



Physical Layer Components, Architectures and Trends for Agile Photonic Layer Mesh Networking

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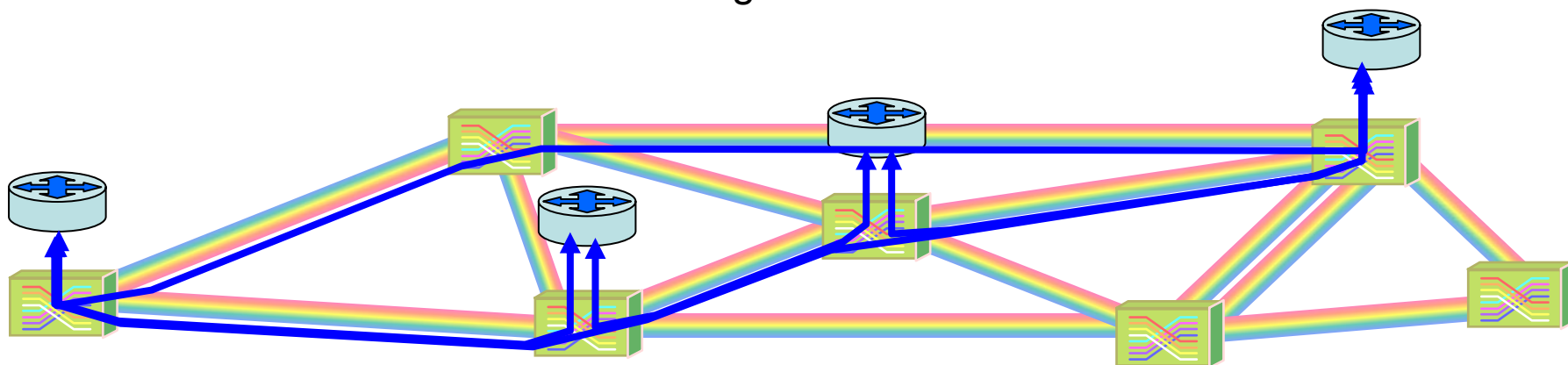


Outline

- Advantages of “Static” ROADM Optical Mesh Networks
- The WSS and Current “Static” Mesh Node Architectures
- Applications of “Dynamic” Optical Mesh Networks
- Node Architectures for “Dynamic” Mesh Networks
 - Colorless ports
 - Directionless ports

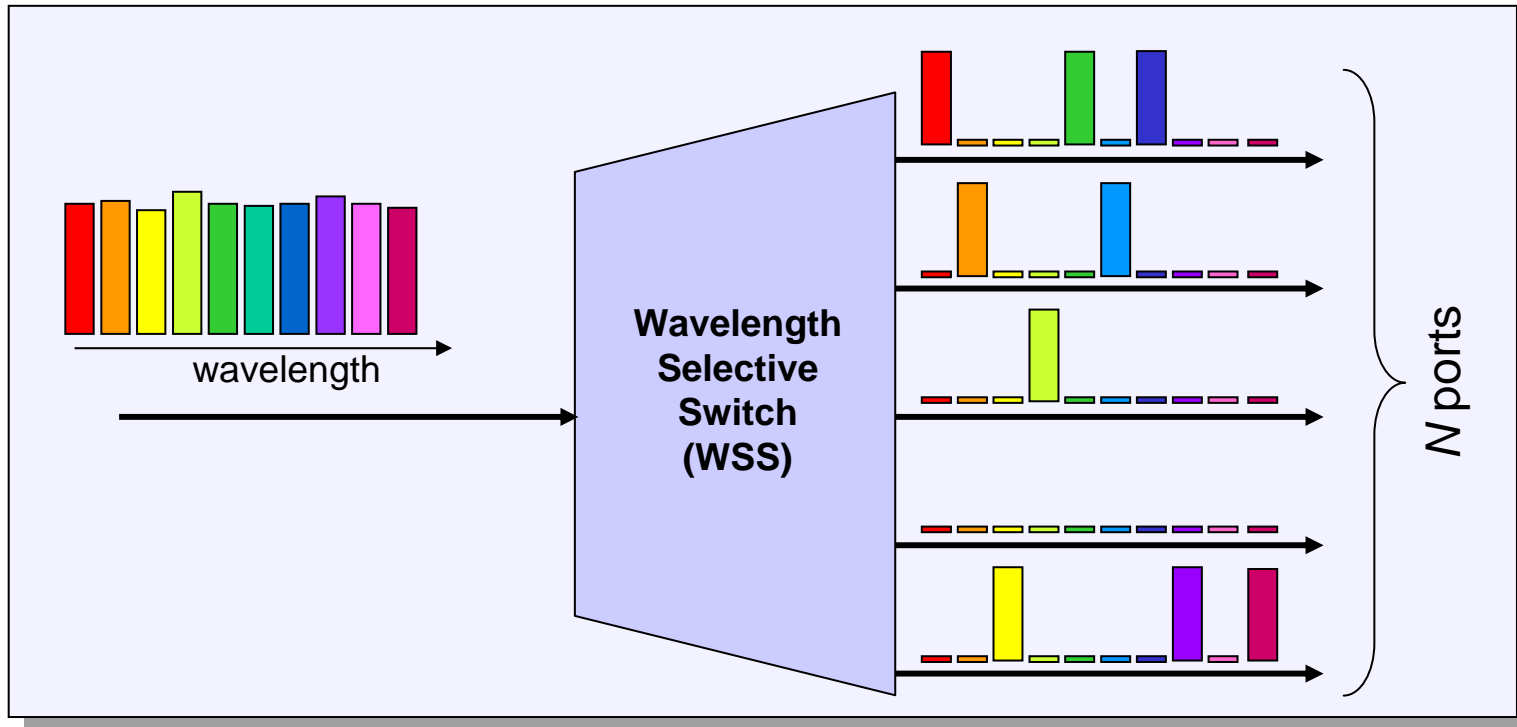
Advantages of Static ROADMs Optical Mesh Networks

