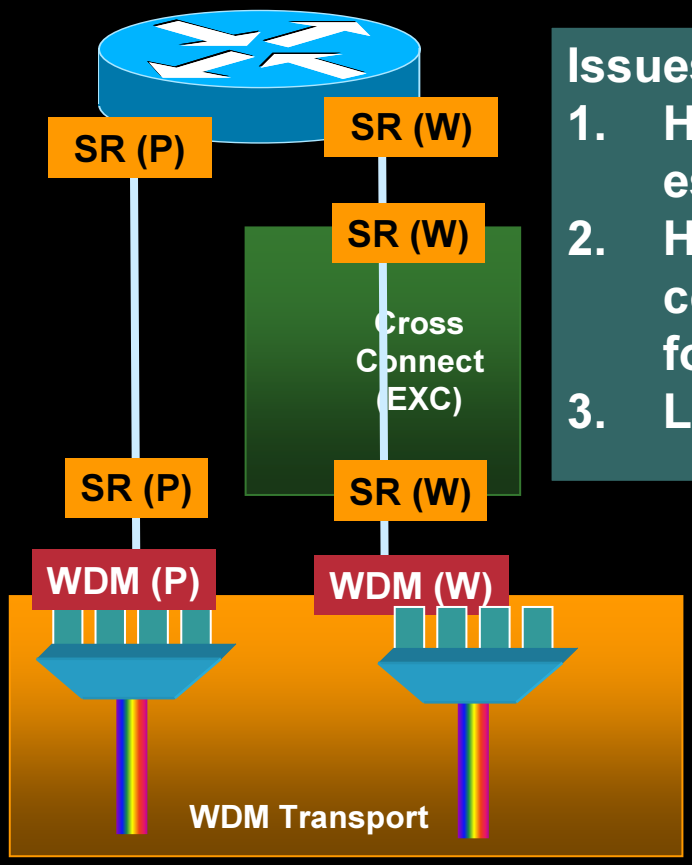
1. Colored interfaces directly on the router
2. Switched Optical Layer
3. Integrated management
4. Integrated control plane



CAPEX Issues with Current Architecture

Many non-revenue generating costly interconnections

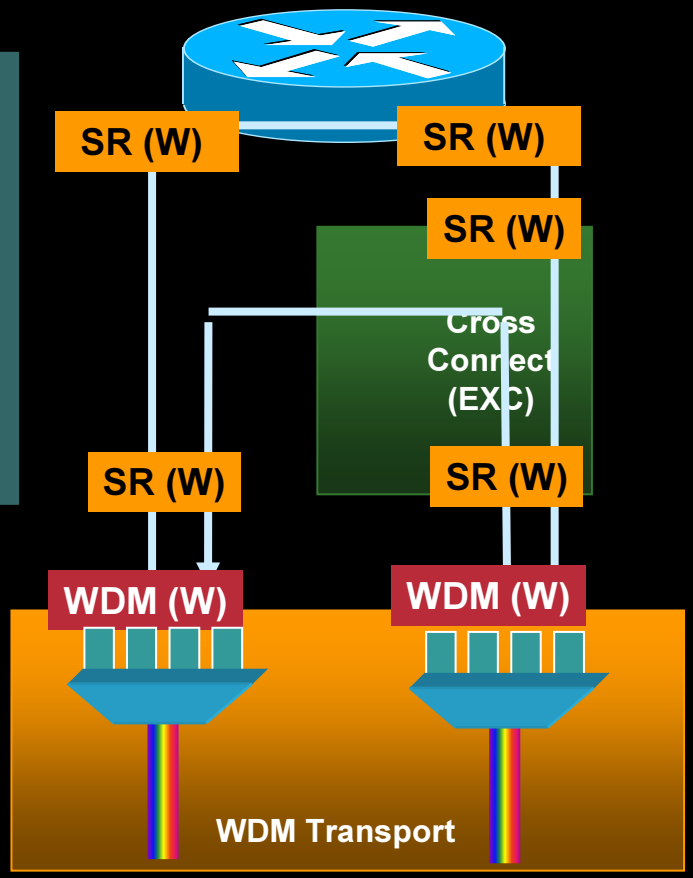
IP Source/Sink Nodes



Issues:

