SDN IN WAN

NETWORK PROGRAMMABILITY THROUGH CENTRALIZED PATH COMPUTATION

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Aaron Tong
Senior Manager
High IQ Networking Centre of Excellence

JUNIPER'S AUTOMATION HORIZON

SDN IS A JOURNEY NOT A DESTINATION

Traditional Planning

Complete Human Workflow

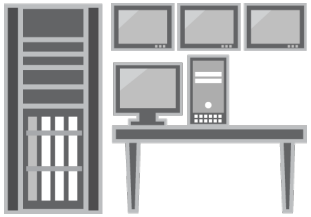
- **OFFLINE** design and planning
- Pull analytics, pull topology, pull configuration
- Simulation, optimization, and network trending

Network Design and Planner

Strategic Modeling

Combined Human and Machine Workflow

- **ONLINE** design, planning and monitoring
- Near real-time analytics and integrated topology discover
- Provisioning templates



Network Operation Center

Autonomous Optimization

Human Programmed, Machine Executing

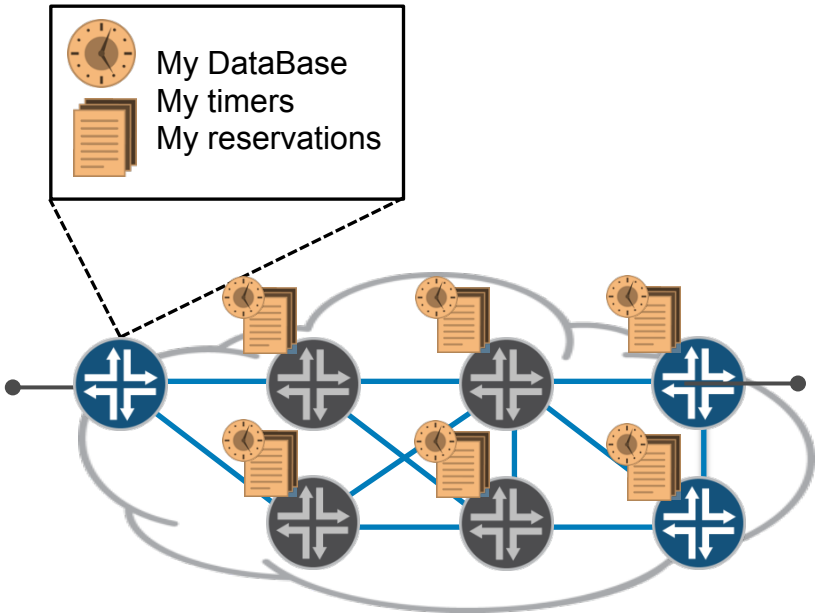
- **CONTINUOUS** self-optimizing
- Real-time analytics and topology
- Rest APIs to integrate applications

Self Aware Network

DISTRIBUTED PATH COMPUTATION

Distributed Path Computation:

- Path computation algorithms distributed to each node in the network
- Local view of network state – per node perspective
- CSPF results local in nature – only distributed node's requests are computed
- Highly resilient architecture
- Many adaptive (auto-B/W, RSVP multi-path, …) applications available



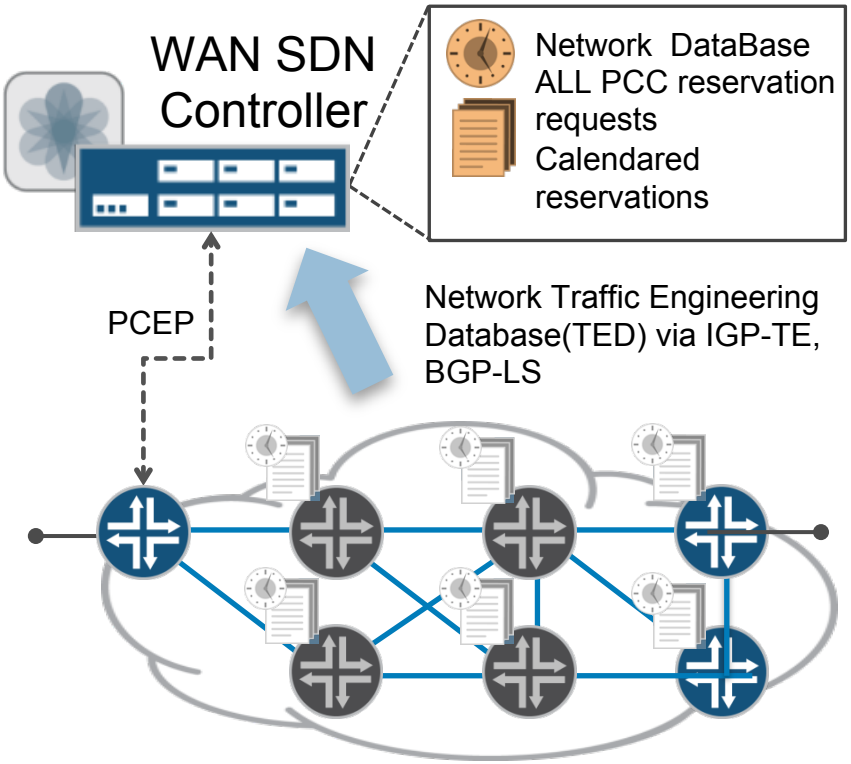
Current Mode of Operation:

- All distributed nodes 'race' to reserve their resources as they need them.

