



Resilient Networks

From Prevention to Recovery

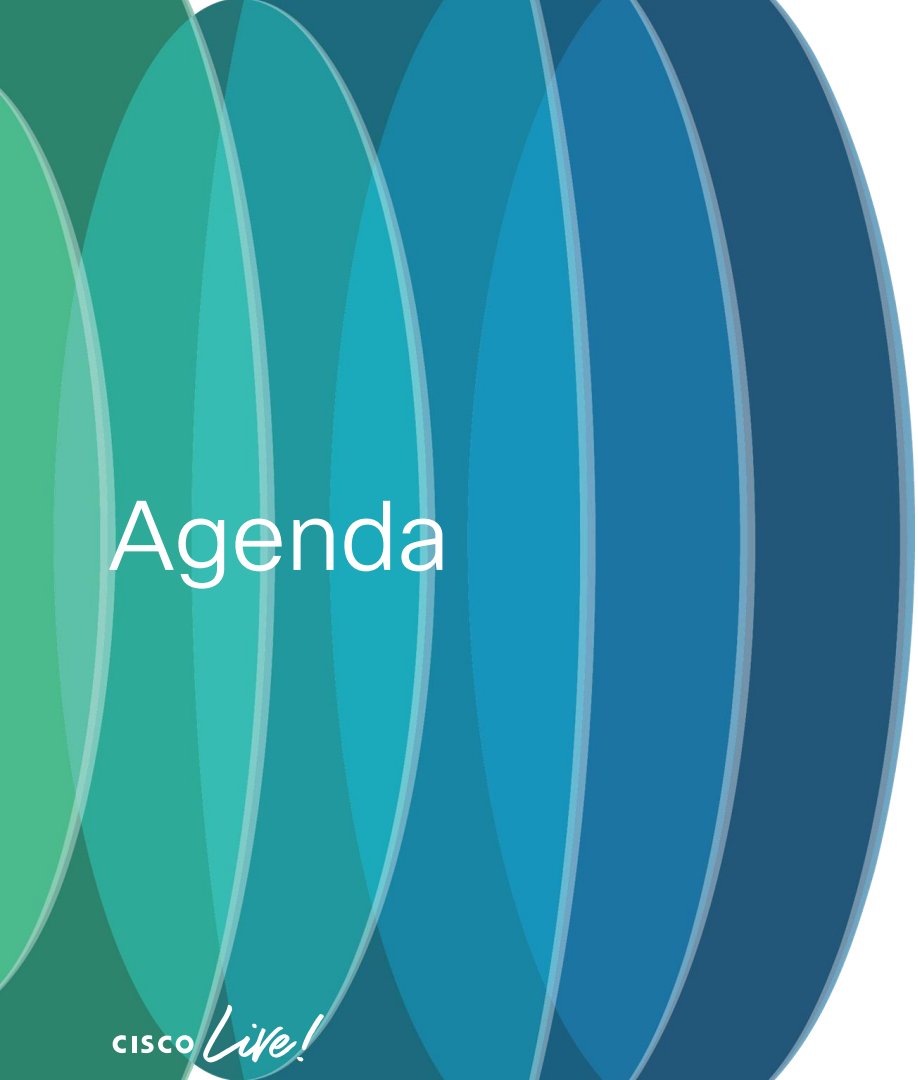
Marius Stoica

Leader, Customer Experience Product Management

BRKSPG-2695

CISCO *Live!*





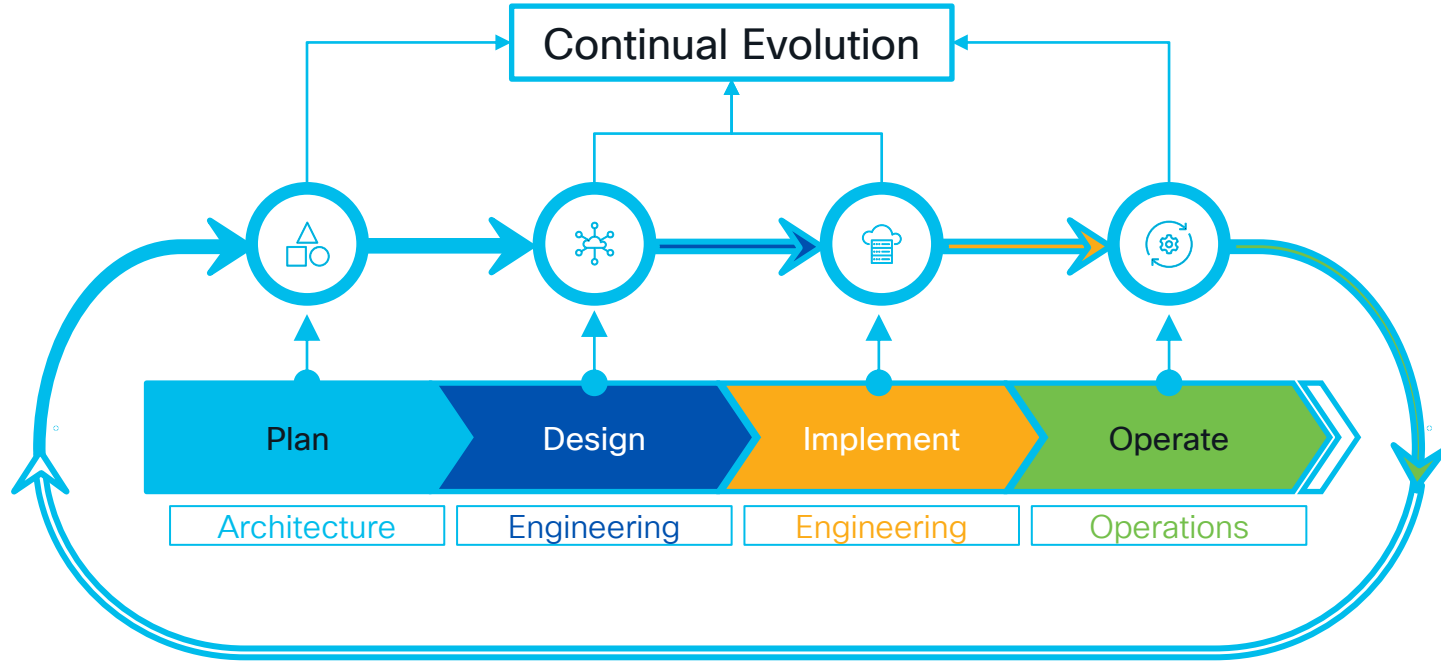
Agenda

- Introduction
- Best Practices for Operations
- Operation and Maintenance
- Network Management tools
- Incidents and Recovery
- Next Steps

*A resilient network is
not just about surviving
a storm but thriving in
its aftermath.*

Lifecycle of a Network

Close the loop



Best Practices for Operations



Best Practices for Network Operations

- Network Documentation

- Maintain up-to-date documentation of your network topology, device inventory, IP addresses etc.
- Use automated documentation tools to keep records current

- Configuration Management

- Use configuration management tools to maintain consistent configurations across network devices and to automate the deployment of changes
- Keep a version-controlled backup of all configurations to facilitate quick recovery

Best Practices for Network Operations

- Network Monitoring

- Continuous monitoring for performance, availability, and security events
- Use network monitoring tools to identify and alert on abnormal conditions

- Performance Management

- Regularly analyze network performance metrics and traffic patterns to identify bottlenecks or degradation of service