1. High CAPEX – especially at 40G!
2. High OPEX: power consumption & footprint
3. Lower reliability

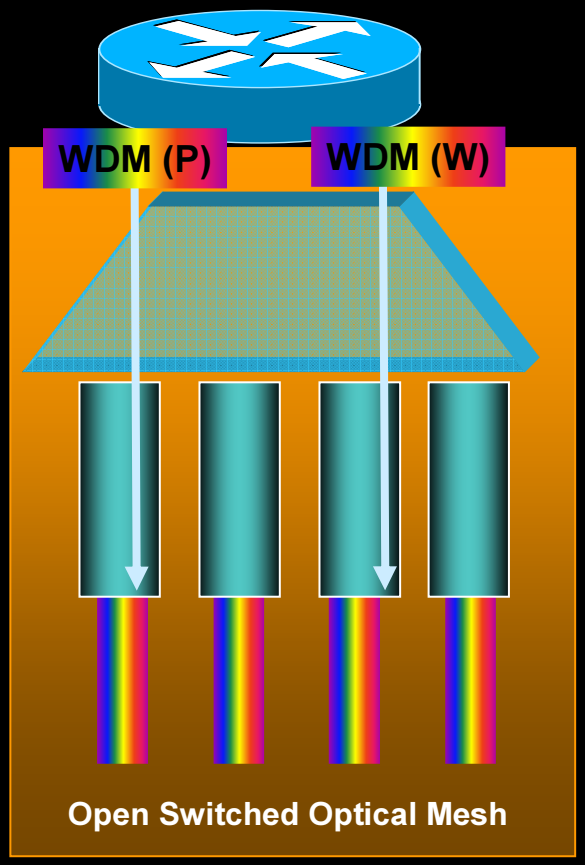
Transit Nodes



Cisco's IP+Optical Strategy:

Simplifying the Network and Reducing its Cost

IP Source/Sink Nodes



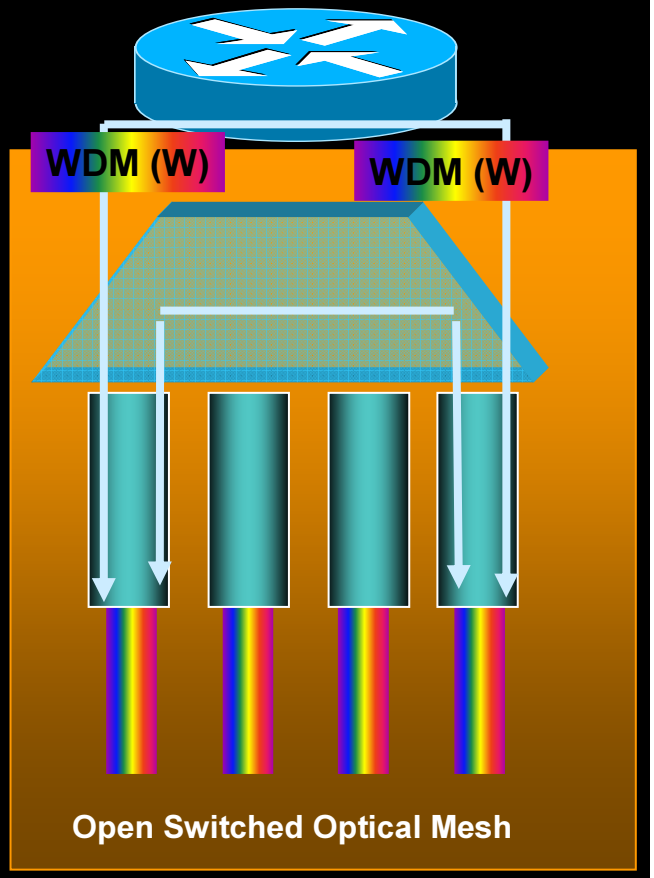
Transponder-less network:

