



# Next Generation Flexible Photonic Networks

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*JDSU*

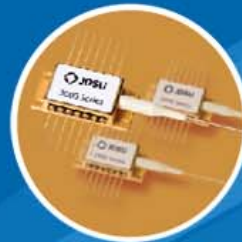
*Chief Technology Officer*

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*WDM and Next Generation Optical Networking, Monaco*

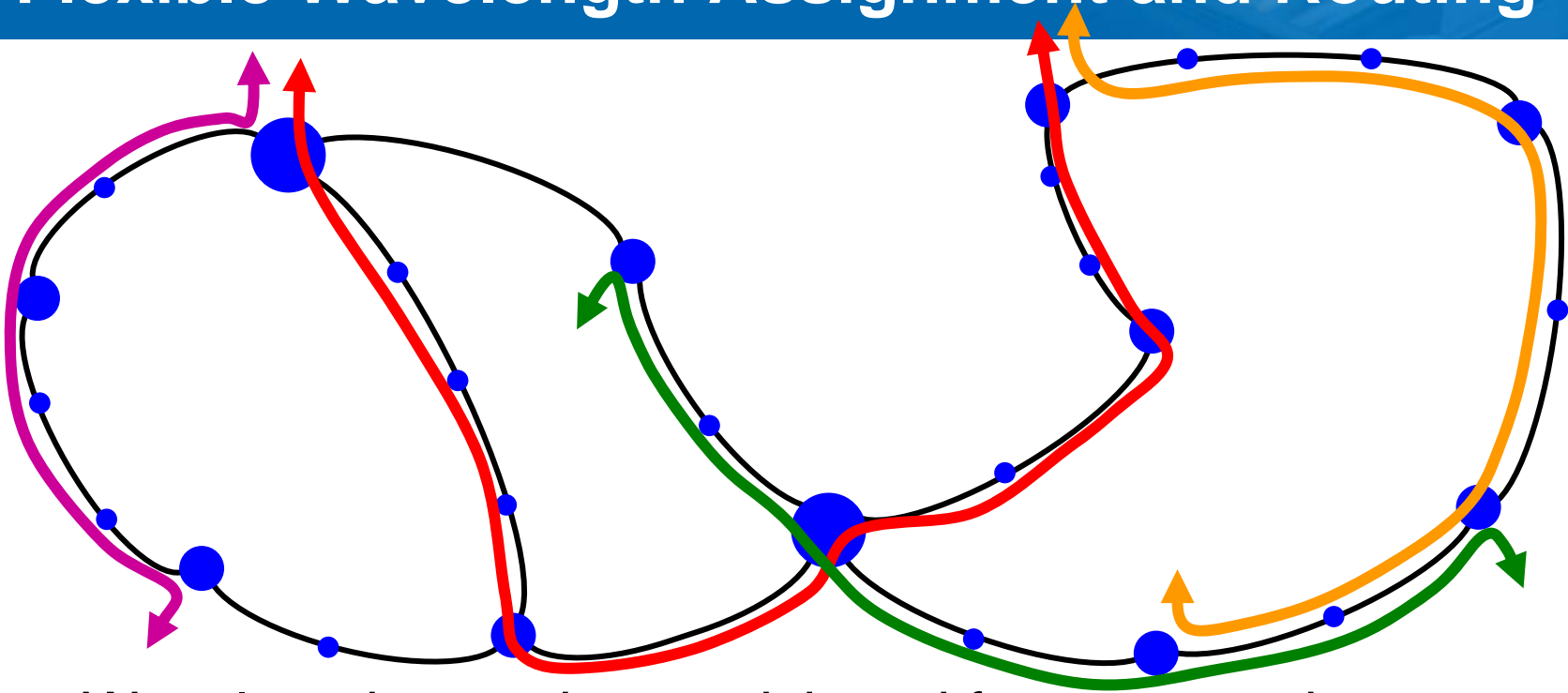
*June 17, 2010, 16:45*



# Agenda

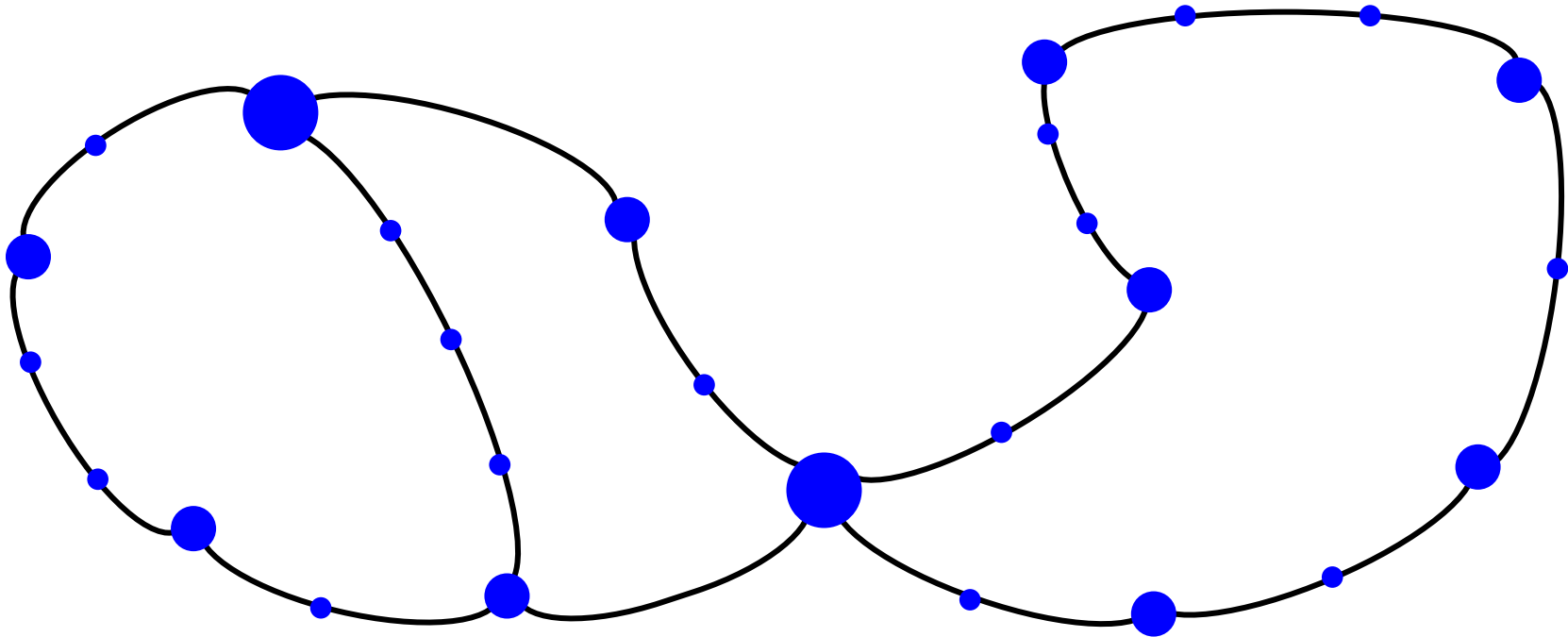
- Characteristics and limitations of today's ROADM networks
- Next generation features
  - Colorless and directionless add/drop ports
- Applications and Motivation for Colorless and Directionless features
  - Wavelength restoration and increased photonic layer availability
  - Traffic Load balancing (network de-fragmentation)
  - Pre-emptive routing of traffic around planned maintenance activities
  - Increased deployment velocity and TxRx predeployment
- Implementation of Colorless and Directionless features
  - Wavelength blocking
  - Wavelength contentionless
- Summary

# Flexible Wavelength Assignment and Routing



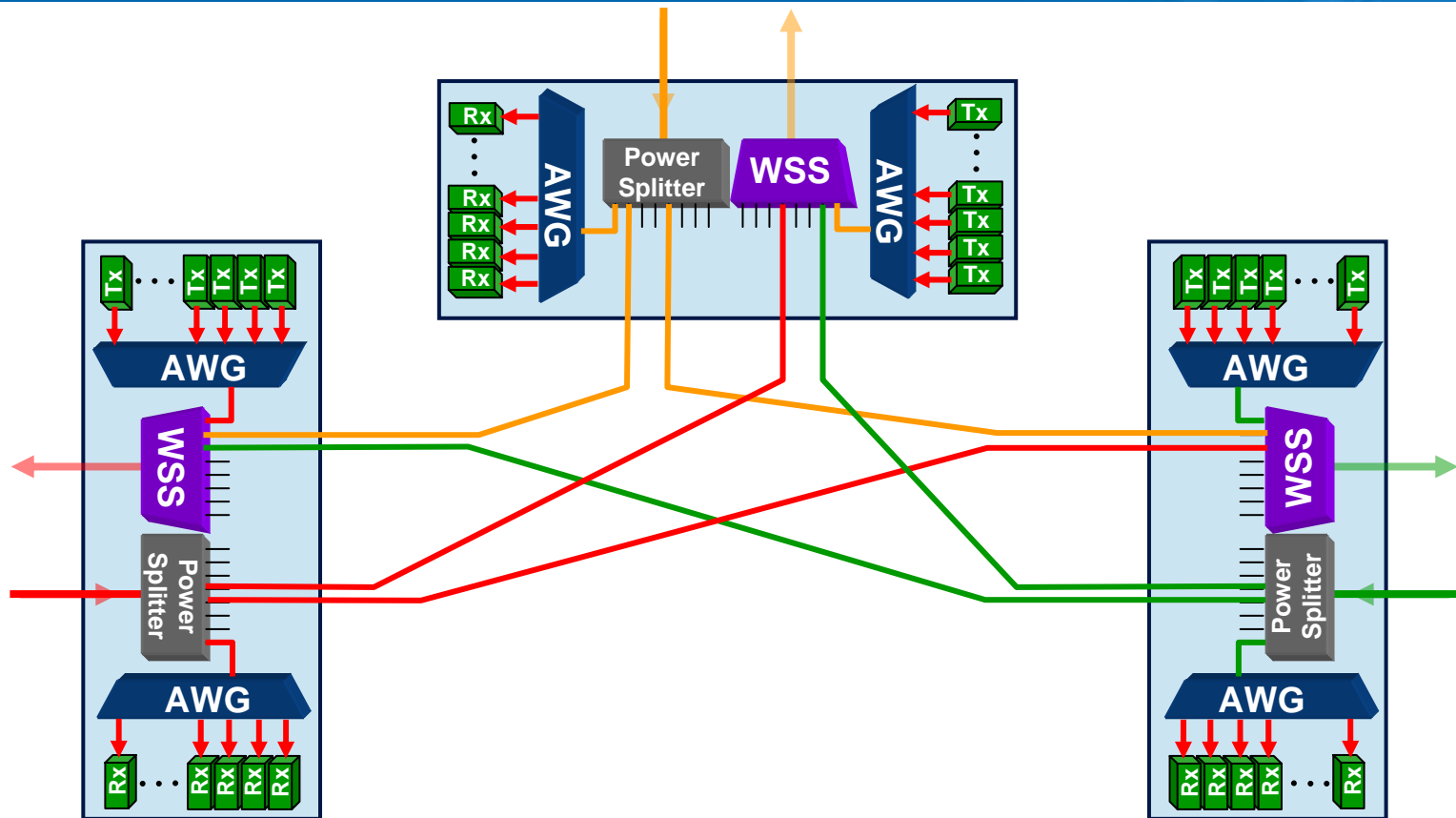
- Wavelengths can be provisioned from any node, to any node and using any wavelength at the time of deployment
  - Lowers potential for bottlenecks from inaccurate network planning
- Wavelengths transition optically through nodes without extra equipment
  - Enables selection of most efficient physical route