- Eliminate OEO at network junctions
 - Considerable cost, complexity and maintenance savings
- Flexible wavelength topology enables efficient capacity growth
 - Most efficient routes can be selected
 - Extends lifetime of system
- Add new connectivity via unused degrees as needed
 - Parallel spans, spurs, extensions, ring interconnects
 - Maintains in-situ HW and management



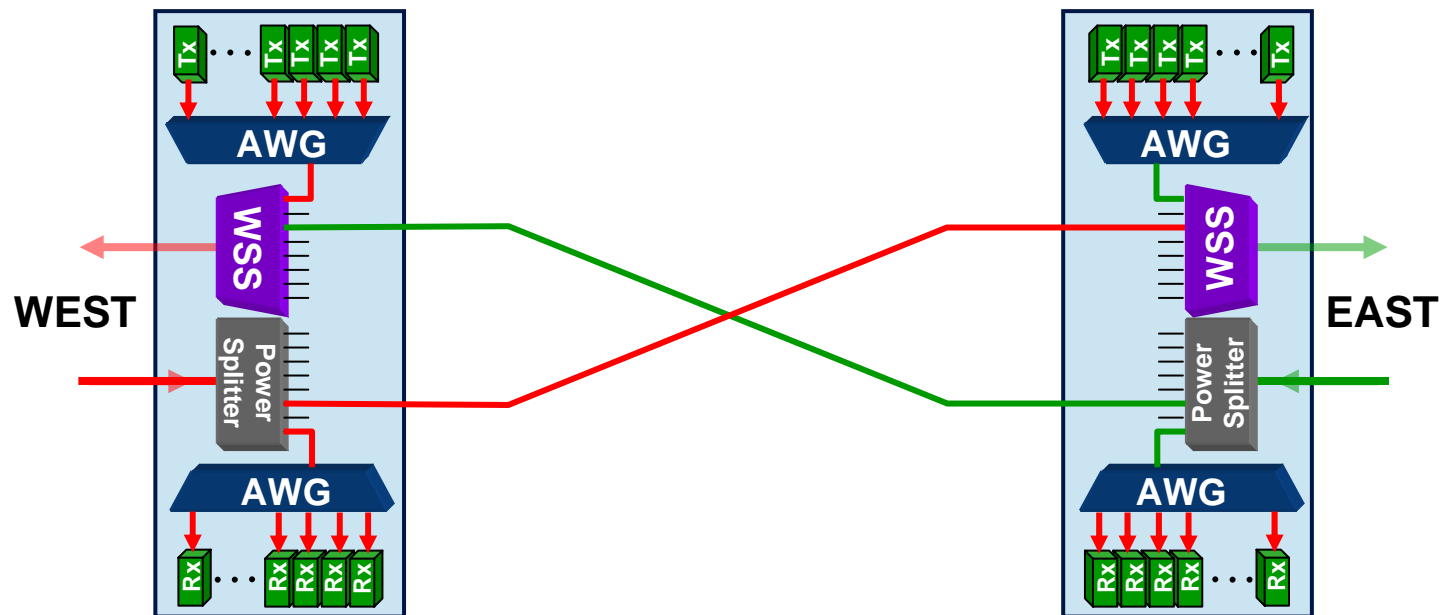
The Wavelength Selective Switch (WSS)