1. No conversion form SR to λ
2. No regens

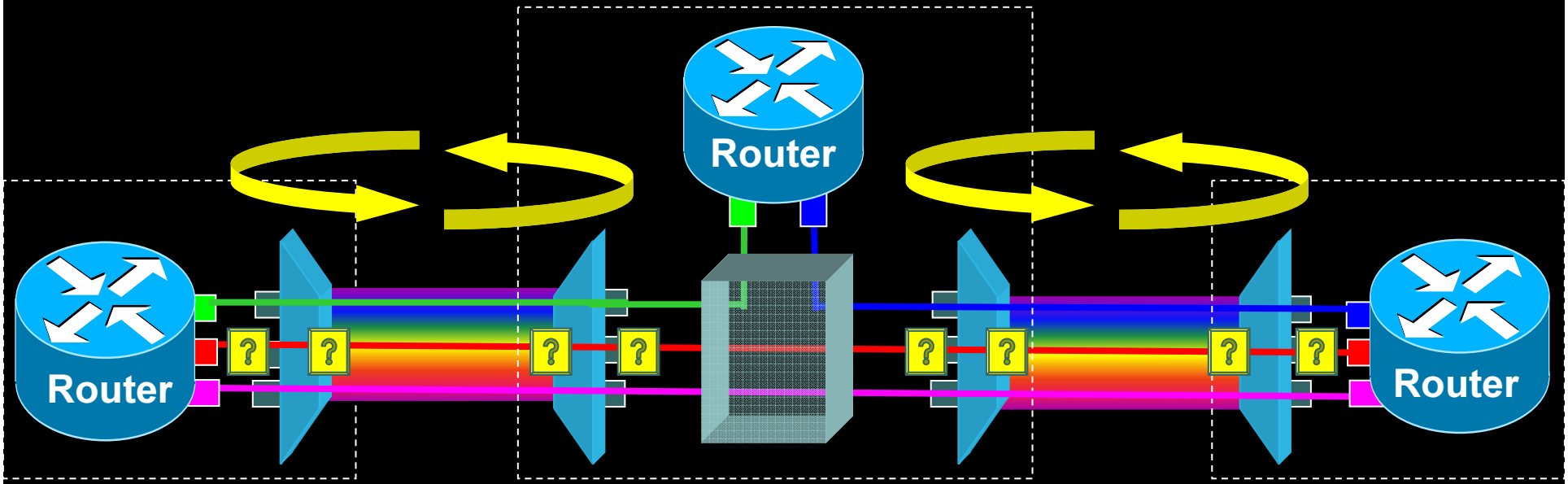
Issues solved:

1. Racks of transponders eliminated
2. Reduced number of O-E-O conversions increases reliability

Transit Nodes



Addressing the Operational Challenge (1):
Making DWDM operationally friendly



- Concern: An end-to-end optical layer may be hard to manage
- Solution:
  1. Instrumentation in the optical layer to monitor the signal everywhere
  2. Automated “analog control plane” to create adaptive system that eases installation and maintenance

Legacy DWDM Systems

Manual DWDM Network Life-Cycle

Manual provisioning of optical design parameters

Manual provisioning of equipment & topology into EMS/NMS

Complicated Network Planning

Labor-intensive operation

Manual installation, manual power measurements and VOA tweaking at every site for every wavelength

Manual DWDM processes: labor intensive and error prone
Result: high OpEx costs

Next Gen Optical Layer

Automated DWDM Network Life-Cycle

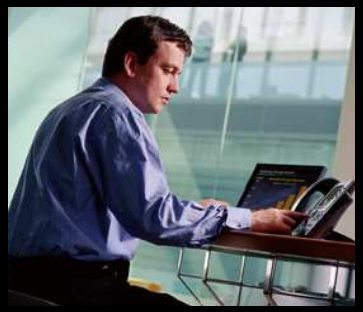
Cisco.com

Automated provisioning of all parameters

Easy changes to design based on actual fiber plant

EMS/NMS learns from the network and stays in sync (Optical OSPF)

Automated end-to-end lightpath setup



Easy planning with sophisticated tool

Automated optical layer for end-to-end connection setup; Manual patching of client at end-points only

Simplified, graphical A-Z lightpath provisioning & trouble shooting

Automated DWDM: simplified TDM-like installation and on-going operation
Result: Reduces OpEx, facilitates wide deployment