CENTRALIZED PATH COMPUTATION

Value of Centralized Path Computation

- Ordering and synchronization of path signaling across different routers
- Global view of network state
- Predictable, deterministic network state to within margin of demand forecast error
- Minimal distributed state; Efficiency gain for accomplishing similar objectives
- Foundation for additional centralized, active network services

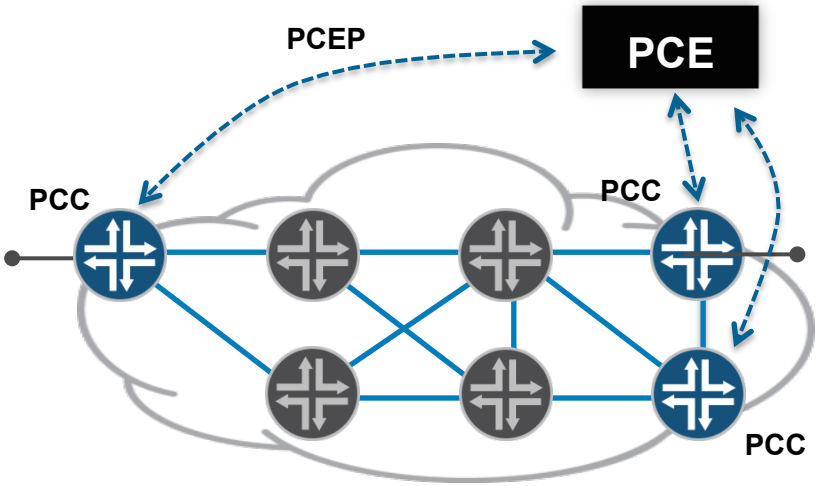


PCE: A STANDARDS-BASED APPROACH

What is it?

- **PCE: Path Computation Element (RFC 4655)**

  An entity that can calculate paths in the network. Can be a network node, a server, an application, etc.



Components

- **PCE: Path Computation Element**

  Computes the path

- **PCC: Path Computation Client**

  Receives the path. Signals LSP using RSVP

- **PCEP: PCE protocol (RFC 5440)**

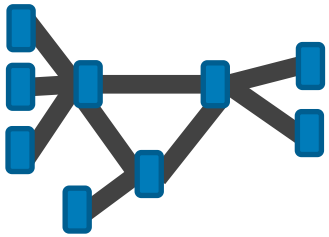
  For PCE/PCC communication

- **Path signaling & definition in the network**

  Static, RSVP, IGP-Labels

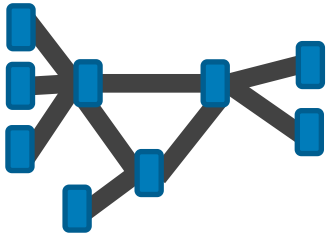
WHAT INFORMATION GOES INTO DETERMINING A PATH FOR PACKET TRAFFIC?

Shortest Path
(IGP, LDP)



Topology

Distributed TE
(constrained SPF)



Topology

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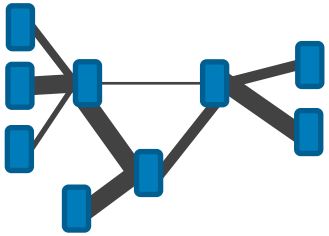


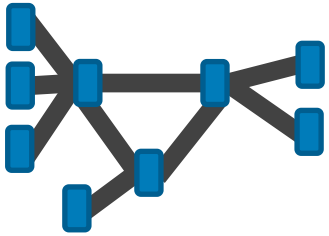
Reservable bandwidth

+

	A	B	C	D	E	F
A						
B	3	-	8	4	7	1
C						
D						
E						
F						

Fragmented view of packet demands

Centralized TE



Topology

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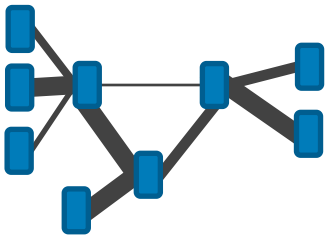