- Implement Quality of Service (QoS) to prioritize critical traffic and ensure bandwidth allocation aligns with business needs

- Capacity Planning

- Proactively plan for future network growth by regularly evaluating bandwidth usage trends and predicting future needs

Best Practices for Network Operations

- Automation and Orchestration

- Implement automation to streamline repetitive tasks, reduce errors, and increase efficiency to expedite fault isolation and reduce Mean Time To Repair (MTTR) by correlating events, logs, and KPIs

- Change Management

- Use a formalized change management process to control and record any modifications to the network environment
- Conduct pre- and post-change analysis to understand the impact and verify success

- Disaster Recovery and Business Continuity

- Develop and regularly test disaster recovery plans to ensure network services can be quickly restored after an outage

Operation and Maintenance



Platforms Lifecycle Operational Checks

- Check vulnerabilities and Field Notices for your installed products to avoid any issues that can bring down the service or worse create a security hole
- Retire end-of-life (EOL) and end-of-support (EOS) equipment with known software defects, security vulnerabilities and no available software updates
 - Know EOL/EOS of your software ahead of time

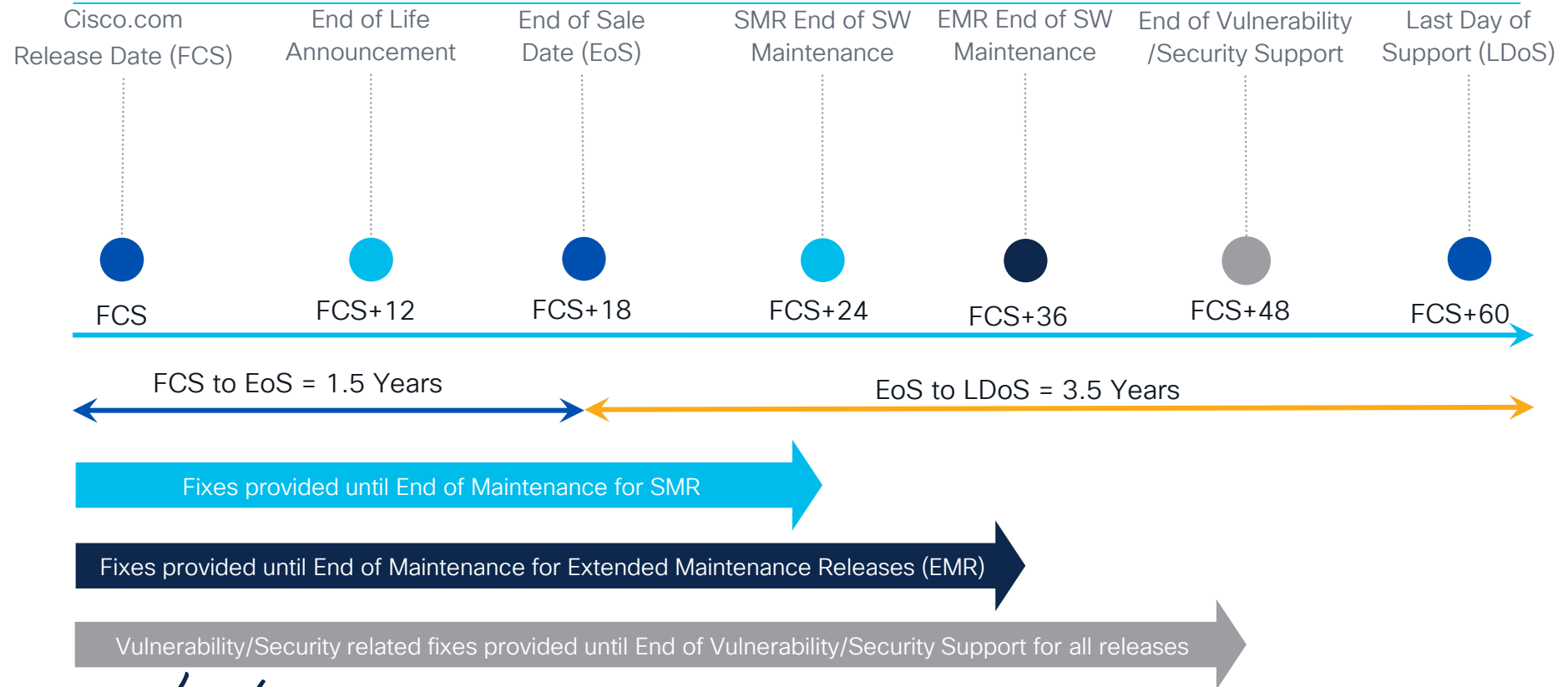
Notifications Services for Cisco Products