Next Gen Optical Layer

Enabling Technologies

Planning & simulation tool

Auto Node Setup

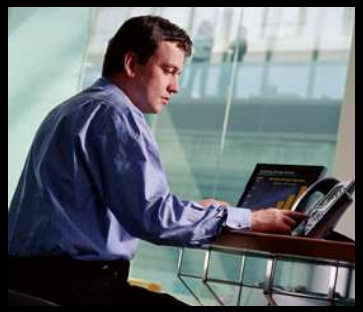
Auto Power Control

ROADM

True power measurement

Optical OSPF

Sophisticated EMS



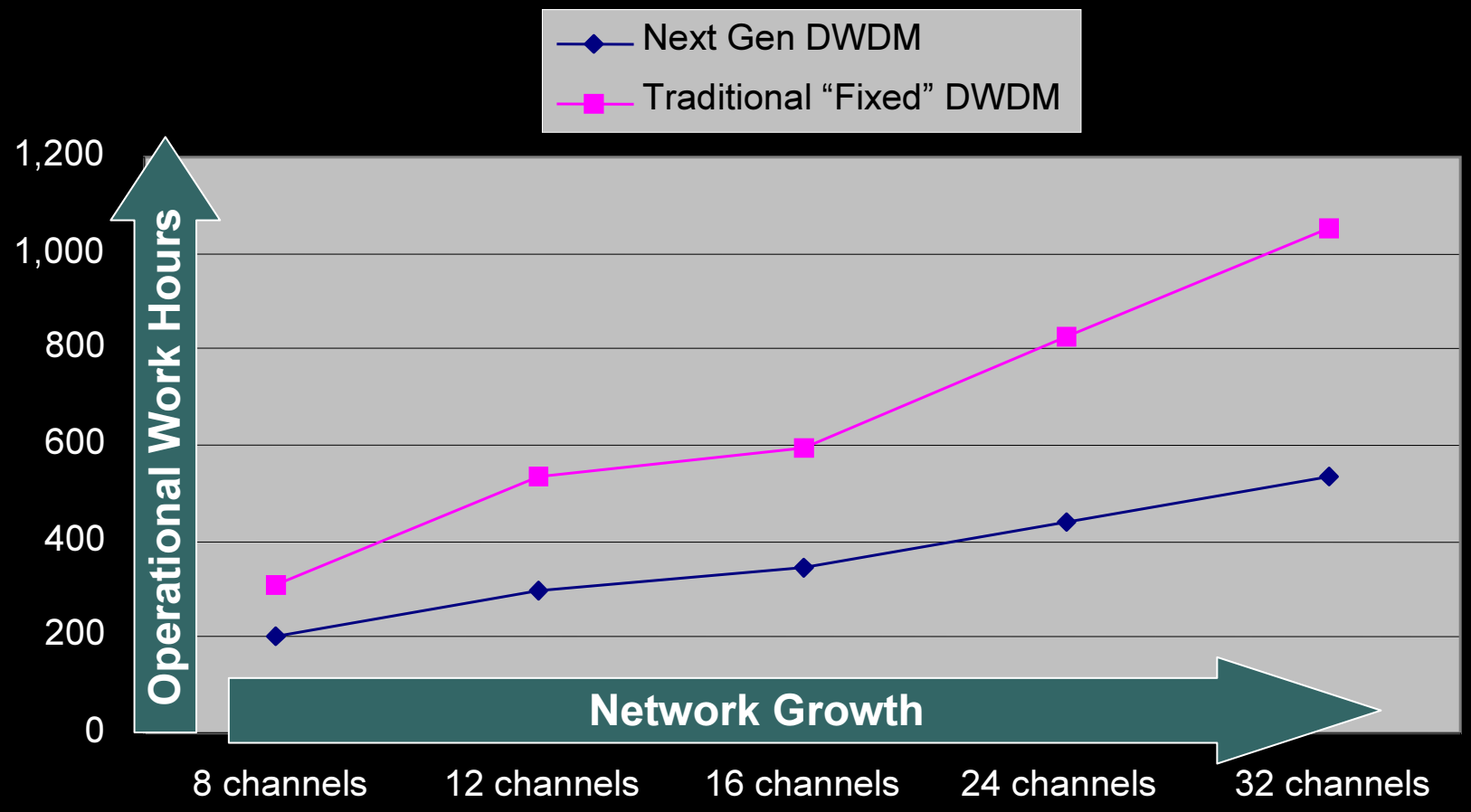
Easy planning with sophisticated tool

Automated optical layer for end-to-end connection setup; Manual patching of client at end-points only