Reservable bandwidth

+

	A	B	C	D	E	F
A	-	5	2	1	9	2
B	3	-	8	4	7	1
C	1	5	-	7	6	2
D	9	2	4	-	7	1
E	4	9	3	5	-	6
F	8	3	1	9	5	-

Complete view of packet demands

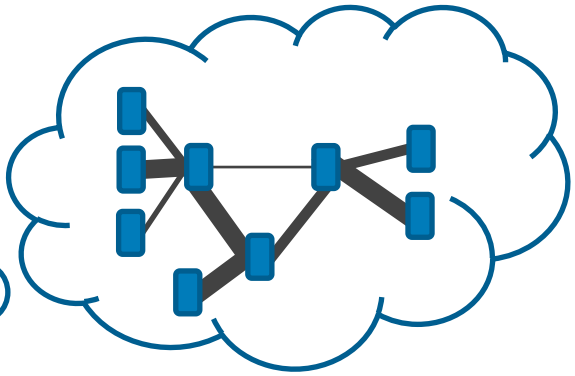
CENTRALIZED PACKET TRAFFIC ENGINEERING

	A	B	C	D	E	F
A	-	5	2	1	9	2
B	3	-	8	4	7	1
C	1	5	-	7	6	2
D	9	2	4	-	7	1
E	4	9	3	5	-	6
F	8	3	1	9	5	-

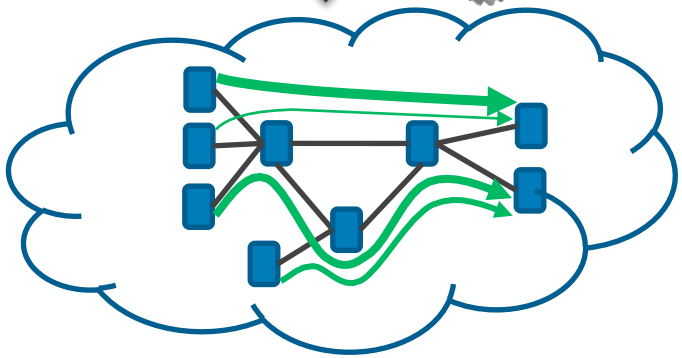
Complete view of packet demands

Application driven routing constraints
(latency, bandwidth, cost, QoS, etc..)

Centralized path computation
(Maximize objective function)