# Typical 3-Degree WSS Enabled Mesh Node



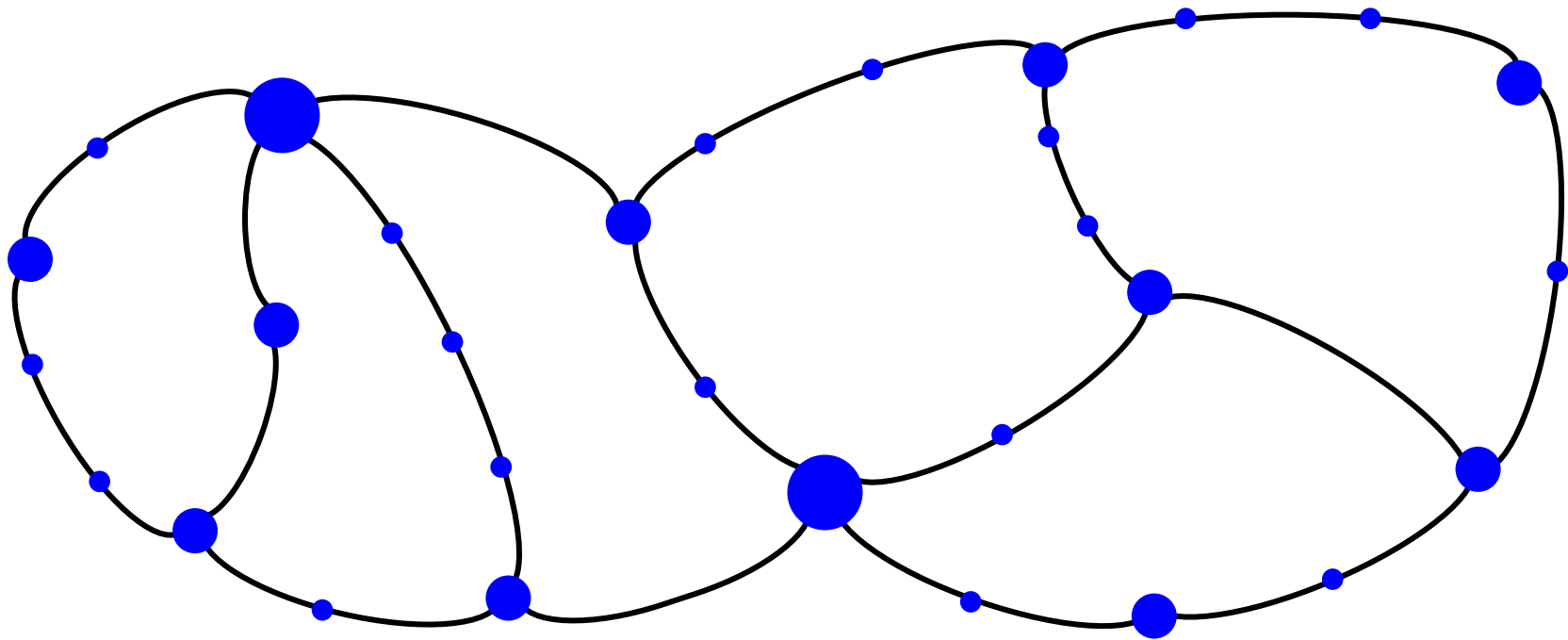
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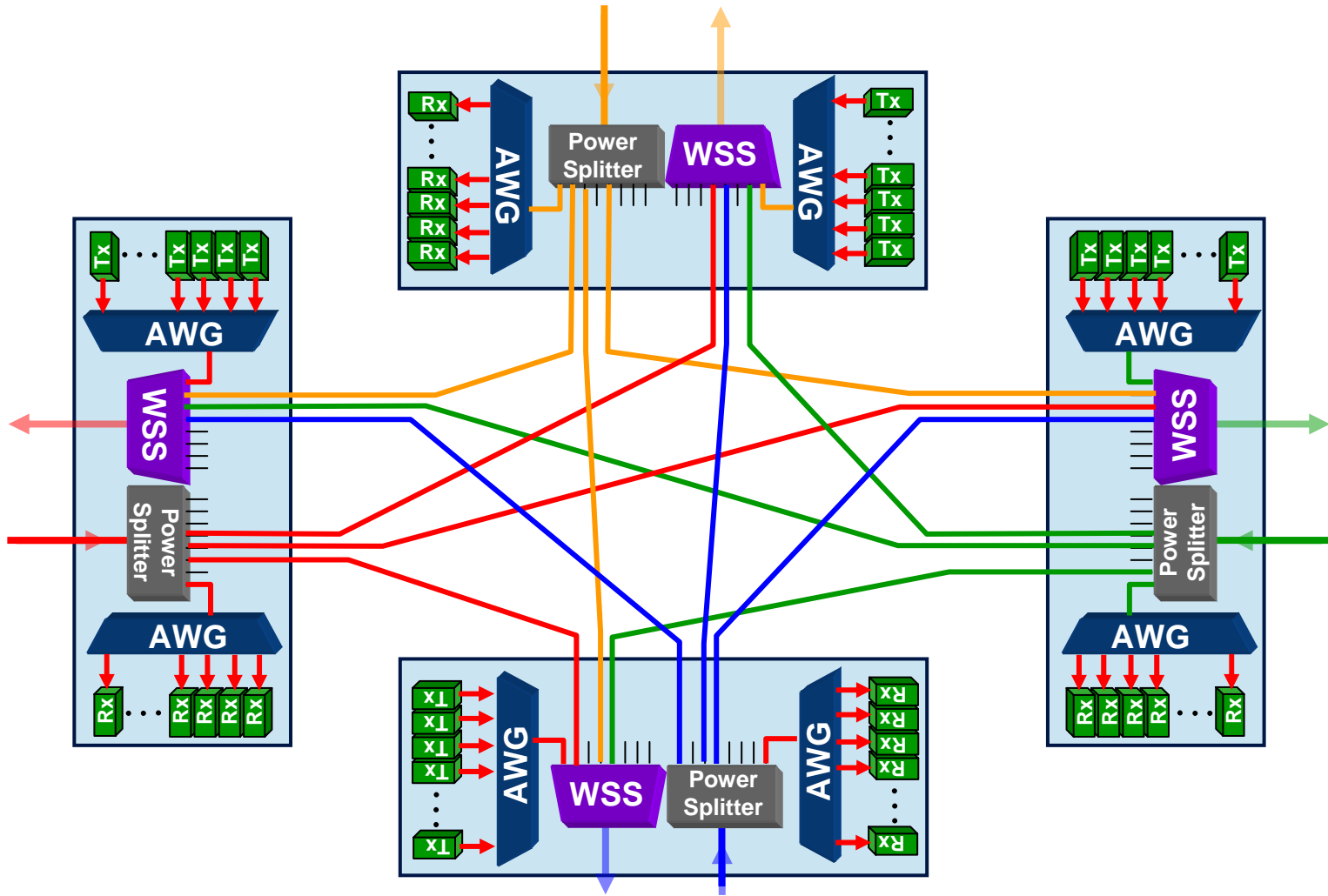
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# Network Topology and Connectivity Growth

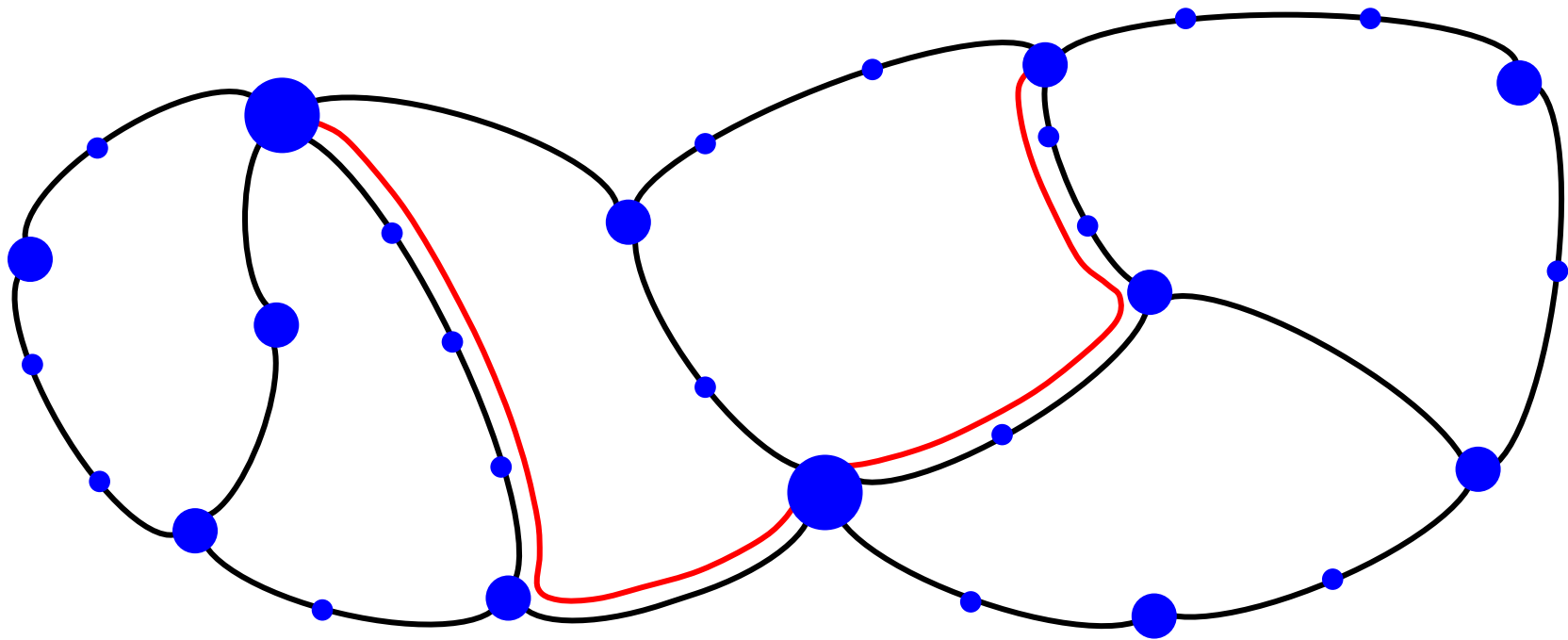


- New routes can be installed increasing the connectivity and expanding the network
  - Uses same equipment and integrates with existing network

# Network Topology and Connectivity Growth



# Improving and Optimizing Network Efficiency



- Direct “express” overlay connections along heavy traffic routes
  - Allows wavelengths to be transitioned off of ROADM enabled route
  - Opens up these fibers for “local” traffic
  - Express routes integrated into network via additional degrees
- Decrease the average number of ROADMs passed per wavelength



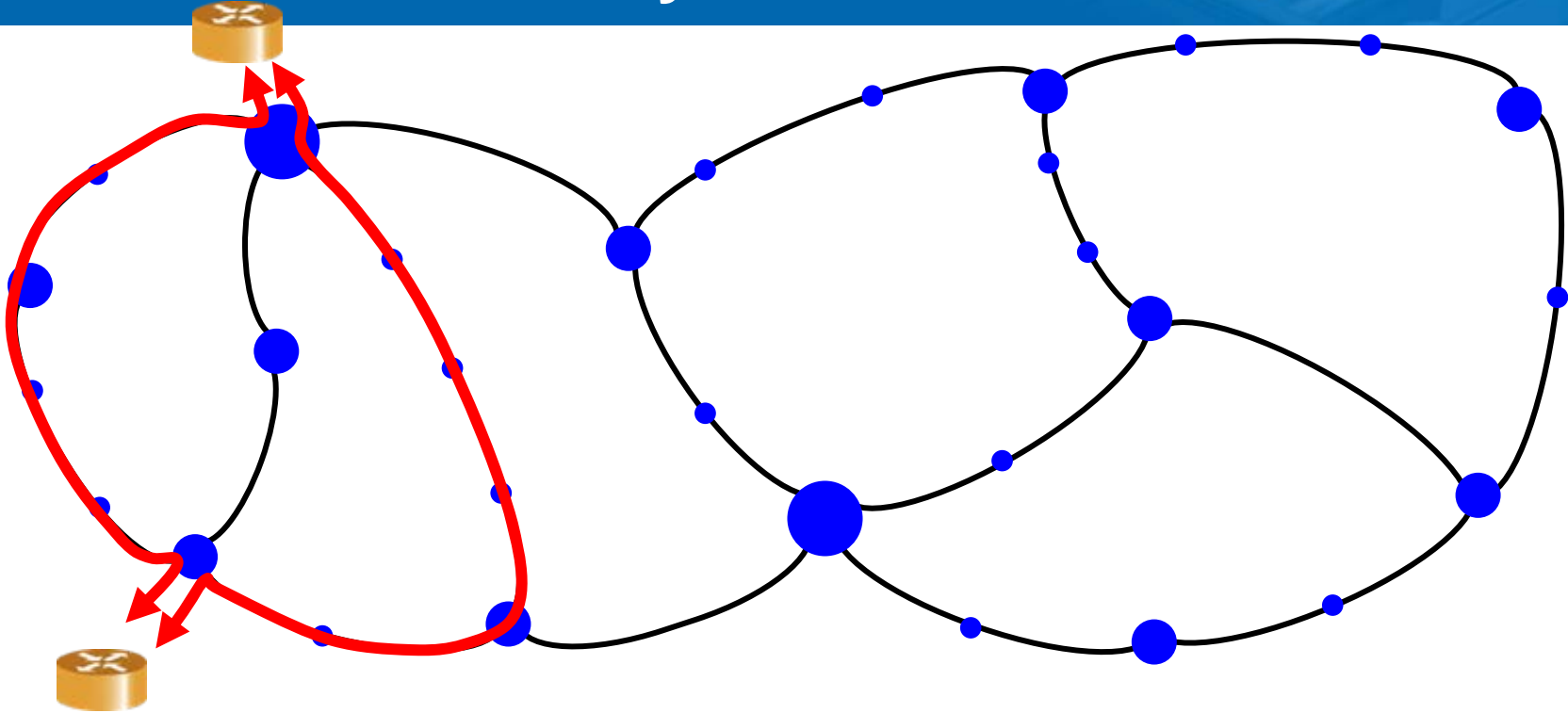
# Current Motivation for Agile Optical Networking