<https://cway.cisco.com/mynotifications>

- End Of Sale
- Field Notices
- Security Advisories
- Software Updates
- Known Bugs

The screenshot displays the 'My Notifications' interface on the Cisco website. At the top, the Cisco logo and 'My Notifications' title are visible, along with the user's name 'Marius Stoica' and language settings. A dark blue banner provides instructions on creating custom subscriptions for Cisco products, series, or software to receive email alerts or RSS feeds. Below this, a form allows users to enter a specific Bug ID (e.g., CSCdi63700), select a frequency (Daily), and specify an email address (mstoica@cisco.com), with a 'Track a Bug' button. The main section, titled 'Subscriptions', features a 'Create Subscription' button and a 'Track a Bug' link. It displays two active subscriptions: 'XR SW' and '8000 EOL', each with a 'Frequency Today' and 'Status Active' indicator. A 'FILTERS' sidebar on the left shows options for 'Email' and 'RSS'. Navigation links for 'Prev', '1', and 'Next' are located at the bottom right.

IOS XR Software Lifecycle

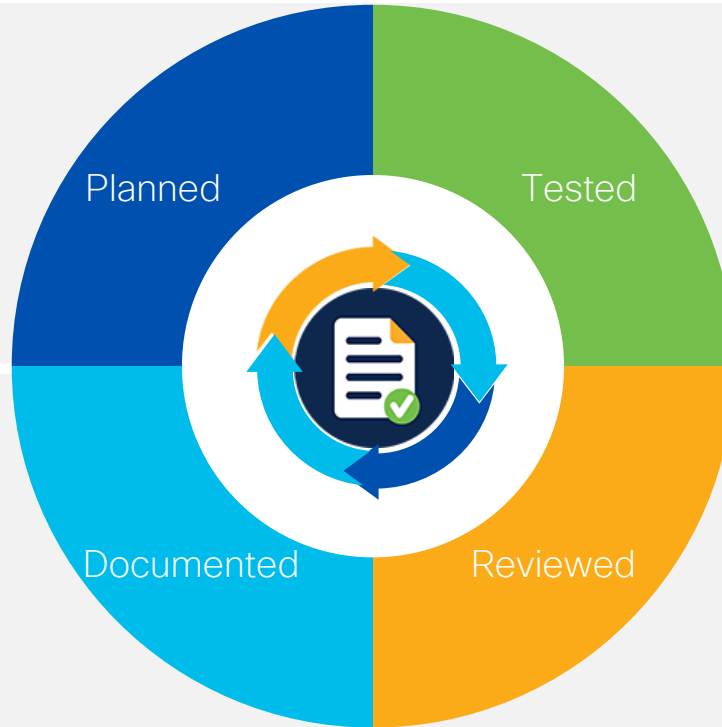


Network Change Process Rigor

- All network change procedures should be explicitly planned, documented, tested and reviewed
- After a successful verification, first time deployment of a network change should be deployed manually (step by step)
- All network changes that may affect traffic forwarding should be performed during a scheduled maintenance window
- After a pilot change procedure successfully deployed by hand, relevant tools and scripts shall be utilized for larger scale deployment (i.e., crawl, walk, jog, run, fly)

Network Change Procedures

- Step by step including pre-checks, change procedures, expected impacts, post-checks and roll-back procedures – no ambiguity!
- Update the initial plan and derive the Method of Procedure (MOP) including automated deployment options.