Optical and packet topology, as well as reservable bandwidth



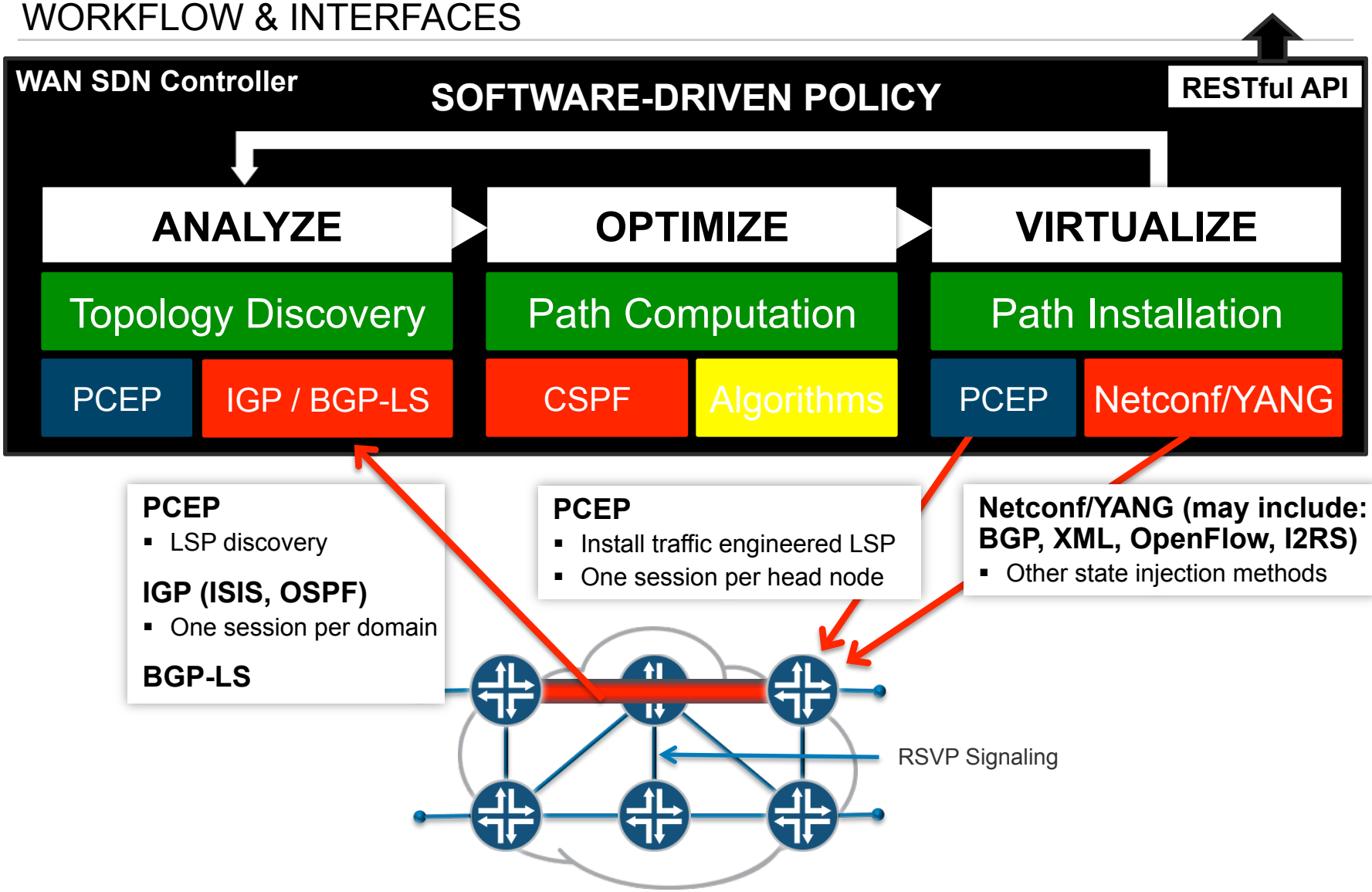
Application-aware traffic engineering

ADVANTAGES OF CENTRALIZED CONTROL

Purely distributed path computation is not optimal for all cases. A central entity with global knowledge can:

- Avoid TE “blocking” problems that occur in distributed computation case through global demand and LSP visibility.
- Use more sophisticated algorithms than CSPF to compute a global optimum for a set of TE paths to make more efficient use of network resources.
- Improve the management of LSP complexity through a GUI showing the full network topology.
- Incorporating external criteria through a Northbound interface.
- Deal with path diversity requirements.
- Give predictability in path placement.
- Take future requirements into account when computing paths.
- Perform efficient path computation in multi-layer networks.

CENTRALIZED WAN SDN CONTROLLER
WORKFLOW & INTERFACES



CENTRALIZE WHAT YOU CAN, DISTRIBUTE WHAT YOU MUST

Centralized TE Controller in a Packet Optical Network

- Performs TE path
  - Discovery
  - Provisioning
  - Monitoring
  - Modification
- Provides centralized processing for massive TE database
  - Operators get total control of routing policy

Network Elements Operate Much as Today

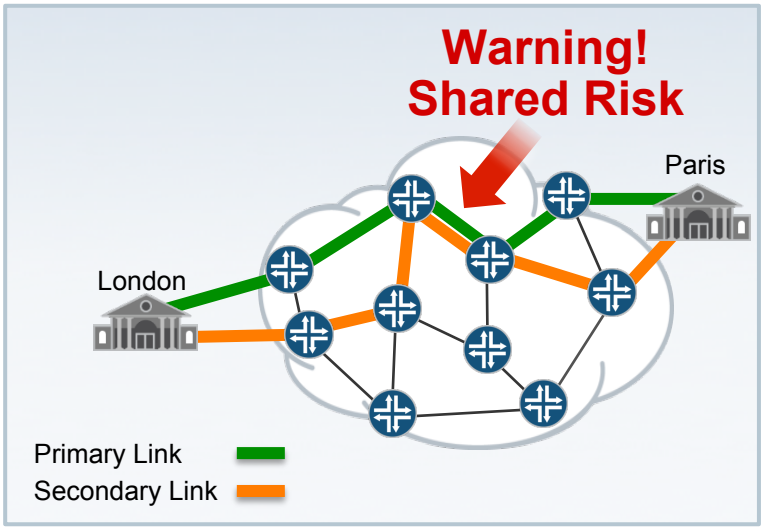
- Retains signaling function
- Offloads path routing function to controller
- Local RIB/FIB based forwarding

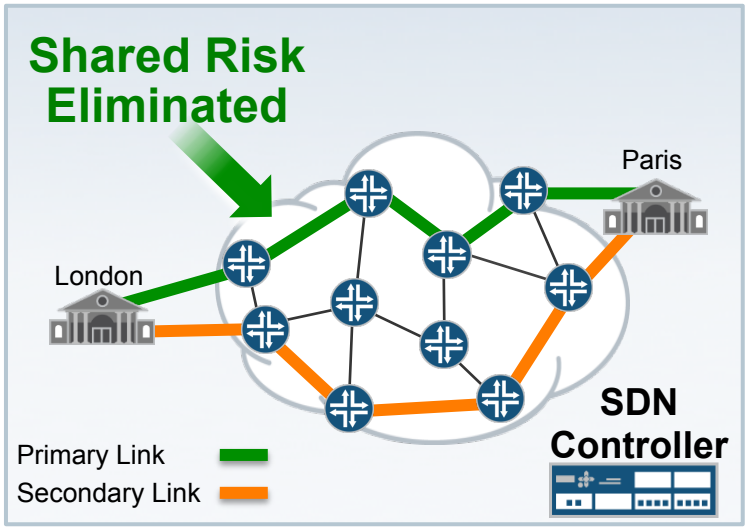
CENTRALIZED WAN SDN CONTROLLER USE CASES

CENTRALIZED WAN SDN CONTROLLER USE CASES
LSP PATH DIVERSITY

What is the benefit from LSP path diversity:

- Eliminates risk that a primary and secondary link are both broad down by a single failure in the network. This is key to guarantee strict SLAs for business services.
- Eliminate the risk of Shared Risk Link Groups (SRLGs) on the transport layer.
- Path diversity allows for differentiated services by offering customers the choice between 1:1, 1+1 and/or 1:N protection options.