- Network Topology Efficiency
  - Provide ability to provision new wavelengths along optimal paths
  - Minimize OEO hardware to transport a wavelength
  - Add new connectivity to streamline network
- Deployment Velocity
  - Minimize the amount of customized, manual or extraneous activities to deploy new bandwidth
  - Translates into more reliable and faster deployments

## → Optimize Photonic Layer Topology and Provisioning

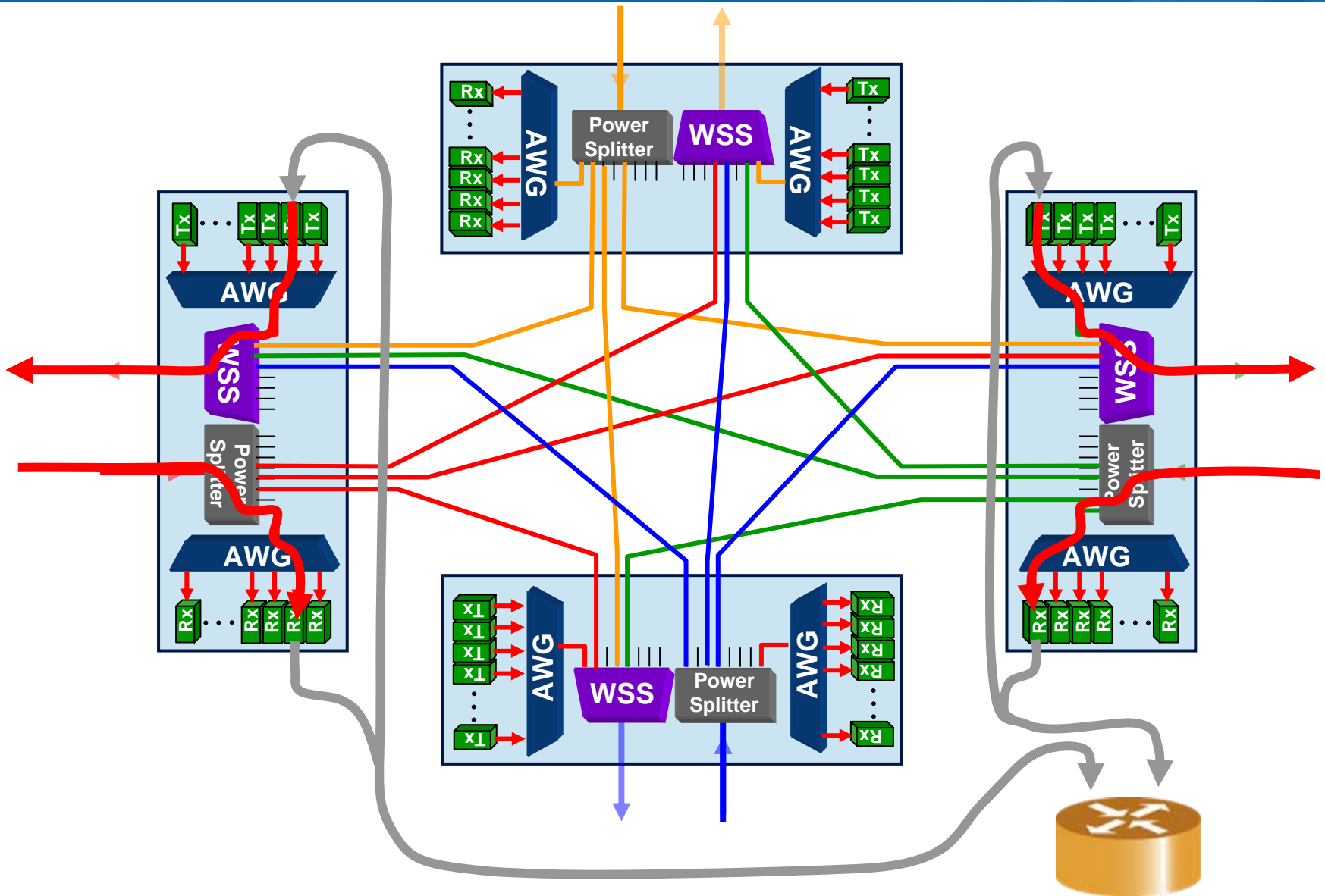
- However, the provisioned wavelengths are largely “static” as they are seldom moved or the process is highly manual

# Limitations of Today's ROADM Photonic Networks

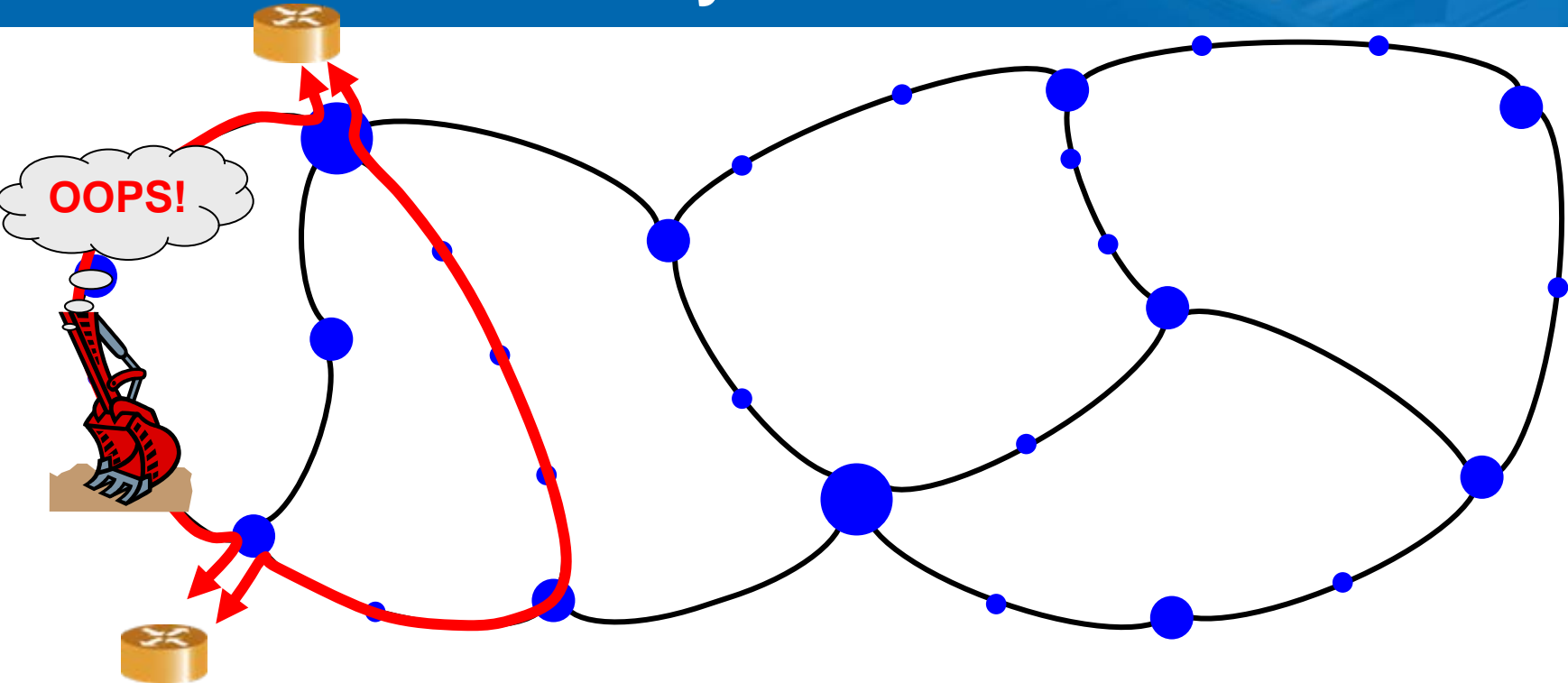


- Add/drop ports (transponders) assigned permanent wavelength and network direction
  - Prohibits re-routing wavelengths in many cases
  - To re-establishing wavelength connectivity following a fiber break requires
    - Repair of the problem (fiber, node failure, misconnect)
    - Or manually re-deploying that wavelength onto a new route

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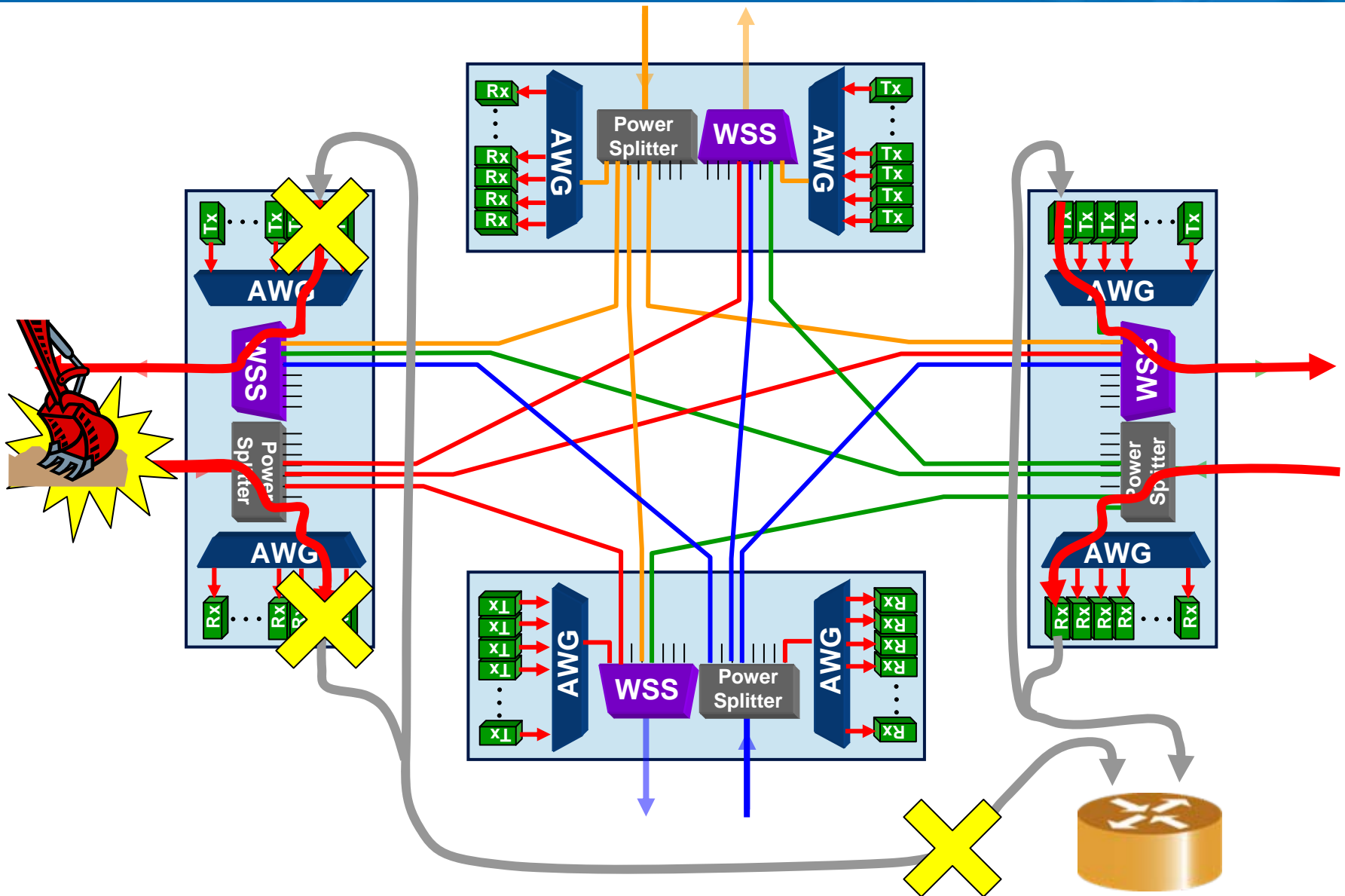