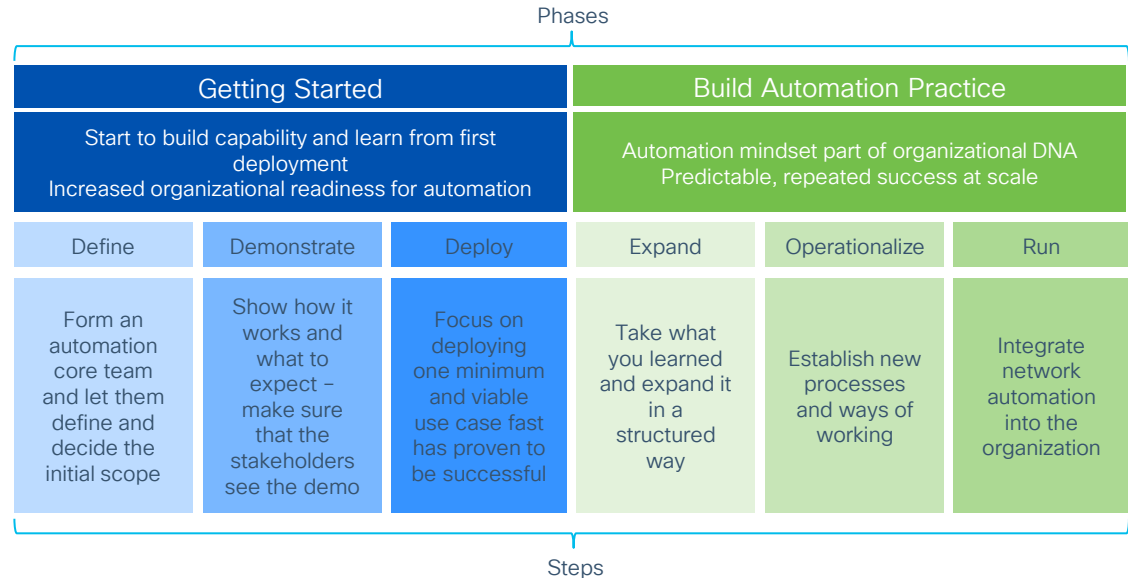
- Build a replica lab and conduct lab tests – written by one person tested by another.
- Employ testing tools and scripts.
- Review tests results with all stakeholders including vendor teams.
- Agree on “Green light” criteria

Provisioning via Network Automation

- Leverage **Zero Touch Provisioning** for Day0 configuration
 - ZTP script can be enhanced to take care of Day0 code upgrades.
- **Golden ISO image**
 - Build GISO image based on the required package/SMUs
 - GISO simplifies code upgrade process, reduces the complexity of managing individual packages and maintains standardization across the network infrastructure
- **Automate Day2 changes**
 - Tools like NSO/Ansible/Puppet and others can be leveraged to automate Day2 changes
 - Yang models provide standard way to define the network configuration and data

Automation: Foundation for Success

- Changes and test procedures shall be **automated** and **reusable** leaving no space errors
- Automation as a Practice can be implemented in phases
 - Getting Started
“Proof of Concept”
 - Automation Practice
“Operationalize”



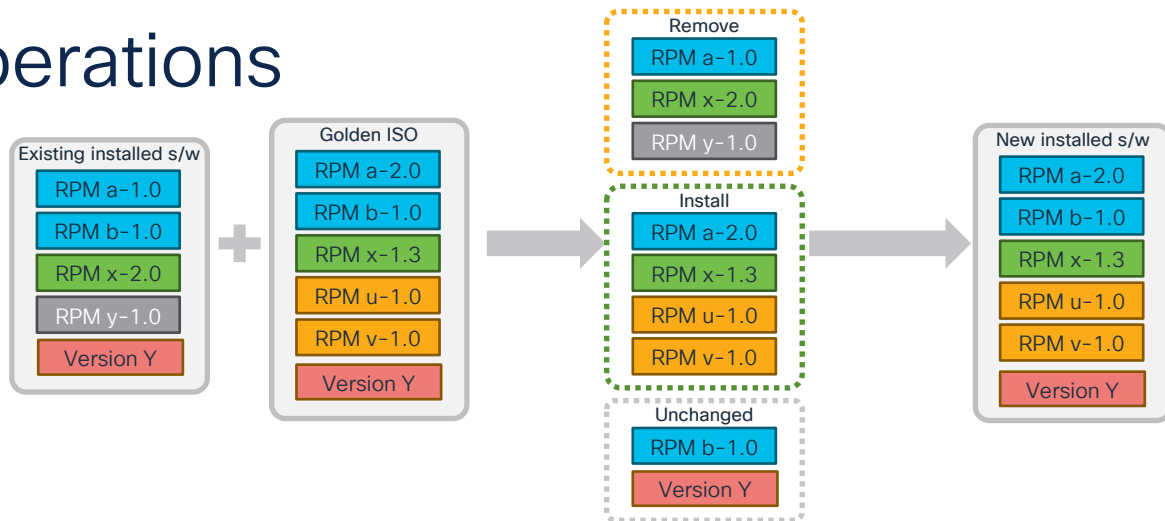
Source: <https://developer.cisco.com/docs/network-automation-delivery-model/network-automation-delivery-model/>