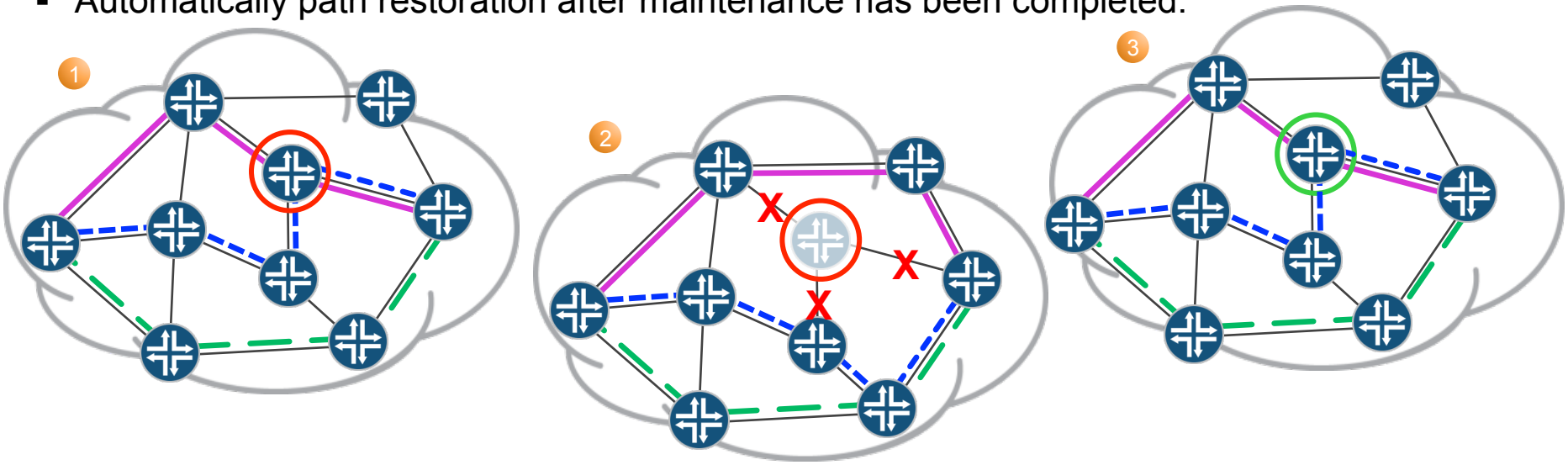




CENTRALIZED WAN SDN CONTROLLER USE CASES
DETERMINISTIC MAINTENANCE-MODE RE-ROUTING

Automate re-routing of traffic before a scheduled maintenance window:

- Eliminate risk that services are mistakenly affected when a node / link goes into maintenance mode – important to guarantee strict SLAs.
- Automatically path restoration after maintenance has been completed.