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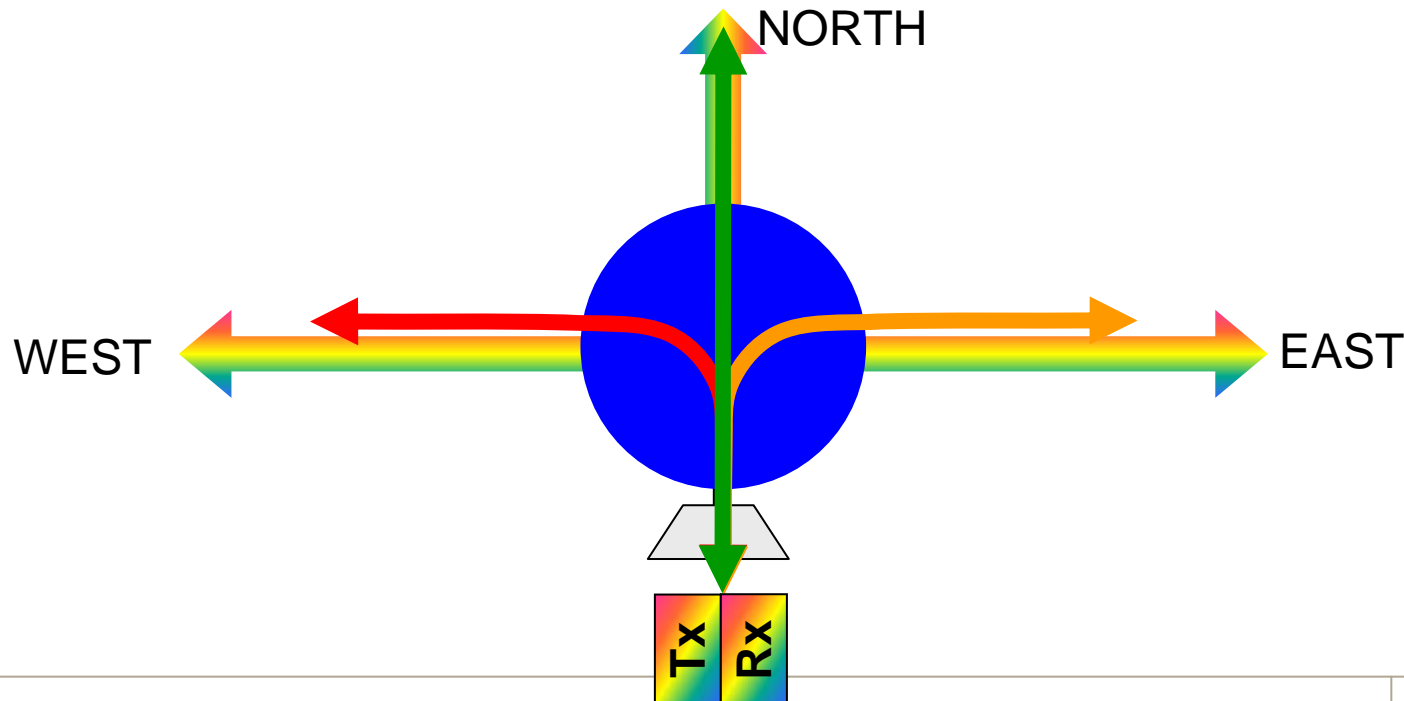
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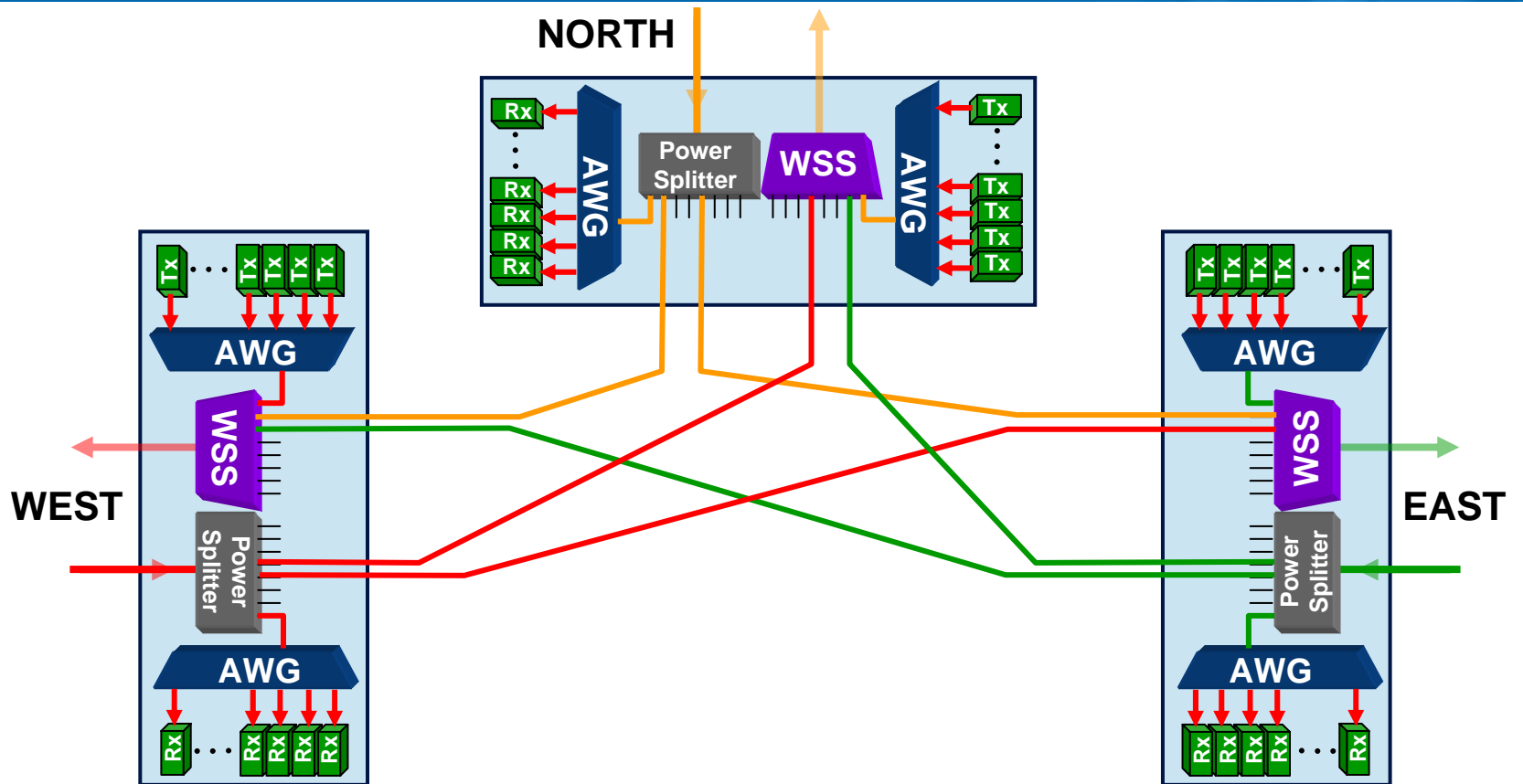


# Next Generation: Colorless and Directionless Add/Drop

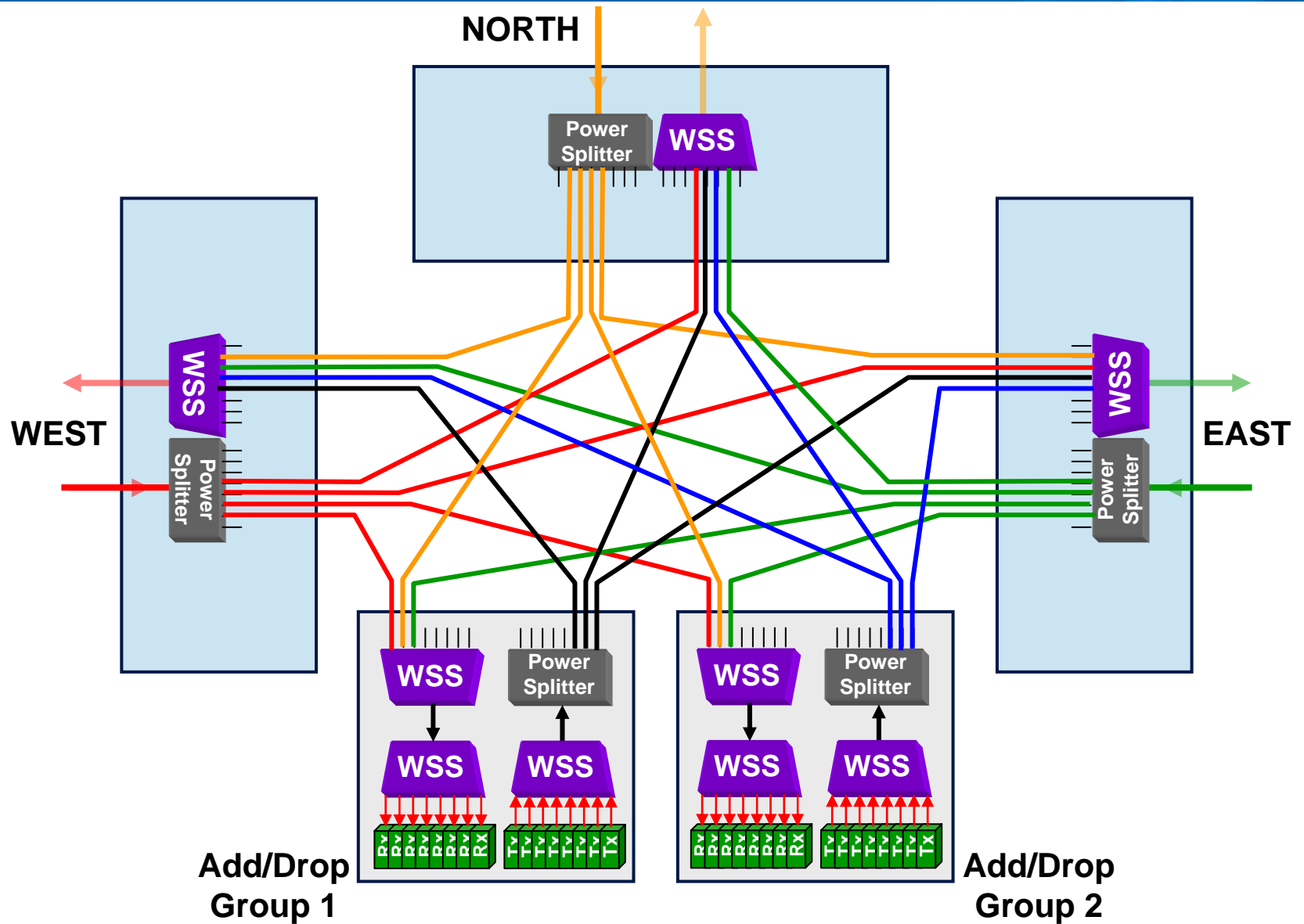
- Enable add/drop ports to be routed out any degree of the node and use any wavelength
  - Directionless also known as: steerable, omni-directional, non-directional
  - Wavelength and direction are provisioned by control plane
  - Transponders are assumed to be C-band tunable