Software Validation and Testing

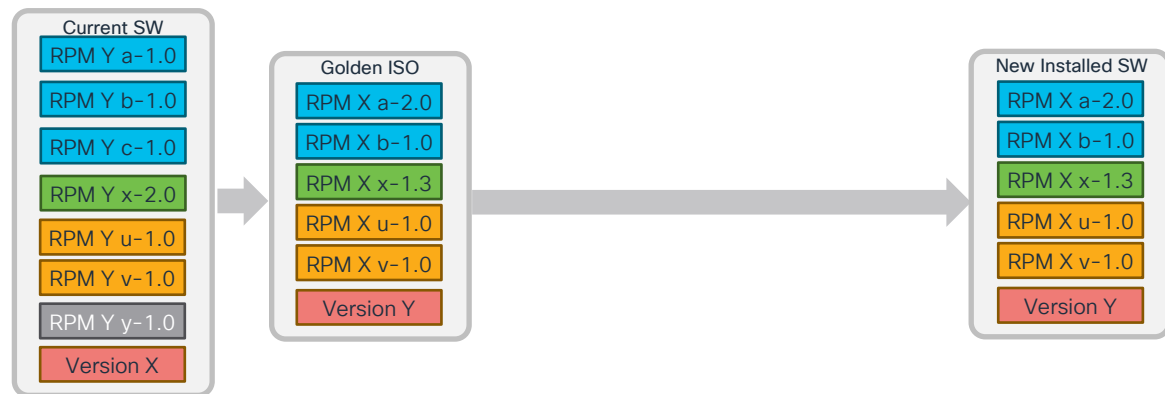
- Software updates shall be seen as **changes**
 - Upgrading the network can be painful if performed every 3 years
 - Upgrades due to bugs and new functionalities require testing
- **Gradual update** – keeping the network up to the latest stable releases – use Golden ISO
- **Scheduled** – checks and maintenance schedules as part of the operation
- **Software validation** – Stable lab build, automated regression testing
- CI/CD and DevOps in managing software releases

Golden ISO - Operations

install replace
same version update



install replace
version upgrade



Building Golden ISO (GISO) workflow

Step 1

Prepare a Linux install - RedHat/Debian based releases.

Step 2

Clone the <https://github.com/ios-xr/gisobuild> repository

Step 3

In setup directory, run the prep_dependency.sh script

Step 4

Download the desired ISO and additional required packages (RPM's)

Step 5

Unpack all the optional packages in a single directory

Step 6

Run the build script - pointing it the desired ISO and packages

Step 7

Check the successful completion - indicates the locations of the ISOs

Step 8

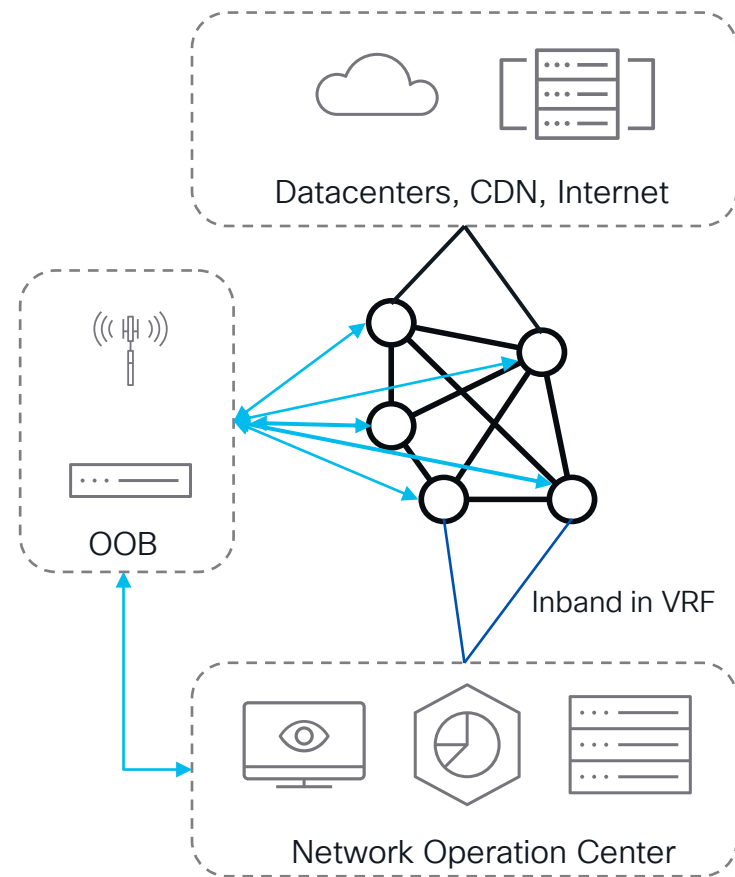
Two images are built - ISO and USB image

Planned Maintenance Events

- **Verify** that both **in-band** and **out-of-band** remote access are operational beforehand to ensure uninterrupted management access during a maintenance activity
- Proactively **inform all involved teams** to check the status after the change
- Optimal techniques available to **gracefully migrate traffic** via alternate nodes/paths (if available) during maintenance activities:
 - IS-IS **set-overload-bit** / OSPF **max-metric**
 - BGP graceful maintenance (or comparable BGP policy)
 - EVPN cost-out

Remote access best practices

- Have separate networks for In-Band, Ethernet OOB and console OOB ports
- Ensure console access is not dependent on either the Management Ethernet network or the In-Band network
- Use dedicated circuits, if necessary, avoid traversing the same fiber or path