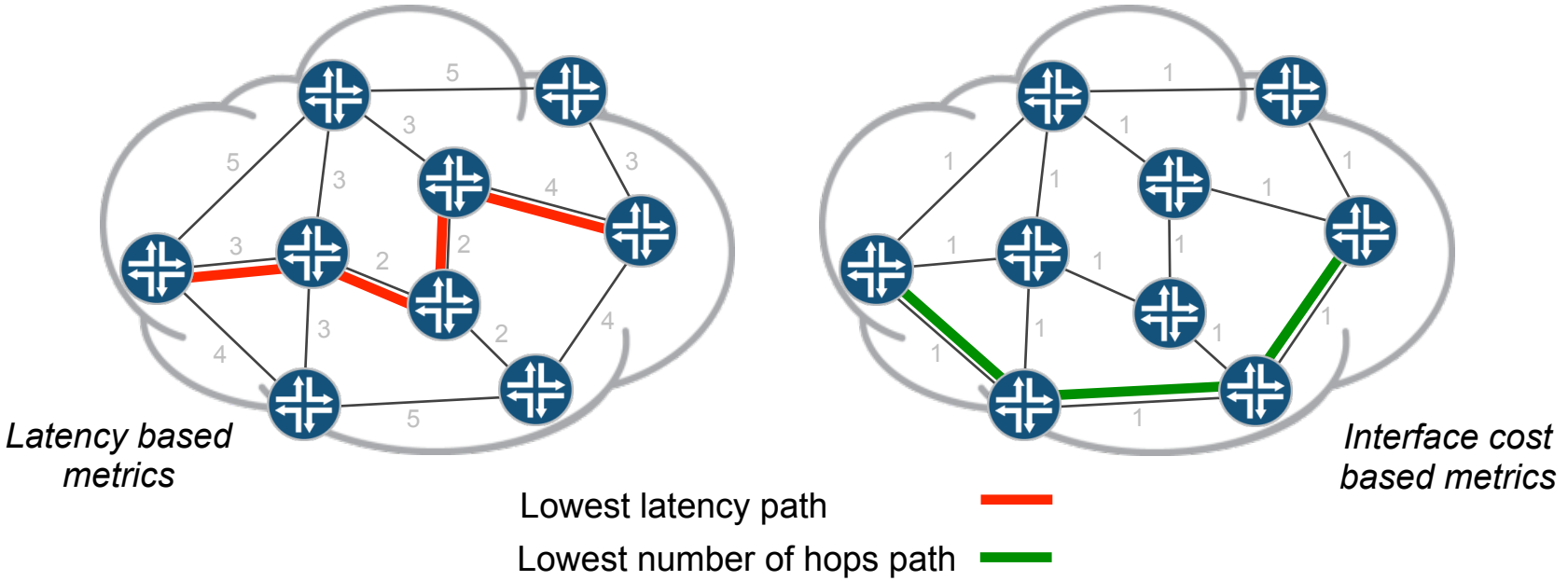


1. Node tagged as going into maintenance mode, affected LSPs are identified by WAN SDN Controller.
2. LSPs are re-computed and re-signaled around the affected node through a PCEP update (all make-before-break). Node is subsequently moved into maintenance mode.
3. Node is tagged as available after maintenance window finishes. Optimum LSP paths are restored through PCEP update and re-signaling.

CENTRALIZED WAN SDN CONTROLLER USE CASES
PROGRAMMABLE PATH OPTIMIZATION

Application-aware routing: optimum path is decided based on application specific requirements

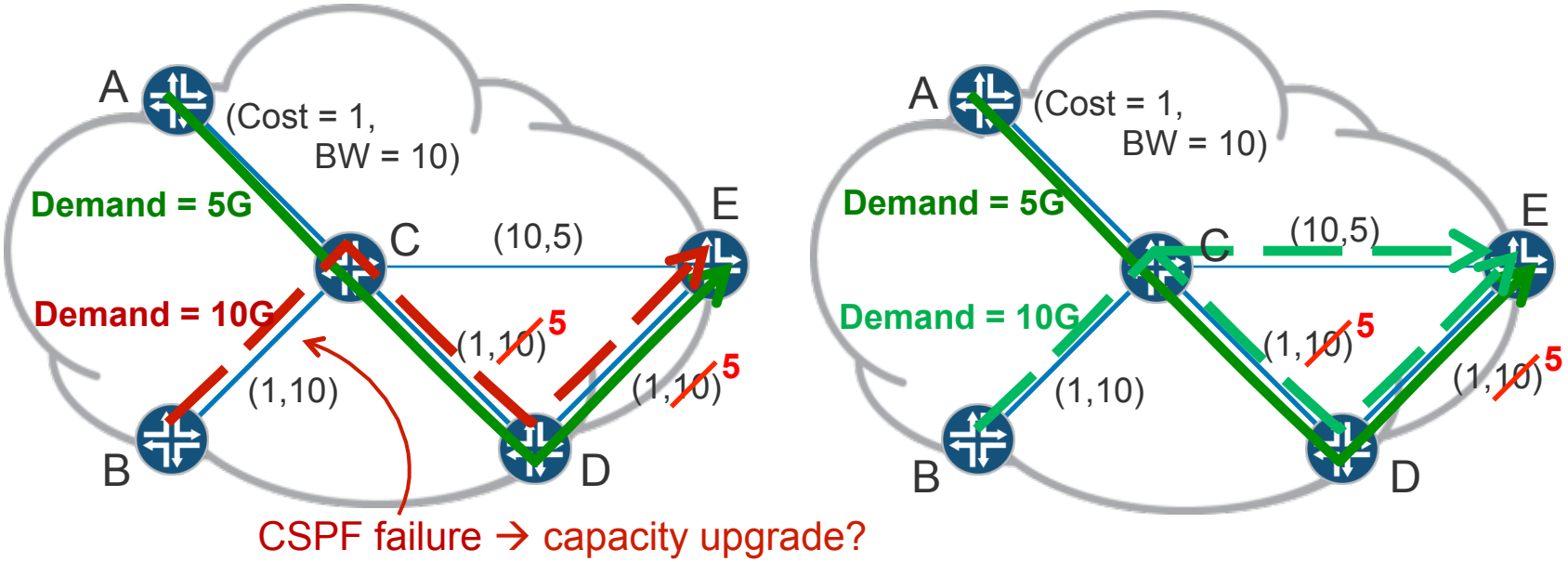
- Today cost metrics are most often based on number of hops (minimize port cost) or distance (minimize transport cost and latency).
- WAN SDN Controller can use additional 'cost' functions for path computation, which are stored in a topology file, to decided the optimum path for each LSP.