# Typical Current Mesh Node Architecture

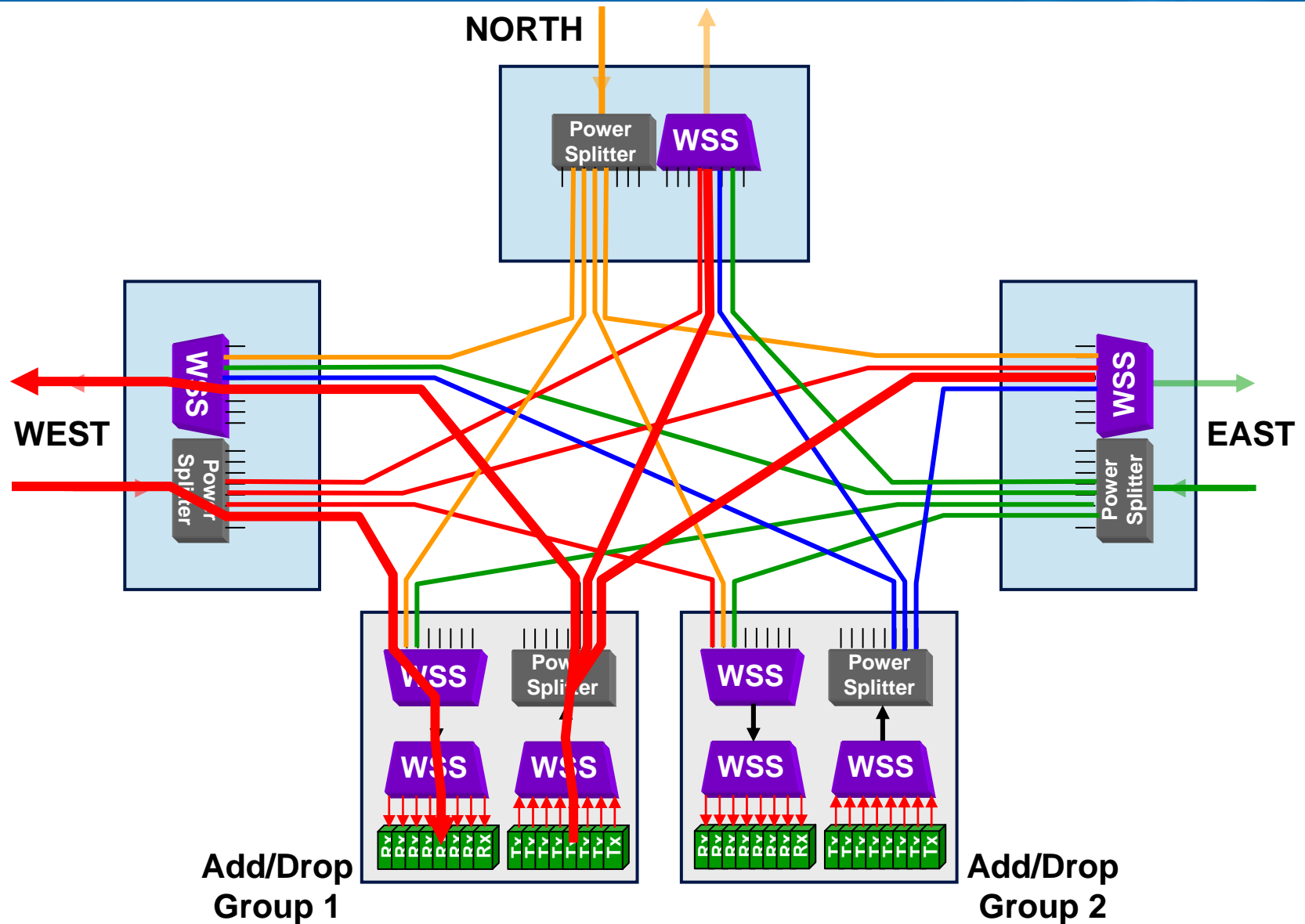


# Typical Colorless and Directionless Node Architecture

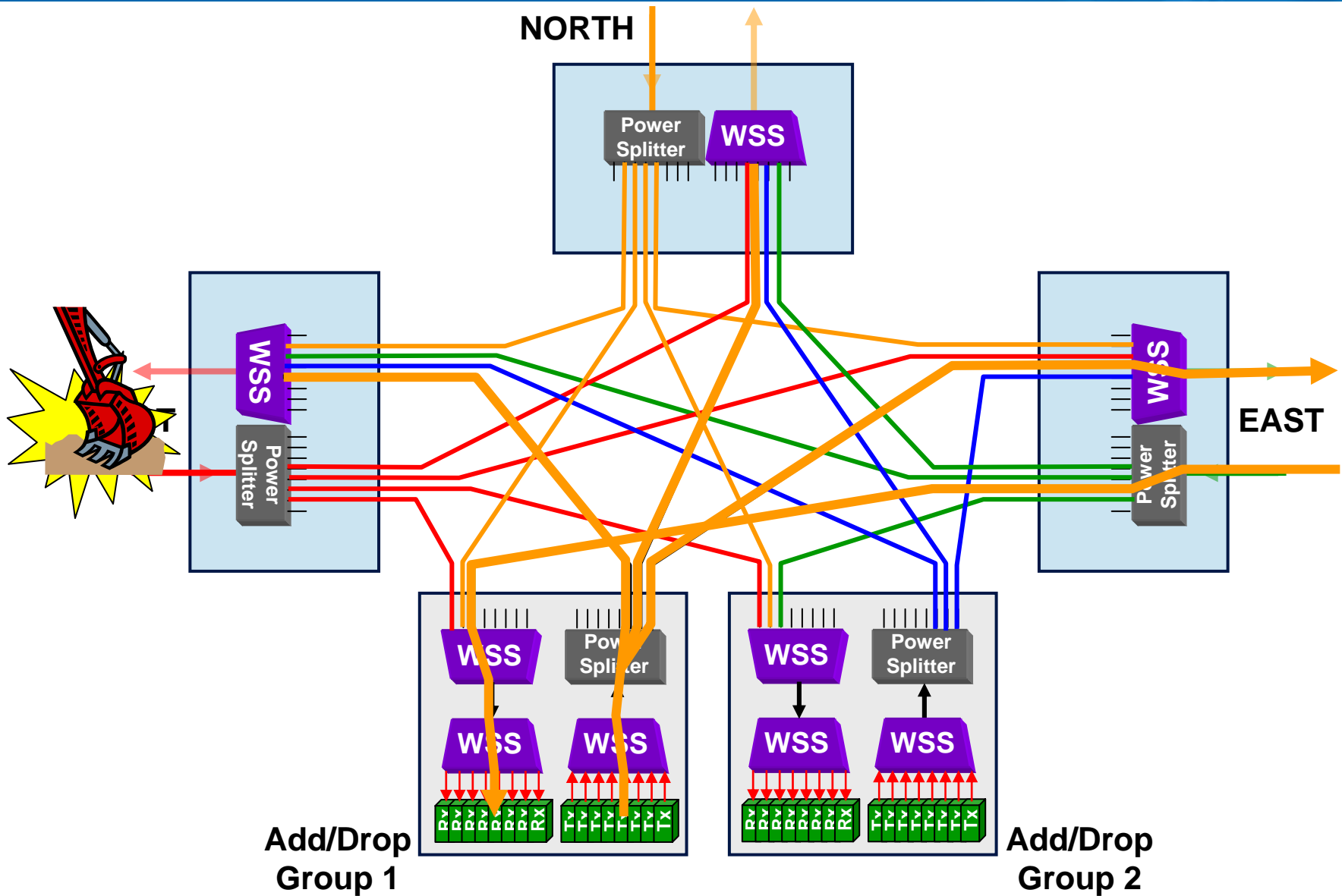




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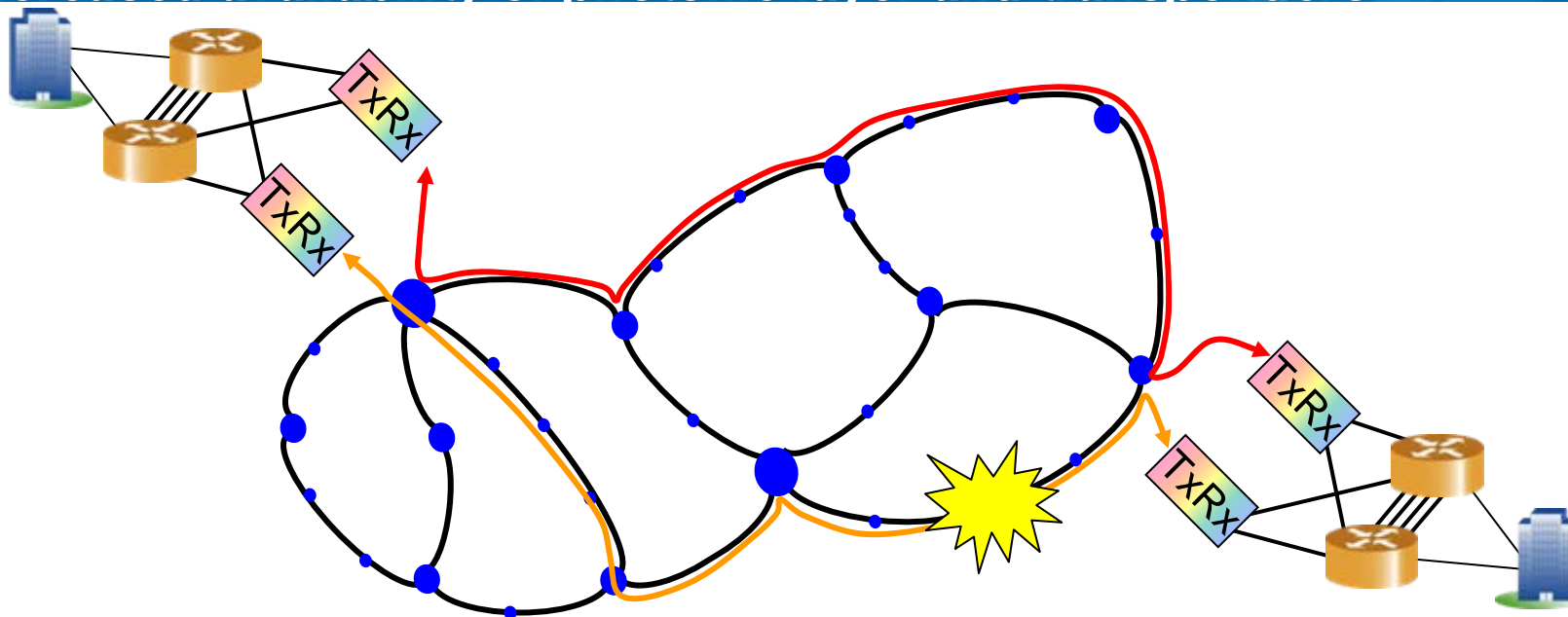


# Typical Colorless and Directionless Node Architecture



# Photonic Layer Restoration

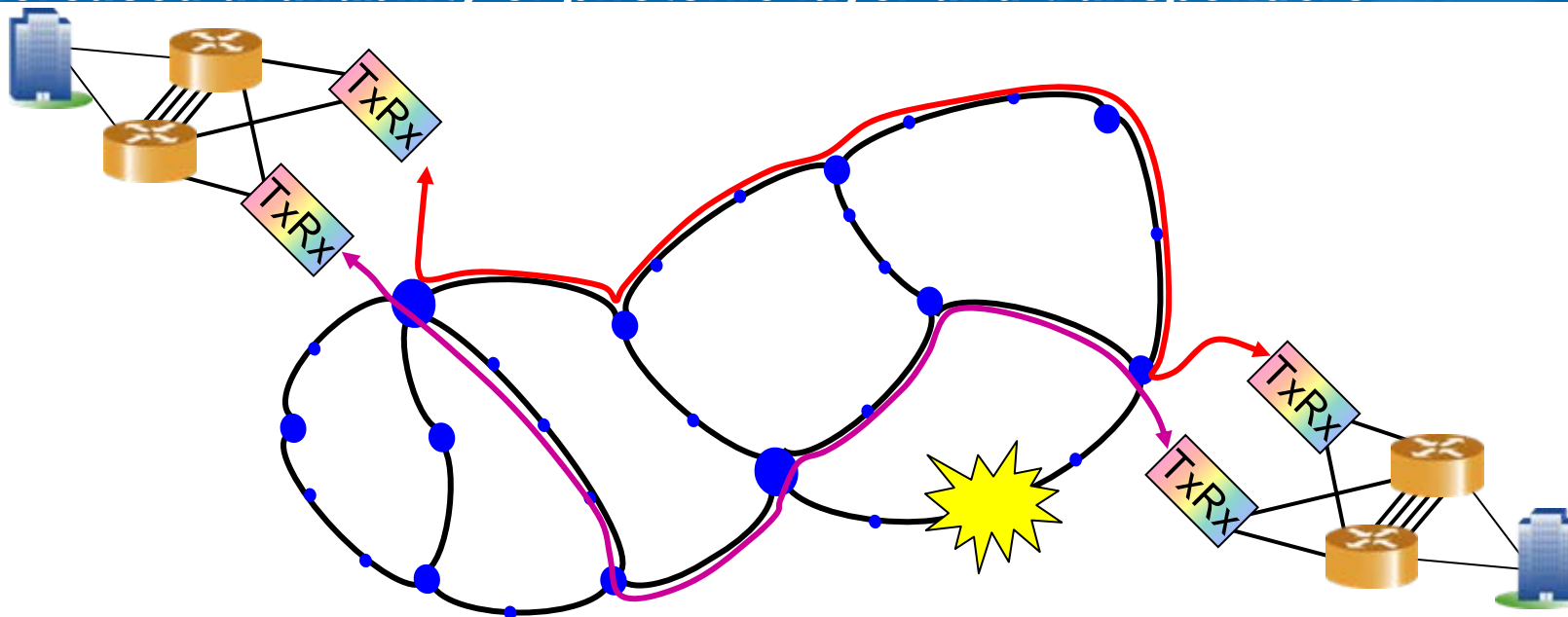
- Increased availability of photonic layer and transponders