- 1xN port device
- Independently routes each channel to one of N ports
- Attenuate and block channels independently
- Optically bi-directional

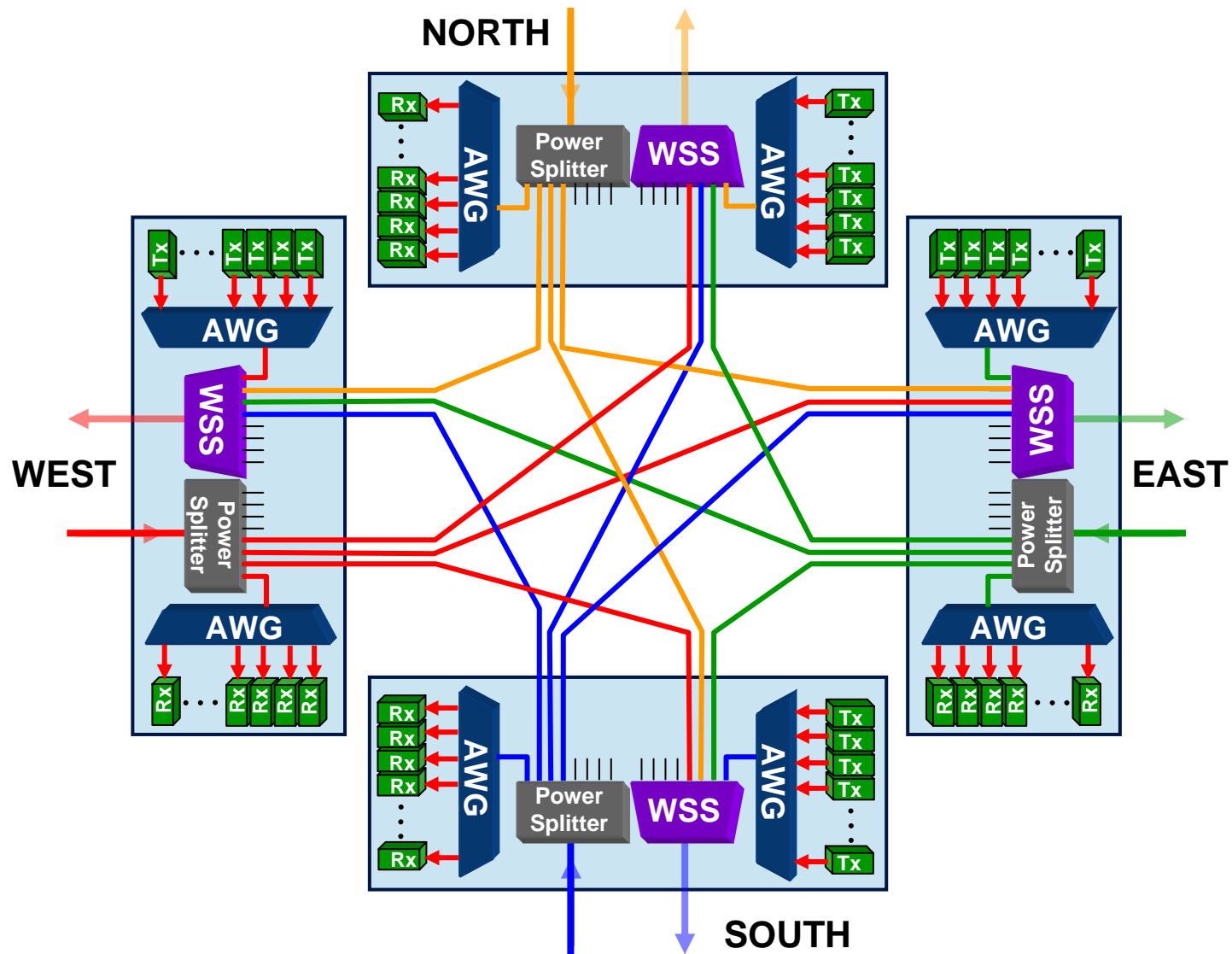


Typical Reconfigurable Ring Node Architecture

- WSS selects outbound wavelength traffic