CENTRALIZED WAN SDN CONTROLLER USE CASES
ENHANCED TRAFFIC ENGINEERING (1/2)

WAN SDN Controller can enhance traffic engineering as it provides a network wide visibility to traffic demands:

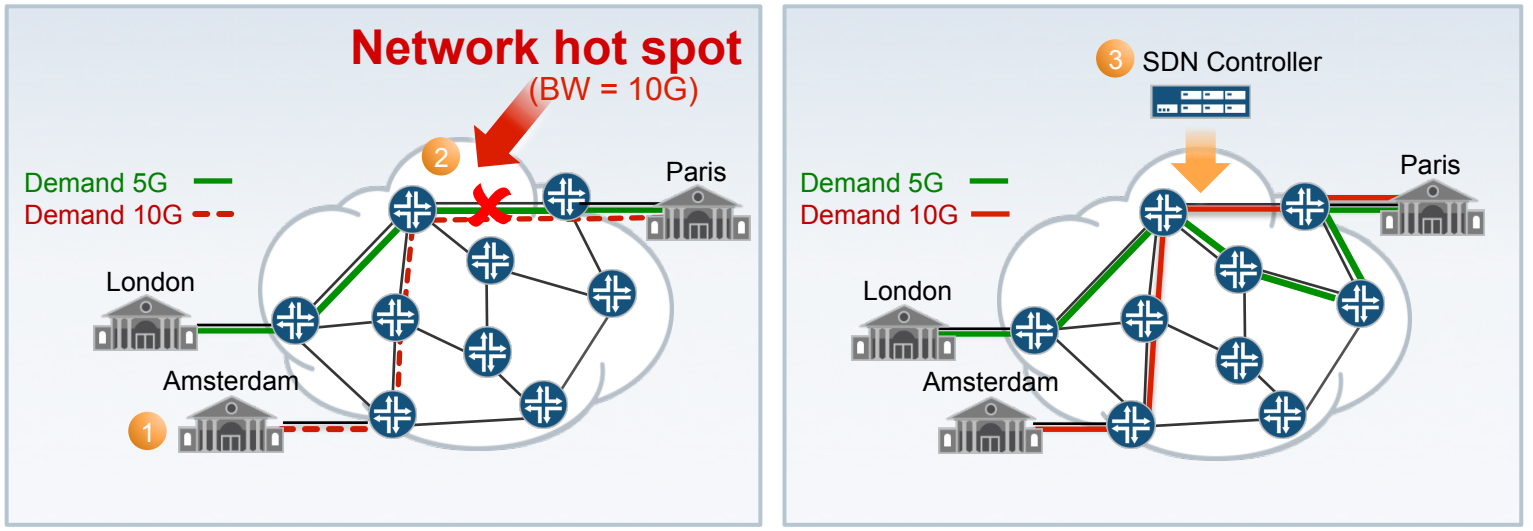
- Centralized path computation can therefore improve ‘bin packing’, i.e. how to place LSPs such that the available bandwidth is used in the most optimal way.
- WAN SDN Controller leverages TE++ for enhanced traffic engineering. This is a JUNOS feature that can dynamically create/tear down LSPs based on the traffic load. WAN SDN Controller especially improves visibility and manageability of LSP optimization.



CENTRALIZED WAN SDN CONTROLLER USE CASES
ENHANCED TRAFFIC ENGINEERING (2/2)

Enhanced traffic engineering makes it easier for operators to offer premium services without the need to overprovision network capacity:

- Efficiently distribute and re-distribute traffic flows across the network in real-time.