- With photonic layer restoration, photonic network can rapidly be reconfigured to restore wavelength traffic
  - Equipment always in use
  - Less likelihood of simplex operation
  - Less manual modification of network
  - Less need for urgent repair
  - Less redundancy incorporated at higher levels

# Photonic Layer Restoration

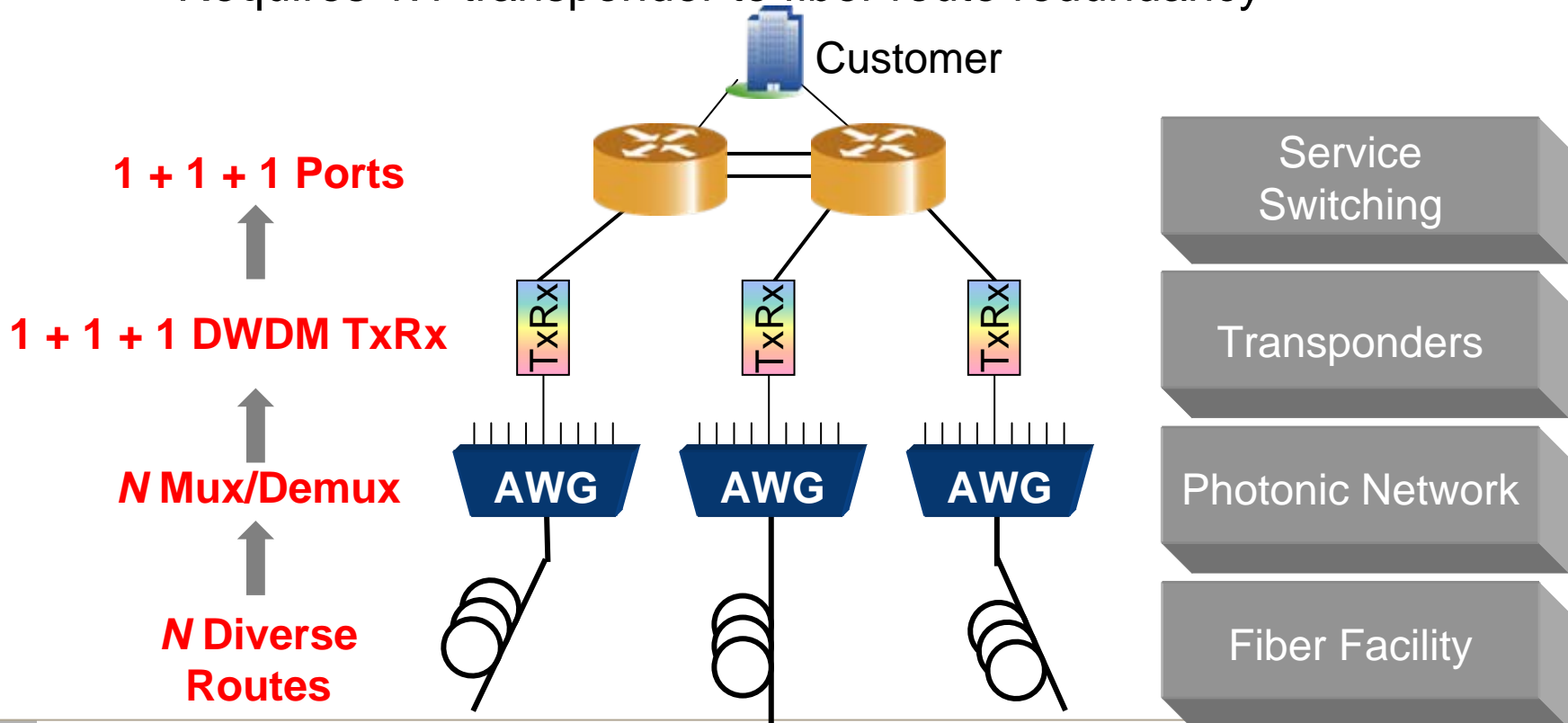
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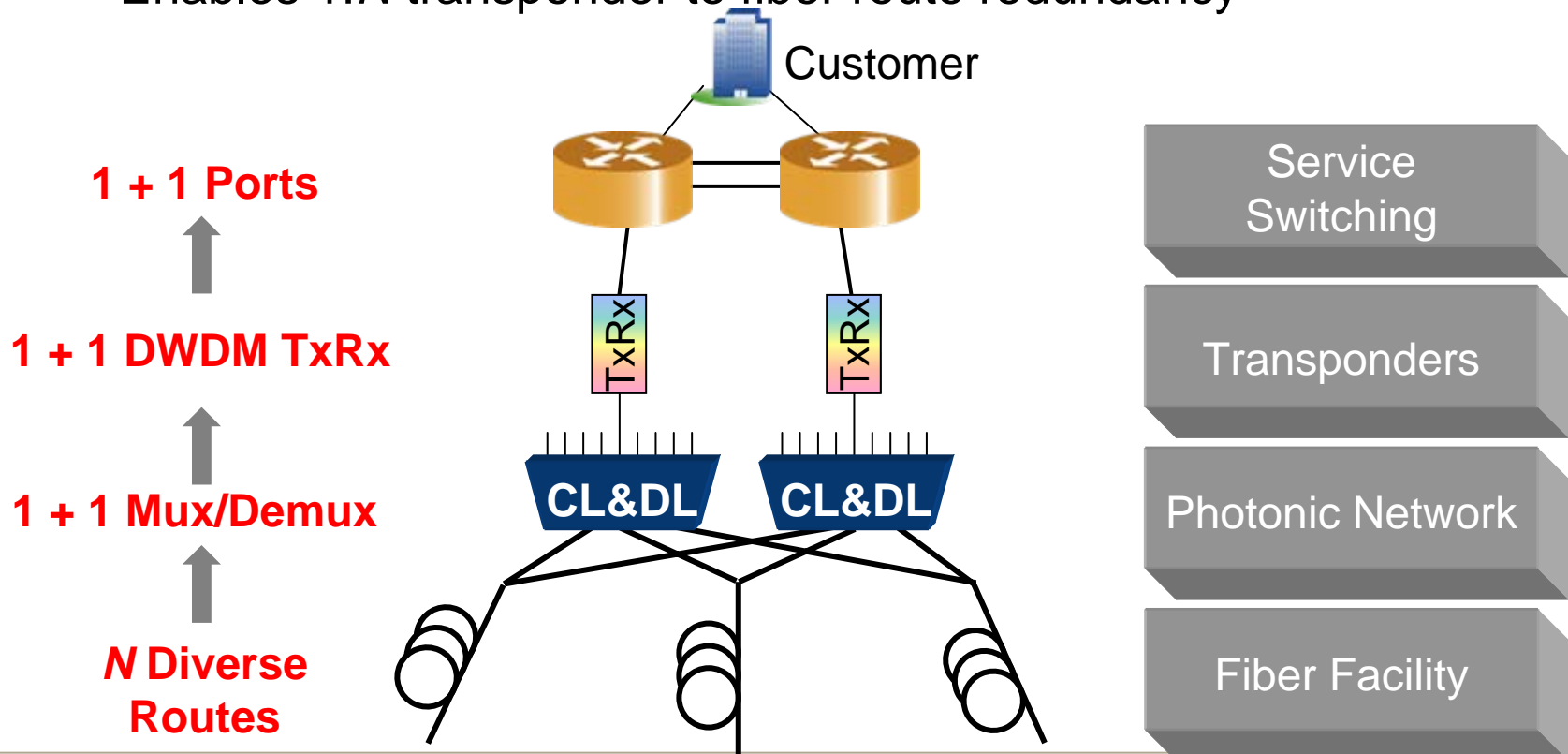
# Service Availability and the “Static” Photonic Network

- Layers must compensate for availability of the layers below
- Layers must accommodate the “redundancy” of the layer below
  - Requires 1:1 transponder to fiber route redundancy

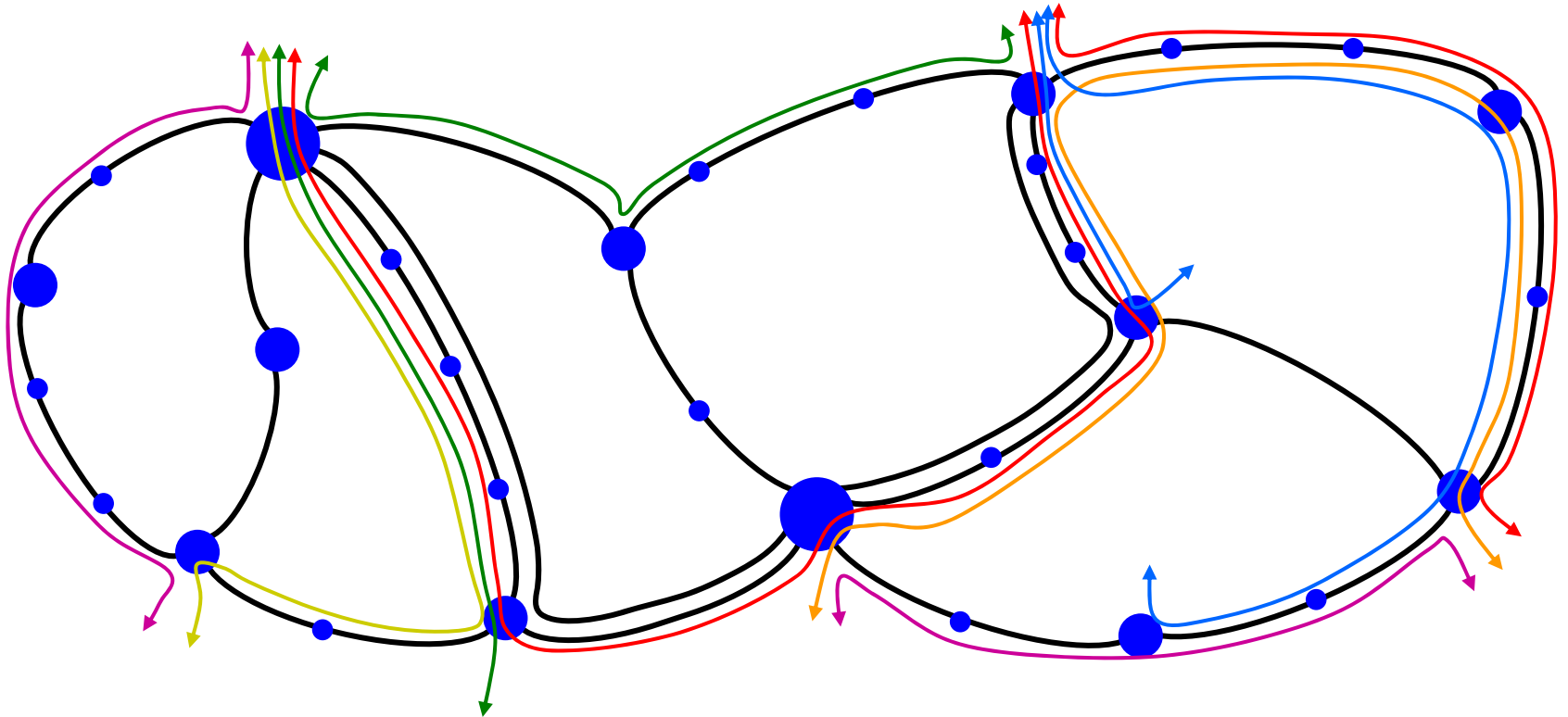


# Service Availability and the CL & DL Photonic Network

- Layers must compensate for availability of the layers below
- Layers **need not** accommodate the “redundancy” of the layer below
  - Enables 1:N transponder to fiber route redundancy