- AWG's used to multiplex and demultiplex locally added and dropped channels
 - “Colored” add/drop ports

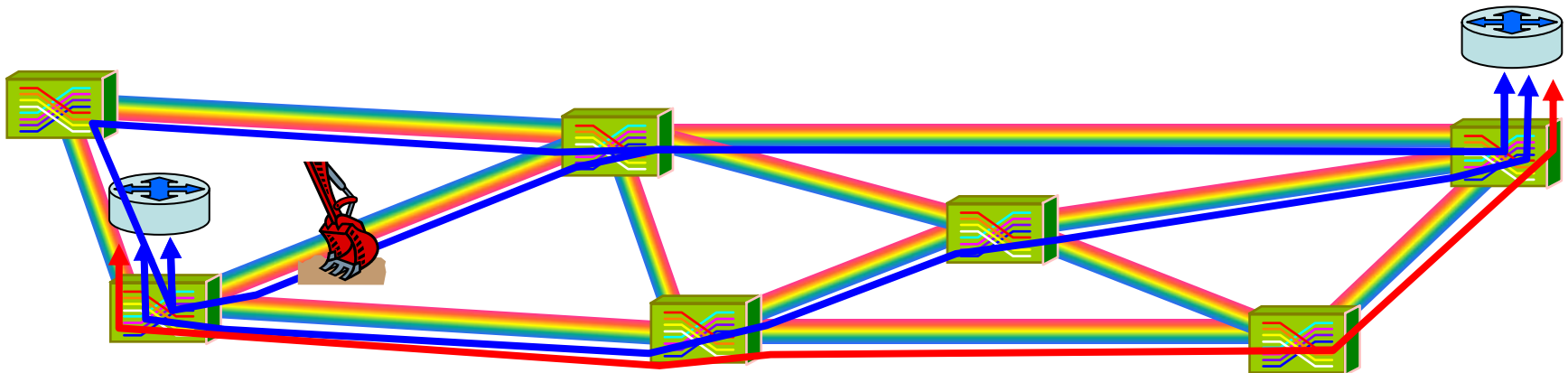


Typical Reconfigurable Mesh Node Architecture



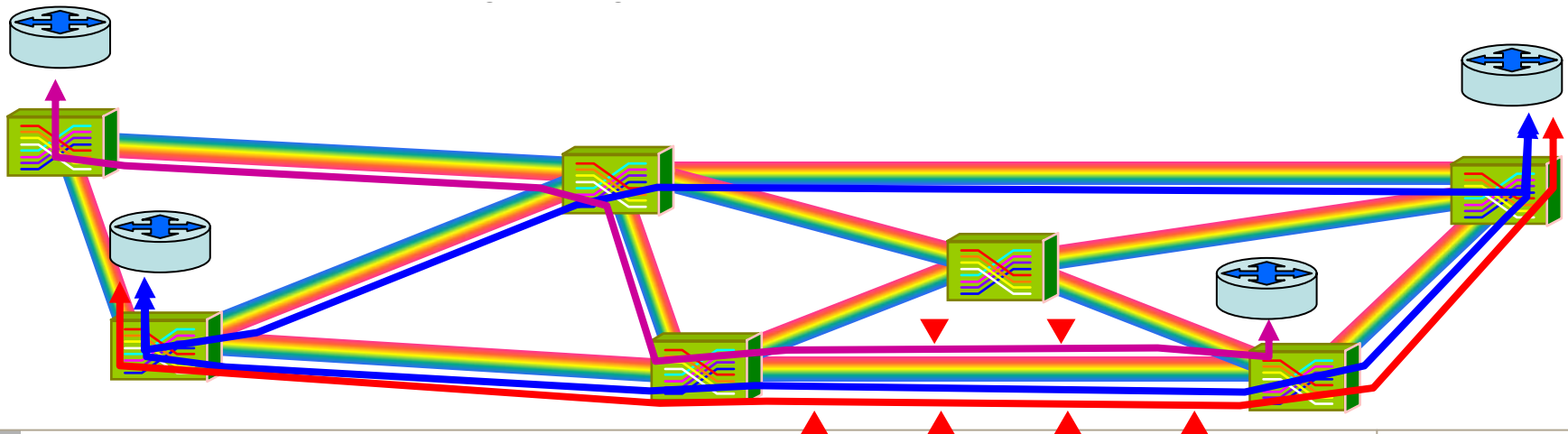
Dynamic Optical Mesh Network Applications