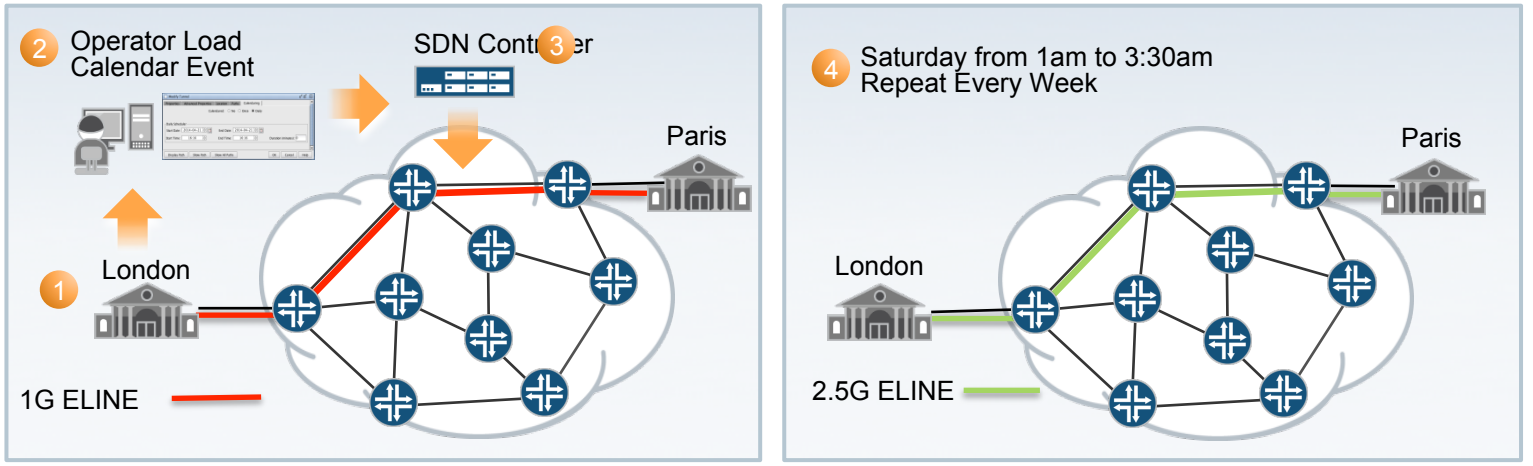


1. A new request is initiated for a premium low-latency path between to two points in the network.
2. Due to other paths already established with in the network, not sufficient bandwidth is available on the lowest latency path to accommodate the new request.
3. WAN SDN Controller has a global perspective and will redistribute existing non-premium paths in order to free up bandwidth on the low-latency path.

CENTRALIZED WAN SDN CONTROLLER USE CASES
BANDWIDTH CALENDARING

Bandwidth calendaring allows network operators to reserve resources up -front or for a dedicated period of time:

- Bandwidth calendaring enables highly accurate usage based charging for bandwidth.
- Reduces the need for on-side configuration at customer premises, for example when upgrading bandwidth.



1. Customer places an order to increase their E-line Service from 1G to 2.5G this upcoming Saturday
2. The Service Order is converted into a Service Request, which can be implemented through a customer portal.
3. The Network Operation Group will execute the Service Request through the WAN SDN Controller GUI or North Bound REST API
4. SDN Controller will increase the customer's E-Line service to 2.5G on Saturday at 3:30am

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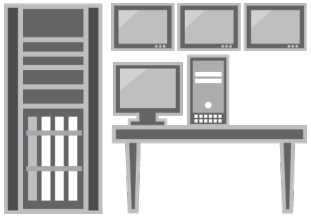

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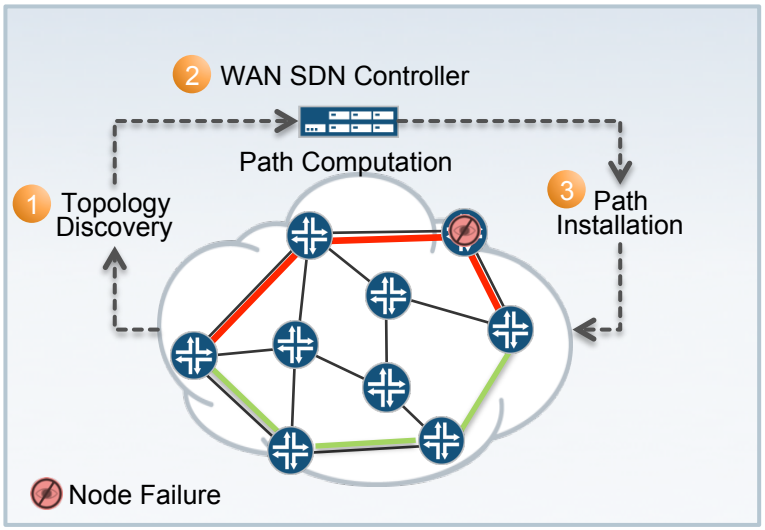
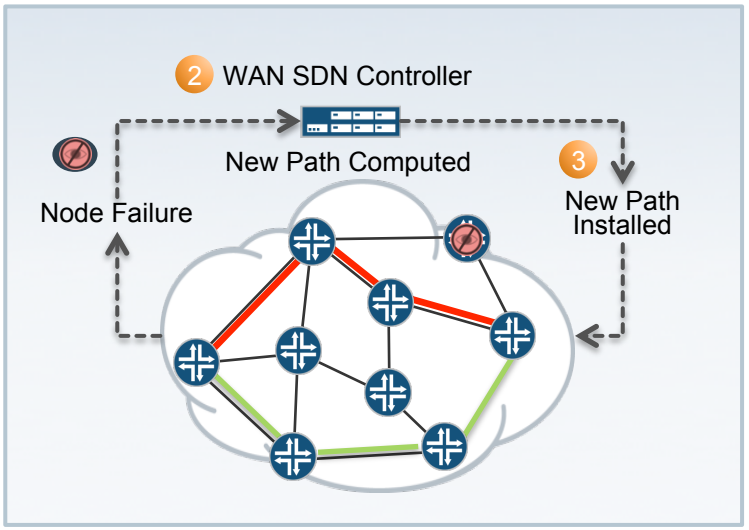
CENTRALIZED WAN SDN CONTROLLER USE CASES
AUTONOMOUS OPTIMIZATION

WAN SDN Controller can autonomously optimize the network for best possible resource utilization, taking into account:

- Packet or optical topology changes (failure, maintenance, capacity upgrade).
- Changes to services through the Northbound interface(s) with user-defined constraints.





1. The WAN SDN controller automatically discovers the network topology through (OSFP,IS-IS) or BGP
2. Powerful path computation algorithms continuously compute new optimize paths based upon network utilization
3. Optimize network provisioning injected via PCEP, Netconf/YANG, Python, etc.

everywhere