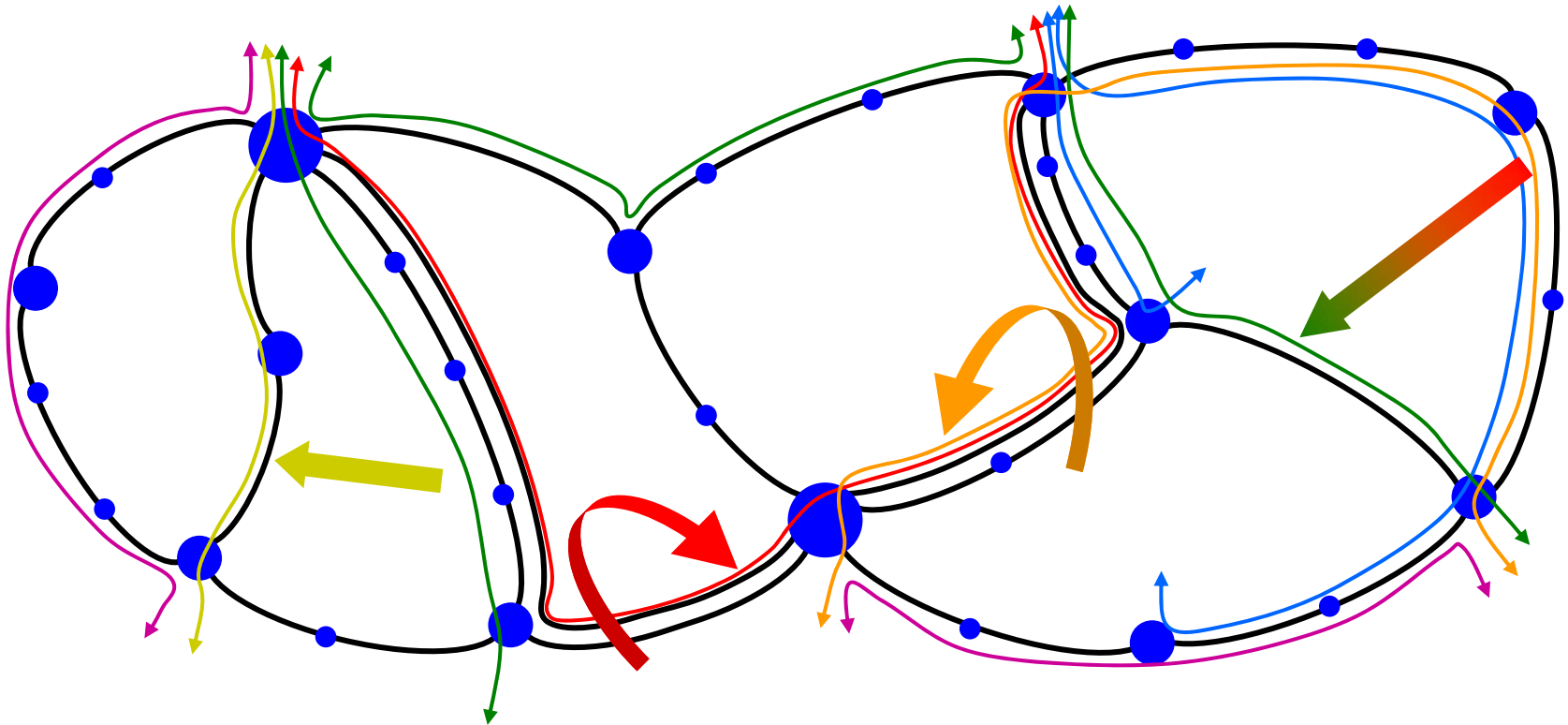


# Traffic Load Balancing (Network De-Fragmentation)



- Network traffic deployed as demand arises (growth not planned)
- New network connectivity installed as need identified
- Rebalance network load to relieve congestion and improve overall efficiency

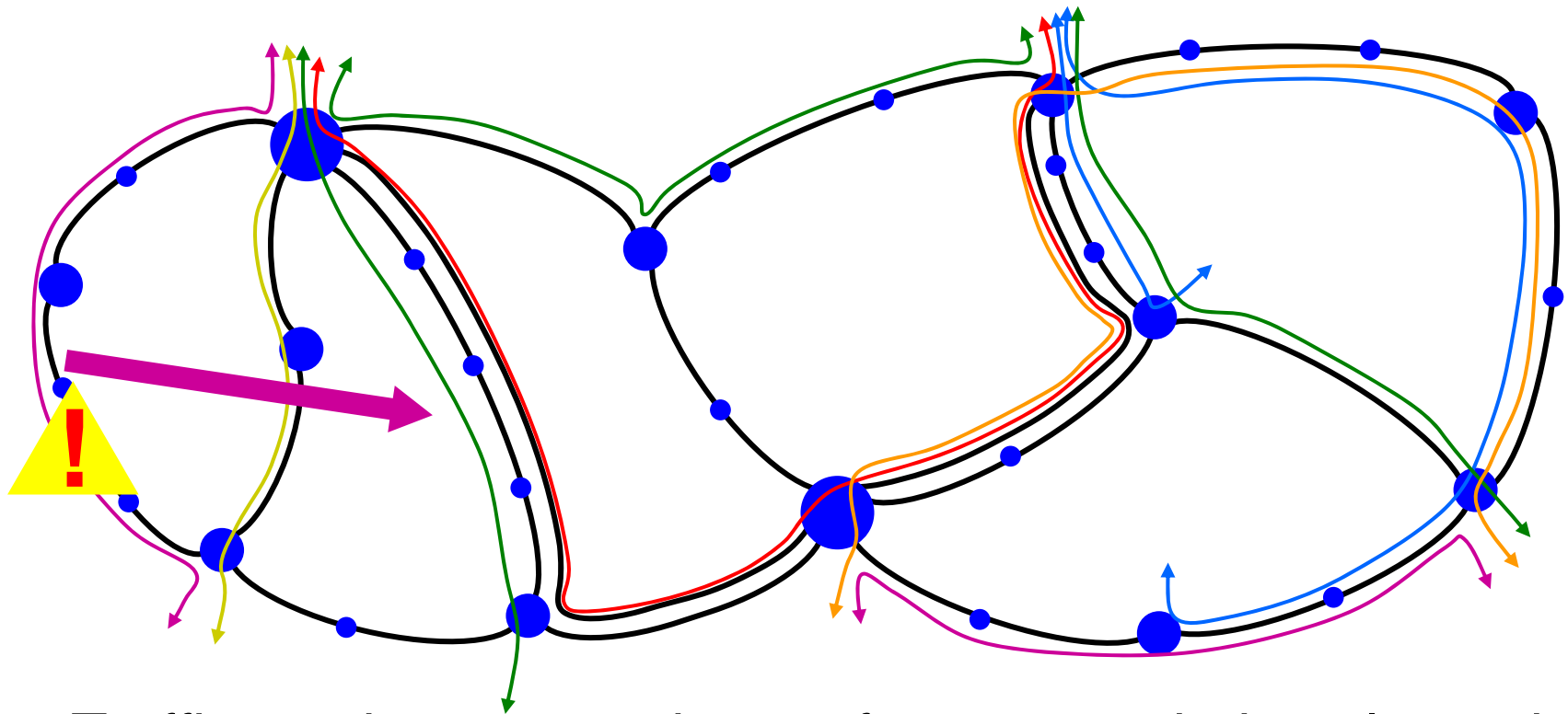
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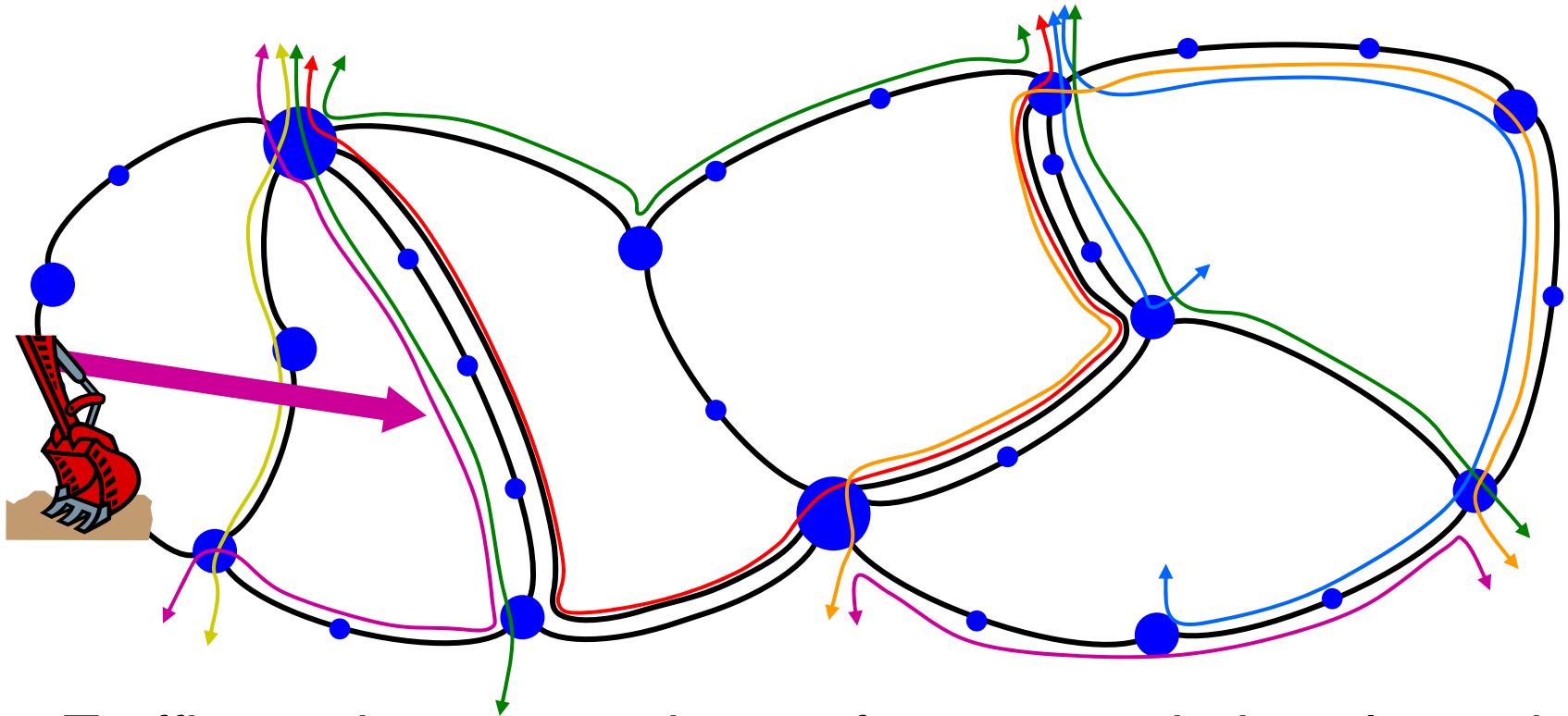


# Pre-Emptive Routing Around Maintenance Activities



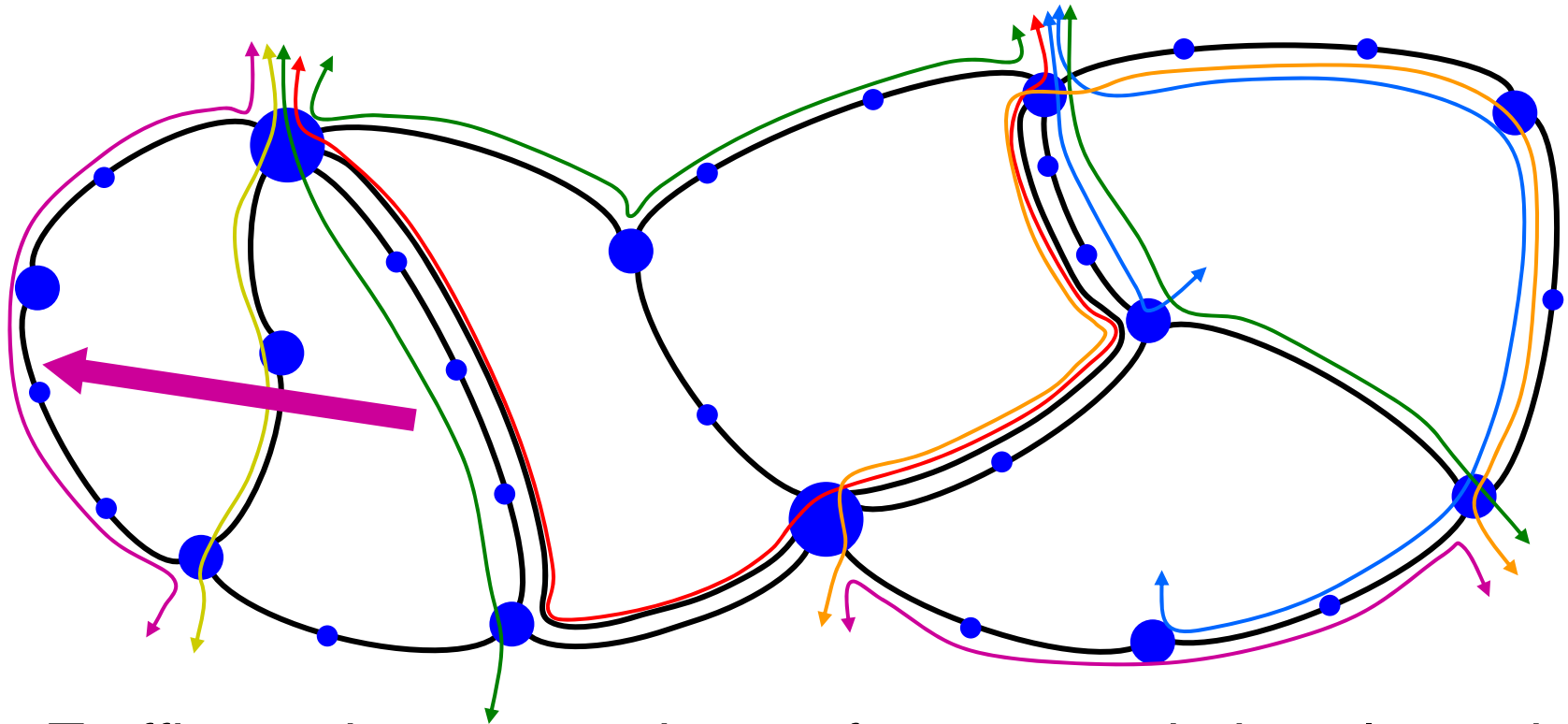
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- After maintenance is completed, traffic returned to original route