Network Management Tools

CISCO *Live!*

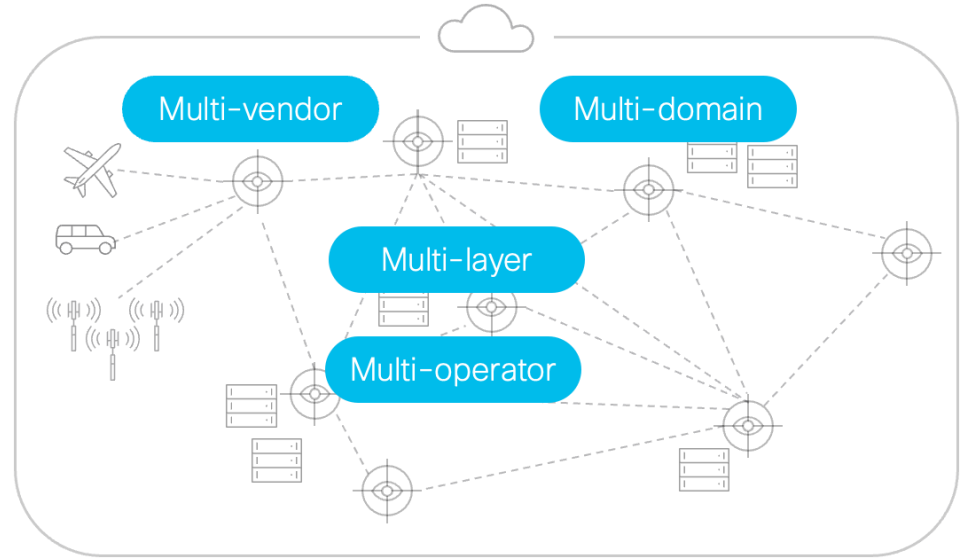


Network Management Tools

- Employ automation and re-usability for **Visibility**, **Insights** and **Action**
- When selecting network management tools, consider factors like:
 - **Scalability** – the tool should scale the intended deployment
 - **Integration capabilities** – REST API's, Programmability and User Control
 - **User-friendliness** – An unfriendly tool will not be used
 - **Support** – The level of support and maintenance shall be known
 - **Multivendor** – Tools should be multivendor and extensible
- Other considerations could include the possibility of the current tool migration complexity

Network complexity and costs

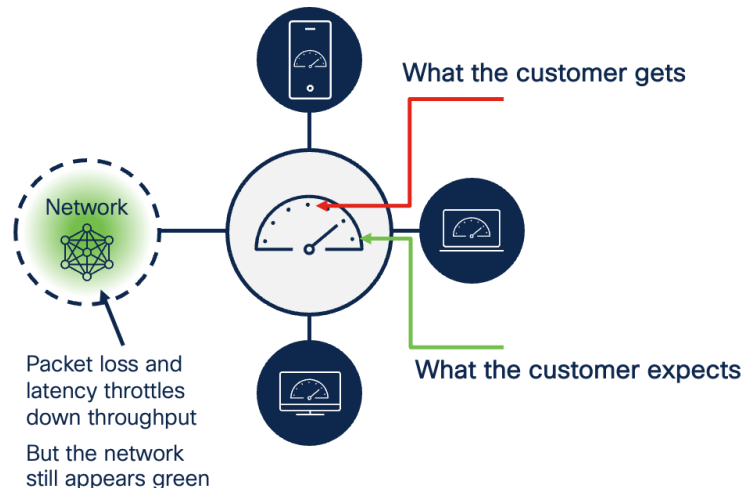
- Higher demands on networks and services
- Complex and distributed network; fragmented tools
- Performance visibility silos
- A tool for every vendor and domain
- Lengthy issue acknowledgement and resolution times



Current tools visibility issues

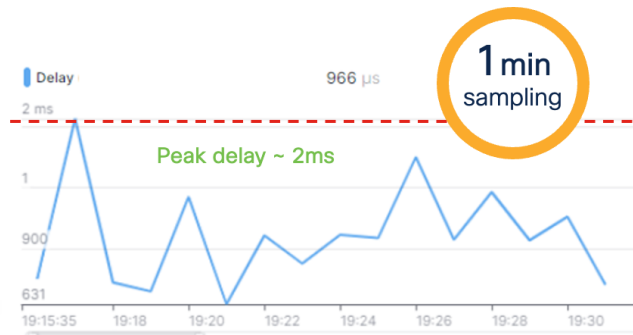
Observations vs. results

- 0.53% **packet loss** → 50% decrease in data throughput
- 5 msec **delay** → 10% decrease in data throughput
- 10 msec **jitter** → 10% decrease in data throughput