- Photonic layer restoration
 - Restoration complements higher layer protection to increase overall availability
 - Relaxes urgency to repair fiber (OpEx argument and reliability increase)
 - Some locations have limited access (disaster zone, subways, remote locations, undersea festoons)
 - Reduces excess capacity allocated for protection contingencies (CapEx argument)



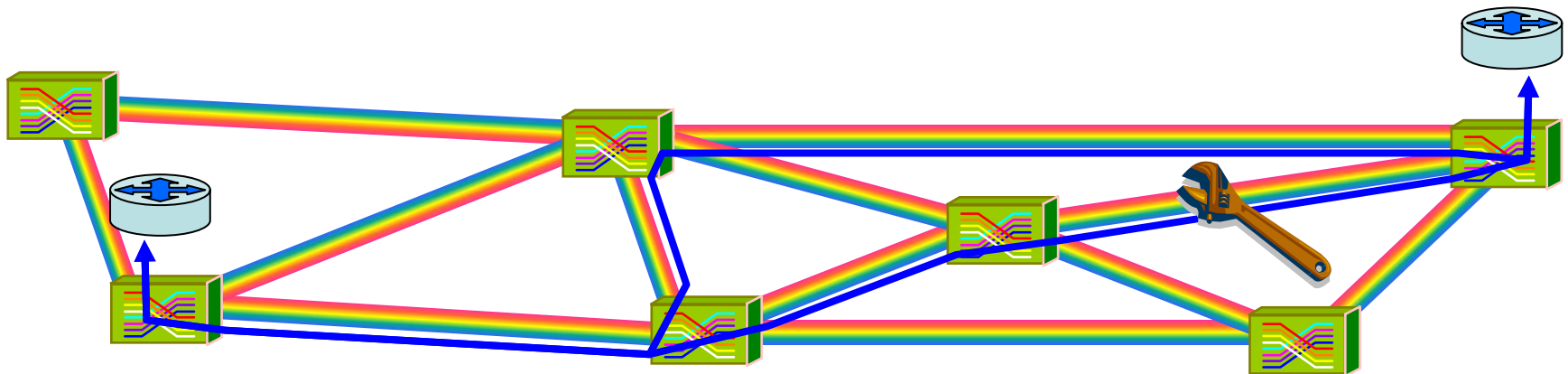
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- Load Balancing
 - Move existing traffic to relieve emerging bottlenecks