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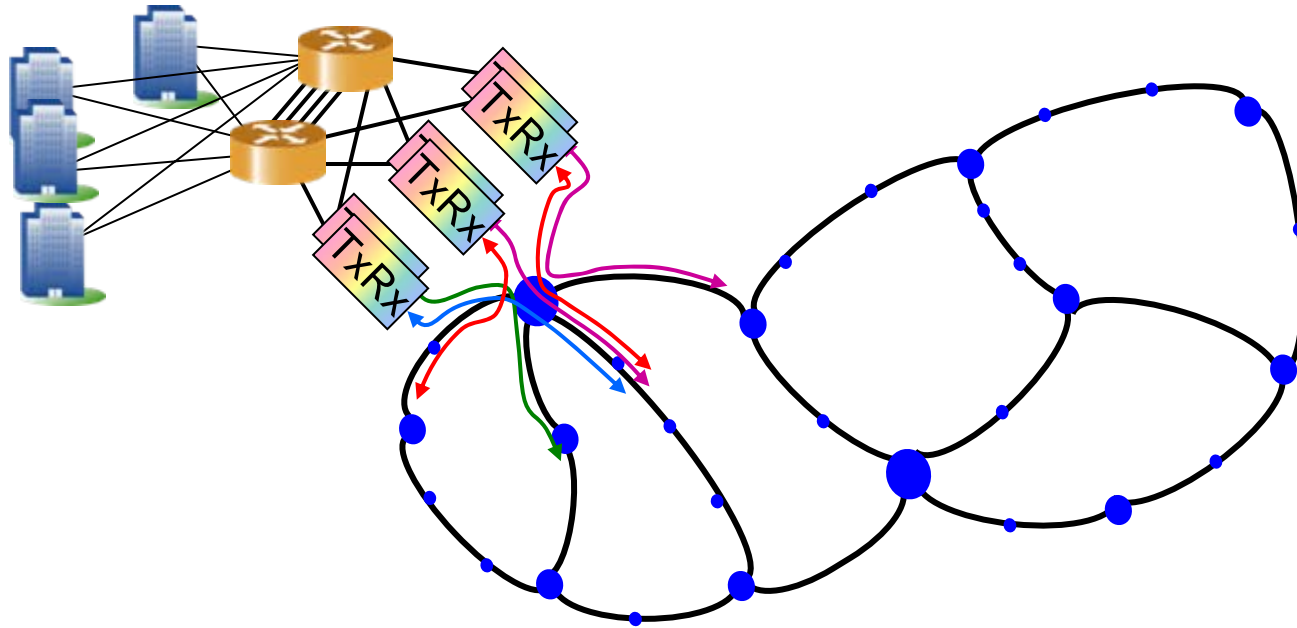
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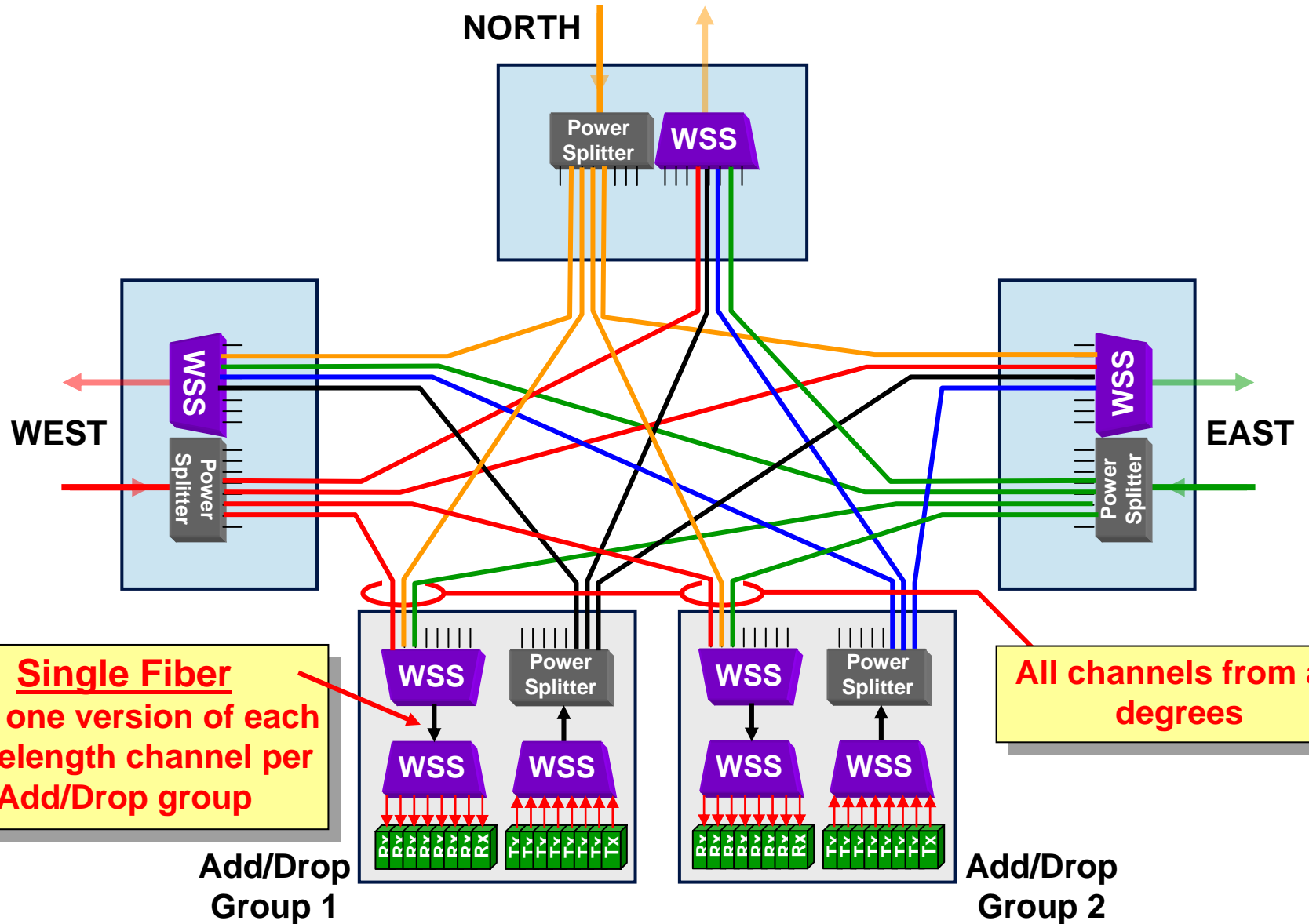
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# Deployment Velocity and TxRx Pre-Deployment



- Multiple transponders can be deployed at one time
  - Streamlines deployment operations
  - Transponders can be used for local traffic or regeneration functions
- Wavelength and route can be remotely provisioned once the transponder is needed
- New wavelengths can be commissioned rapidly and remotely

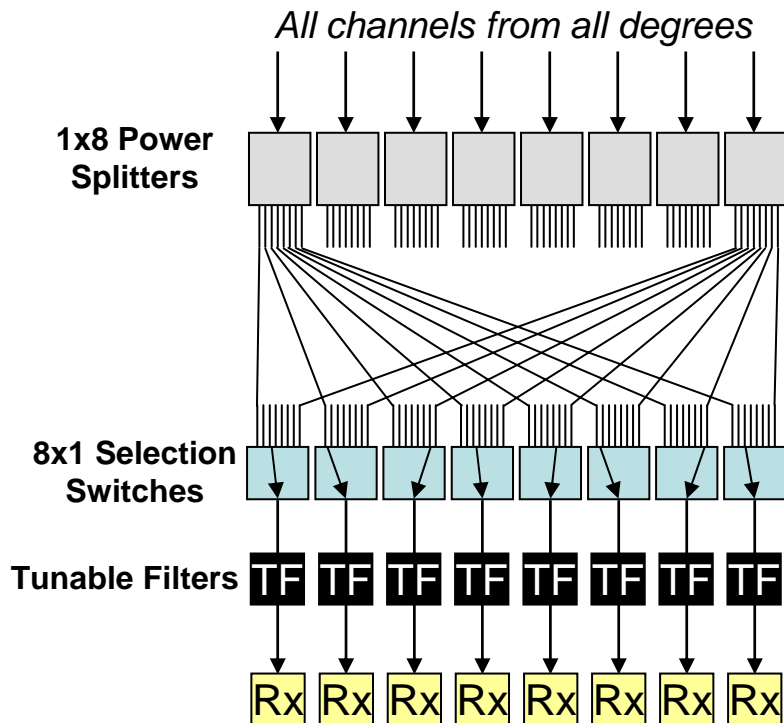
# Wavelength Blocking Colorless and Directionless



# Contentionless Colorless and Directionless Add/Drop

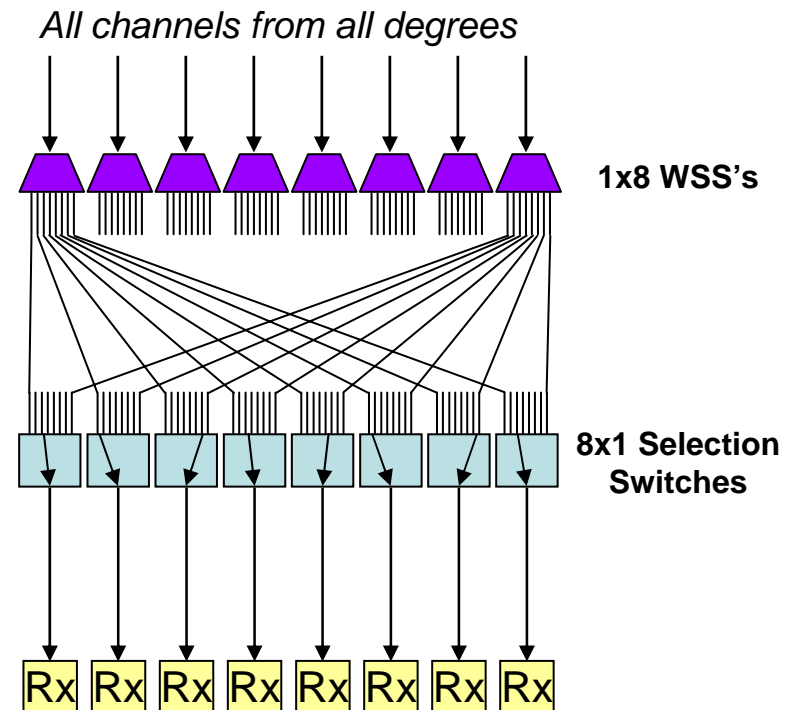
## ■ Broadcast and Select

- Broadcast all channels from all degrees
- Switch selects degree
- Filter selects channel



## ■ Wavelength Routing

- WSS selects and routes wavelength
- Switch selects degree



# Summary

- Current agile ROADMs provide agility for wavelength provisioning and network expansion
  - But less than sufficient agility for existing wavelengths
- Colorless and Directionless Add/Drop brings wavelength and route agility to the transponder interface
  - Higher availability of photonic layer can relieve total equipment requirements at higher layers
  - Enables traffic load balancing and proactive traffic routing
  - Transponders can be pre-deployed and provisioned rapidly when needed for quick service deployment
- Wavelength Blocking versus Wavelength Contentionless



# THANK YOU!

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