Simplified, graphical A-Z lightpath provisioning & trouble shooting

Operational Efficiency: Legacy vs. NG DWDM

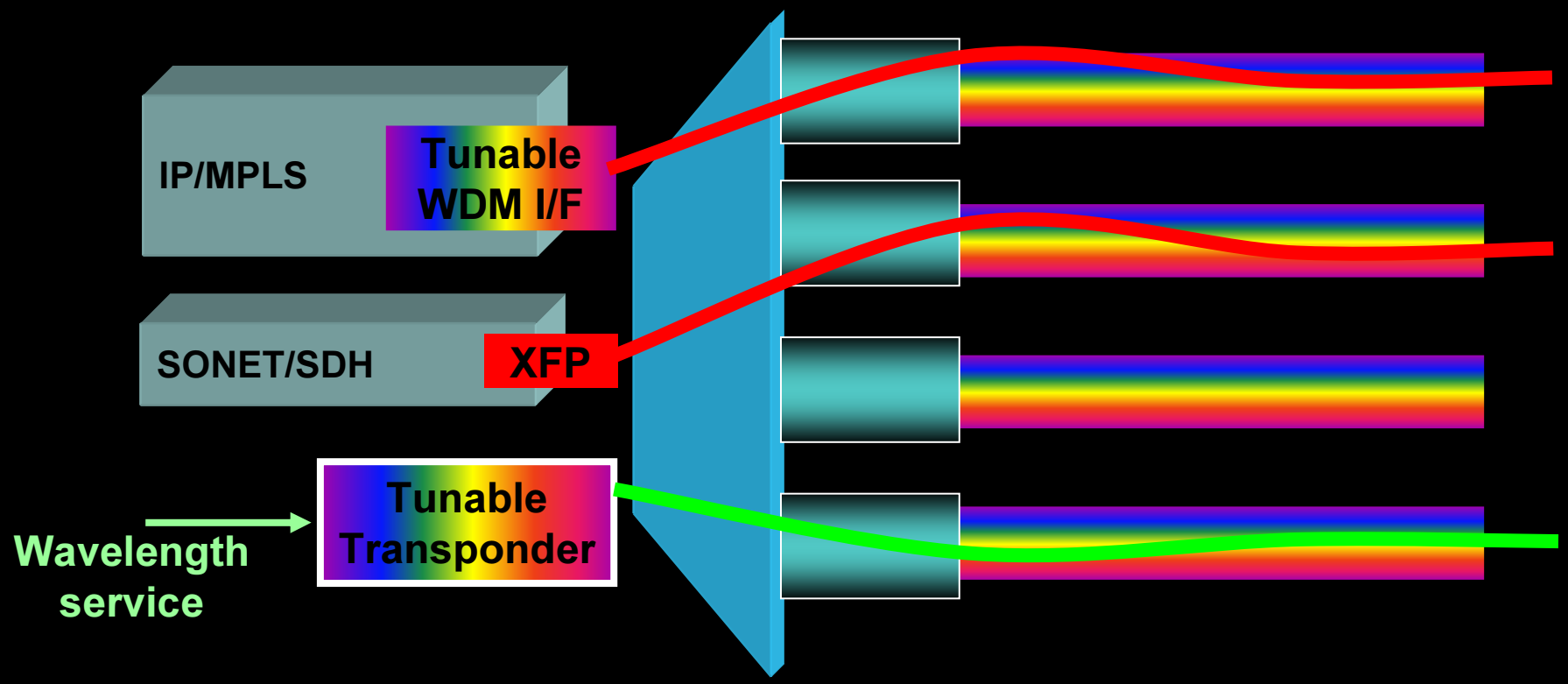
Operationally friendly DWDM – ready for core applications



Analysis done w/ 1 ROADM – further value will exist w/ more ROADMs

The Switched Optical Layer:

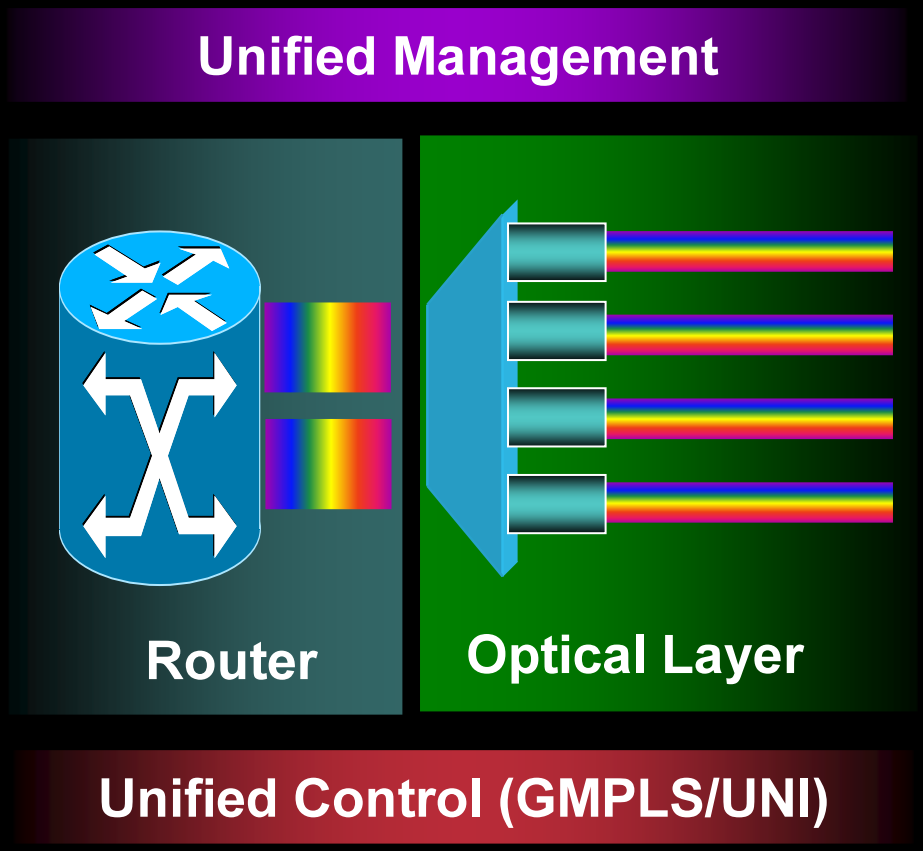
The convergence layer for non-packet traffic as well



One optical layer for packet and TDM client, as well as future high bandwidth "λ on demand"

Control and Management Planes

1. Integrated Management is needed for FCAPS functions, specifically:
   - Provisioning of boxes, card and connectivity
   - Trouble shooting for complex problems
2. Integrated control plane for:
   - Fault isolation
   - Autodiscovery
   - Restoration



Why does the Optical Layer need a Control Plane?

1. There is no trivial answer, taking into account the usage of the optical layer today
   - Proof point: no wide scale deployment of control plane despite 6 years of discussions
2. Network management can provide many of the same features w/out a CP:
   - A-Z connection setup within seconds
   - Fault correlation
3. However, there is significant momentum on the topic:
   - ISOCORE/MPLS Forum multi-vendor interoperability trials
   - OIF multi-vendor interoperability trials for Optical UNI
   - Ongoing Service Provider lab trials
4. What are Network Operators hoping to achieve?

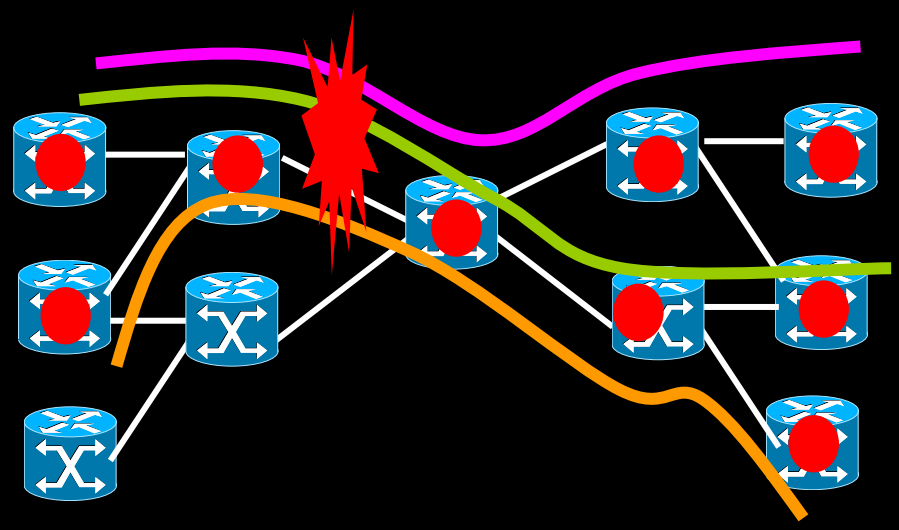
Why does the Optical Layer need a Control Plane?