Customer perception

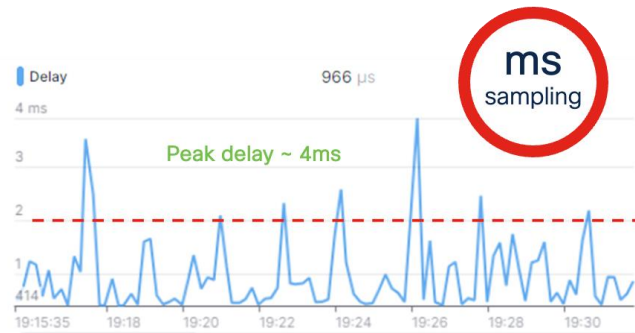
Measured in milliseconds, not minutes



Everything looks fine! Latency is below threshold

Perception

Service is performing according to SLA/SLO



Reality



Customer is impacted!
SLA is breached

Service is impacted by intermittent latency issues

Provider Connectivity Assurance

Assurance in real-time



Single view, network-wide, high-precision service-centric proactive assurance



Provider Connectivity Assurance Sensors

- Accurate synthetic testing
- End-to-end services
- User experience

Assurance
Sensor Agent



Assurance Sensors
(hardware devices)



Assurance
Sensor Control



Assurance
Sensor Module



Assurance
Sensor SFP



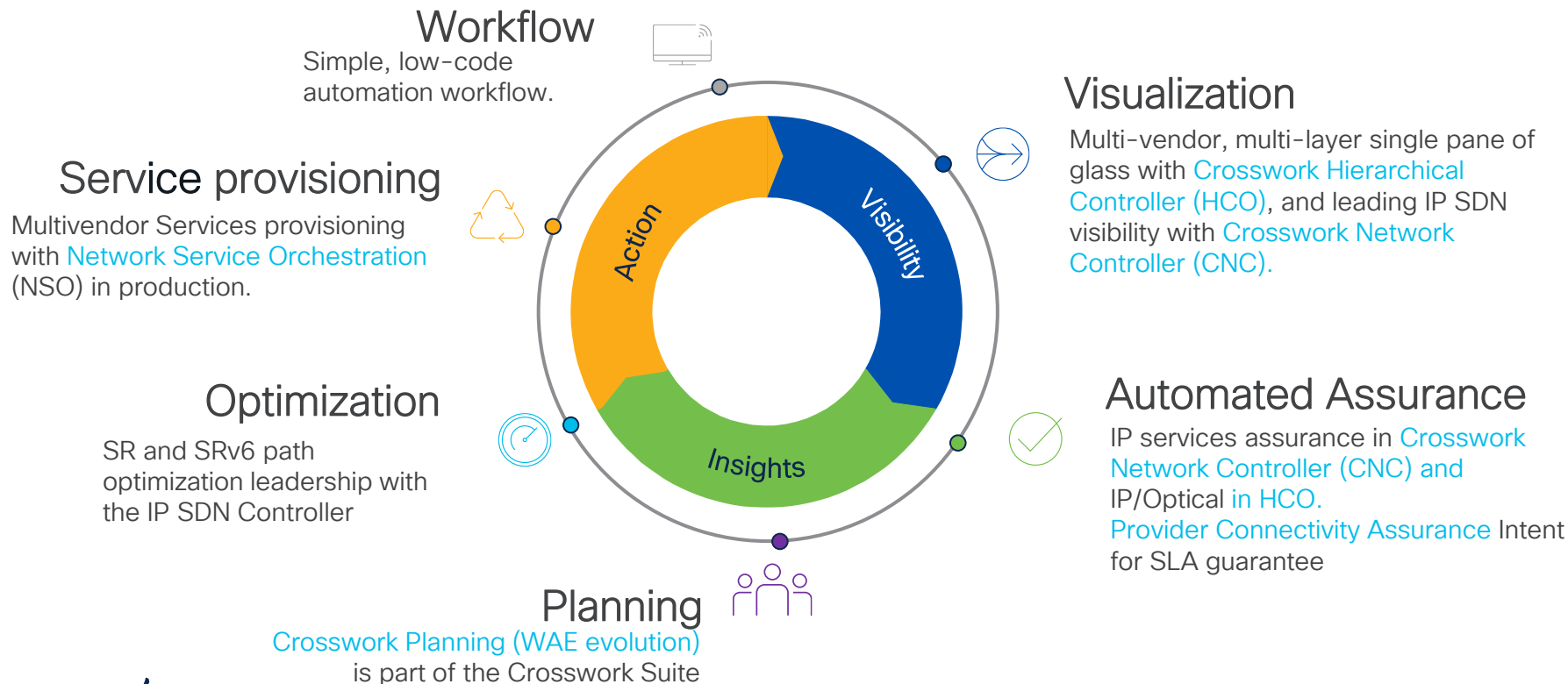
Provider Connectivity Assurance

- AI-enabled predictive analytics
- Multi-layer data ingestion and correlation
- Real-time anomaly detection



Crosswork – Operationalizing Networks

Foundation for closed-loop automation and zero-touch networks



Crosswork Planing: Predictions for Operations

Key Features

Predictive AI

Predict the impact of network changes, traffic growth, new services, and potential failures

Capacity Planning

Leverage measured or simulated traffic data for accurate predictions

Services Optimization

Optimize network design for efficiency and reliability

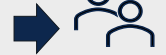
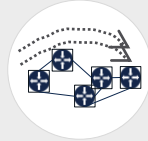
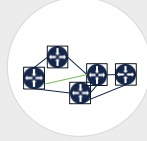
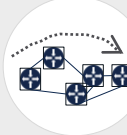
Benefits

- Reduced operational costs
- Improved network performance
- Enhanced agility
- Proactive planning
- Simplified Capacity planning

What-if...