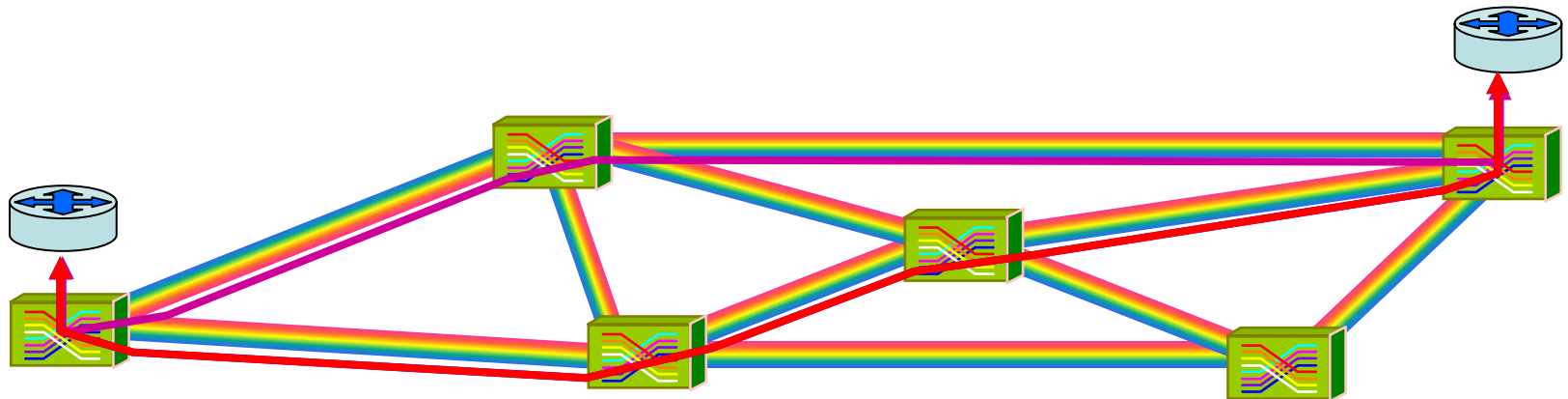
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- Maintenance switching
 - Move traffic away from area of planned maintenance



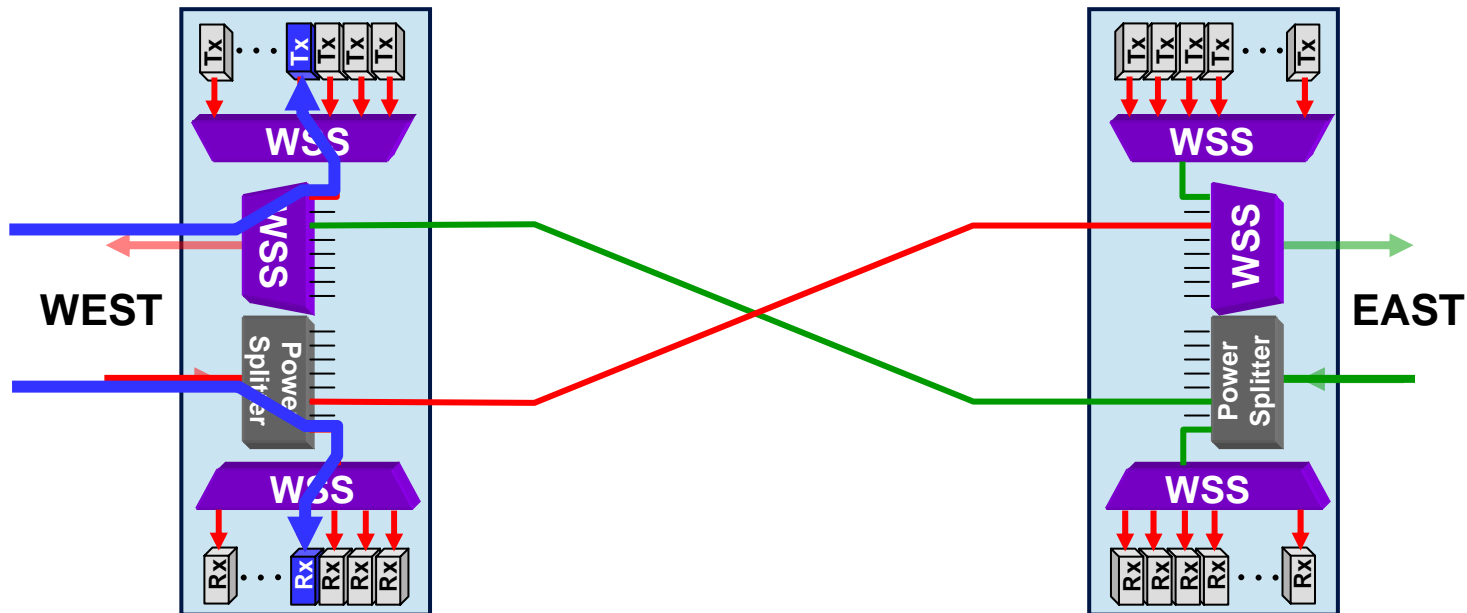
Dynamic Optical Mesh Switching Requires...