1. **Simplifying network integration:**
   - It is hard to integrate new technology into management systems
   - Operators are hoping that getting vendors to interoperate at the CP level, will allow for simpler management systems and faster integration
2. **OPEX reduction:**
   - Automatic discovery mechanisms
   - Alarm correlation and reduction
3. **CAPEX reduction:**
   - Shared mesh restoration
4. **Increased revenue via new services:**
   - CP enables new applications such as BoD

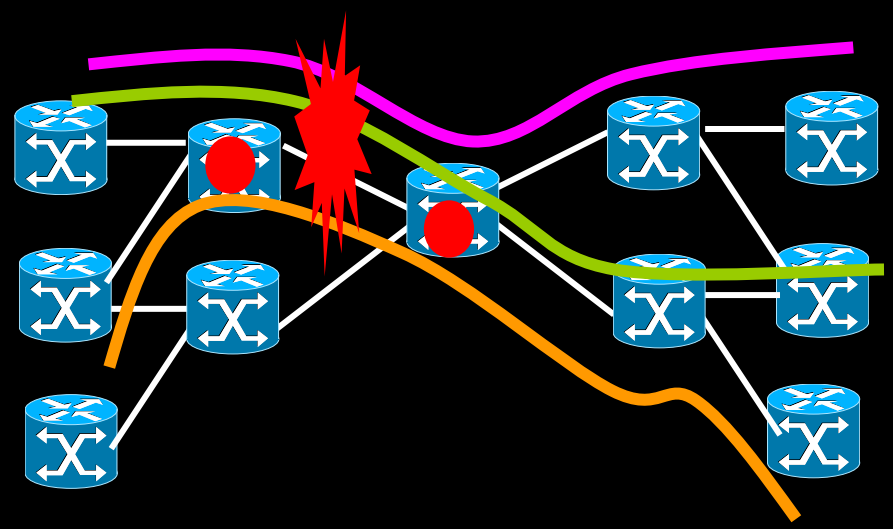
Roles of the Control Plane (1)

Fault Localization

- W/out fault localization: every node alarms of the failure



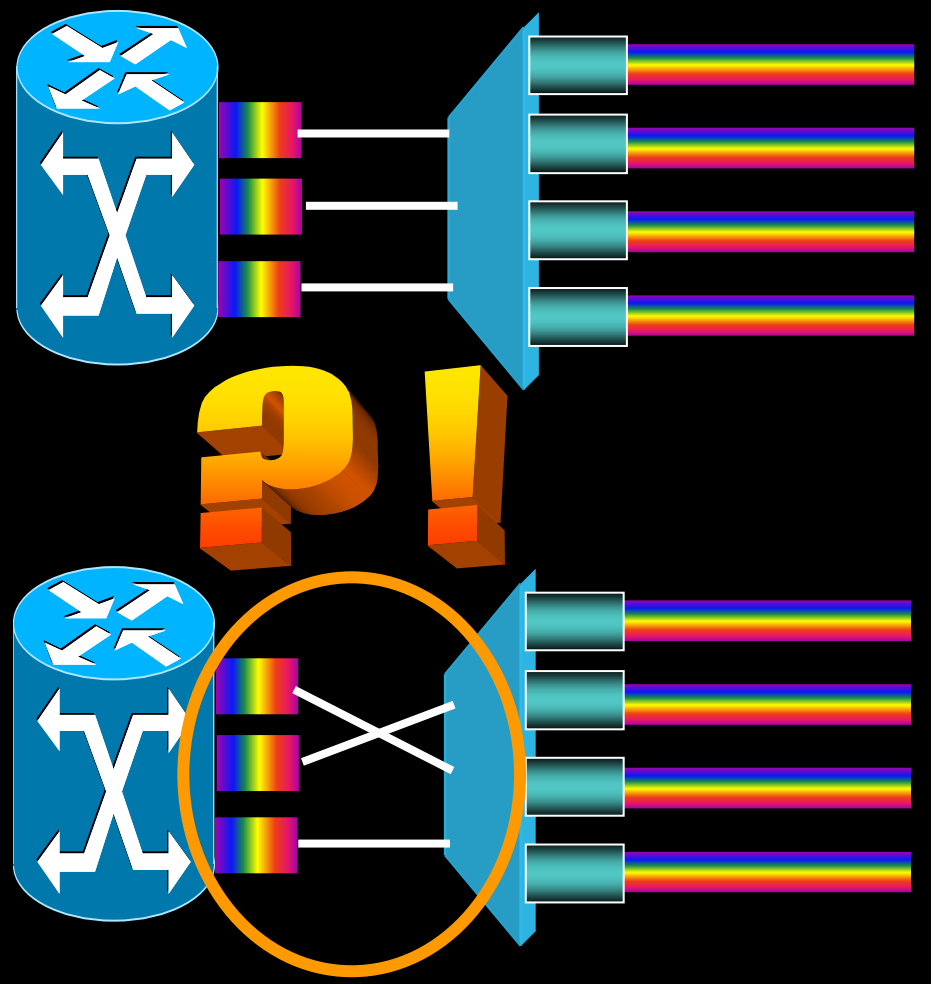
- With fault localization: only adjacent nodes alarm
- Implementation: forward and backward defect indicators via Link Management Protocol (LMP)



Roles of the Control Plane (2)

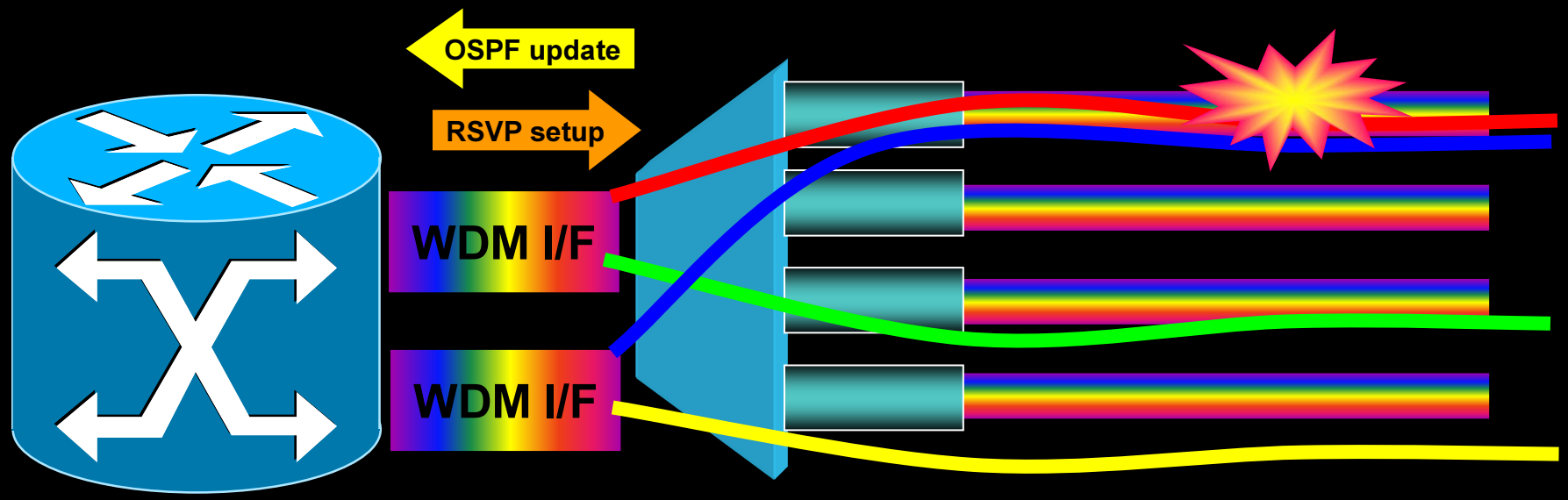
Autodiscovery

- W/out autodiscovery: A misconnection is hard to detect
- With autodiscovery: the right configuration is detected
- Implementation: on/off test messages on interfaces coordinated by LMP



Roles of the Control Plane (3)

End to end intelligence



- Once the router and optical layer understand the end to end topology, combined intelligence can be built into the network
- Upon failure in the optical domain, the router can signal to set up a backup path
- Implementation: GMPLS peer model or border model to allow router to participate in optical layer control plane

Values of IP+Optical Integration

Feature	Benefit
Direct connect of ITU on router into all-optical layer – minimize OEO conversion in the optical layer	1. Lower CAPEX: no transponders 2. Lower OPEX: reduce footprint & power 3. Higher reliability: less components
Full flexibility to configure the core w/out manual involvement	Reduce human labor and human errors (OPEX)
New protocols transported w/out complex mediation	Future proof: no need to overhaul network for new service types (CAPEX)
Operational usability comparable to SONET/SDH	OTN incorporates technologies for easy mgmt & troubleshooting (OPEX)
Scalable to more WLs & higher bit rates (40G)	Future proof: long term use for investment

Summary

Yesterday

- Optical and IP separate
- Network management with limited integration
- Manually intensive WDM

Tomorrow

- Ethernet/MPLS into optical
- WDM into routers
- Fully integrated control plane
- Plug and play, reconfigurable WDM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