- Optical network level features:
 - Colorless add/drop ports
 - Directionless add/drop ports

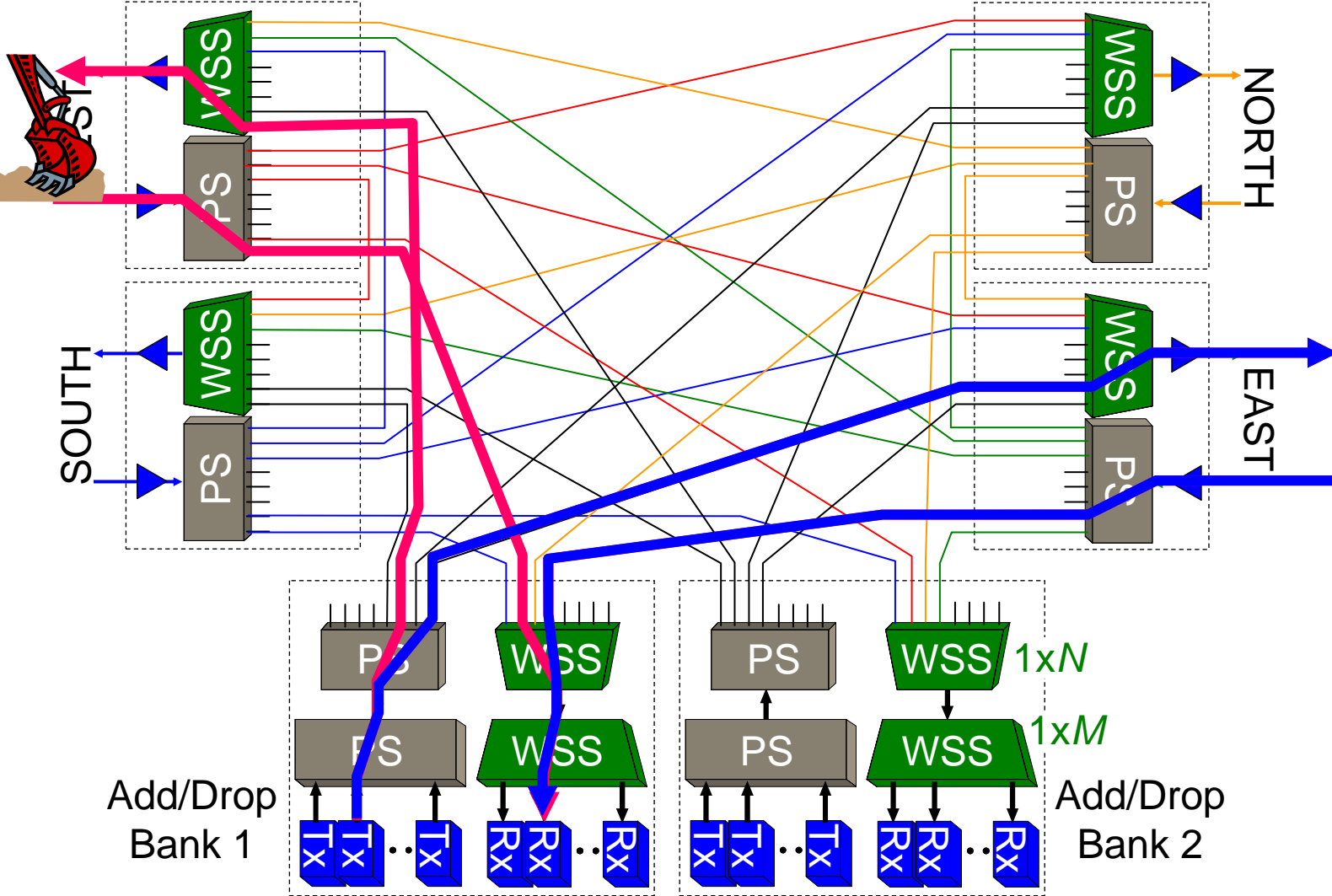


Colorless Add/Drop Ports

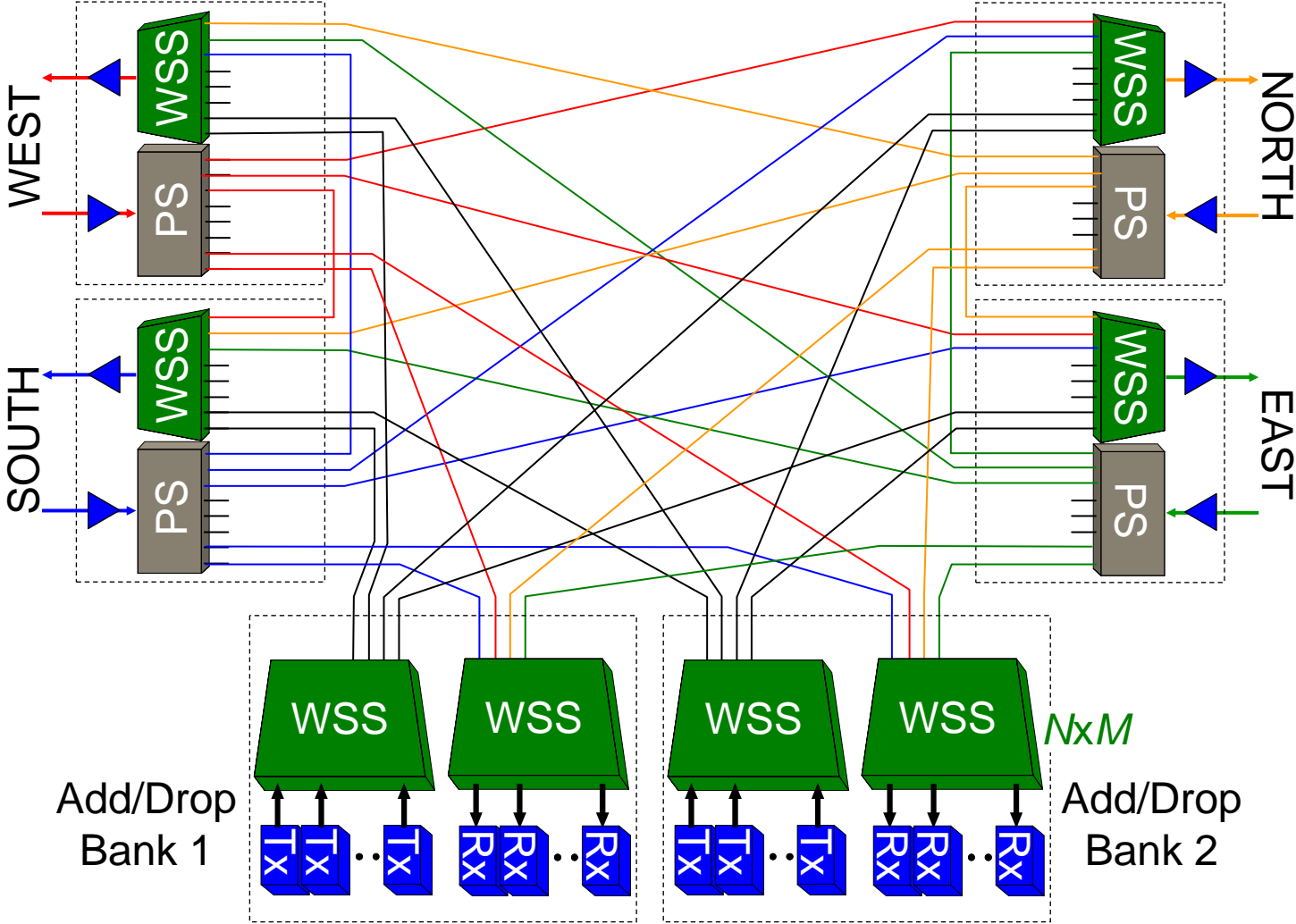
- Replace mux/demux AWGs with WSS's
 - Wavelength assigned to each port is provisionable
- Applications
 - Fewer physical ports present simplifying faceplate
 - Operating wavelength can be remotely modified



Directionless Add/Drop Ports



Directionless Add/Drop Ports: $N \times M$ WSS



Summary

- Past and Present
 - Optical mesh networks currently being deployed for efficient operations and capacity growth
- Present
 - Applications leveraging the dynamic capabilities of the mesh network are emerging
- Future
 - Mesh networks with colorless and directionless add/drop ports
 - Network optimization must become multi-layer
 - Leveraging the strengths of each layer
 - Develop multi-layer management systems which can execute this optimization automatically and seamlessly



Thank You!

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