... a link failed? ... add a link? ... traffic grows?

actual state

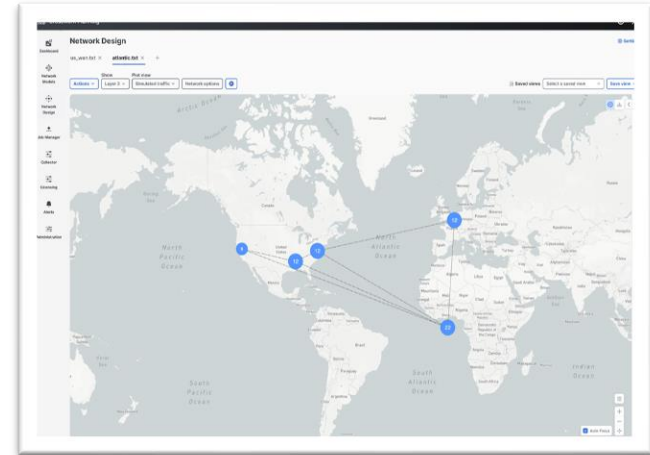


What is the optimal solution?

Where should I add capacity to minimize costs?

How can I meet resilience constraints?

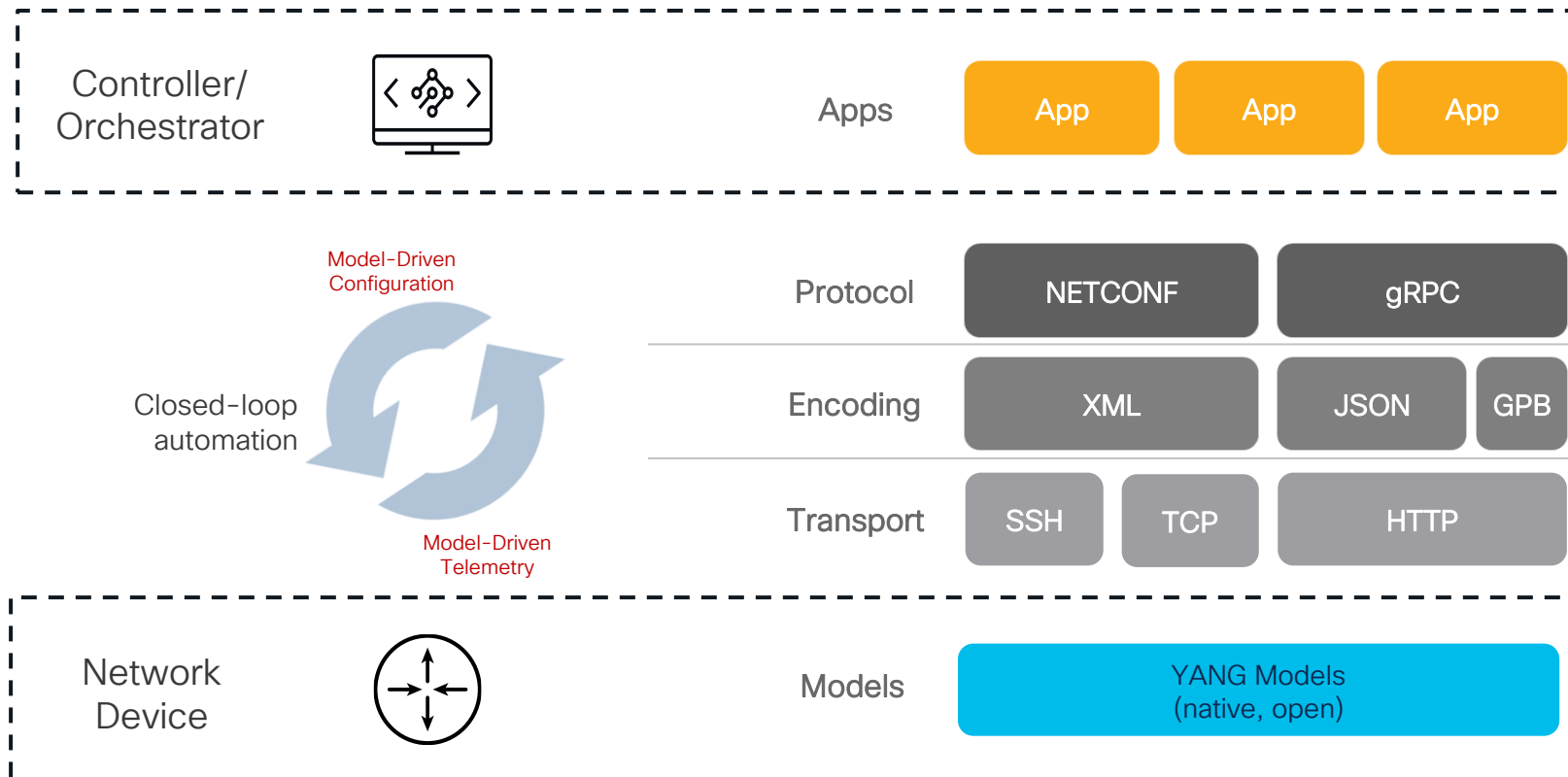
How can I ensure that latency is below a given threshold?



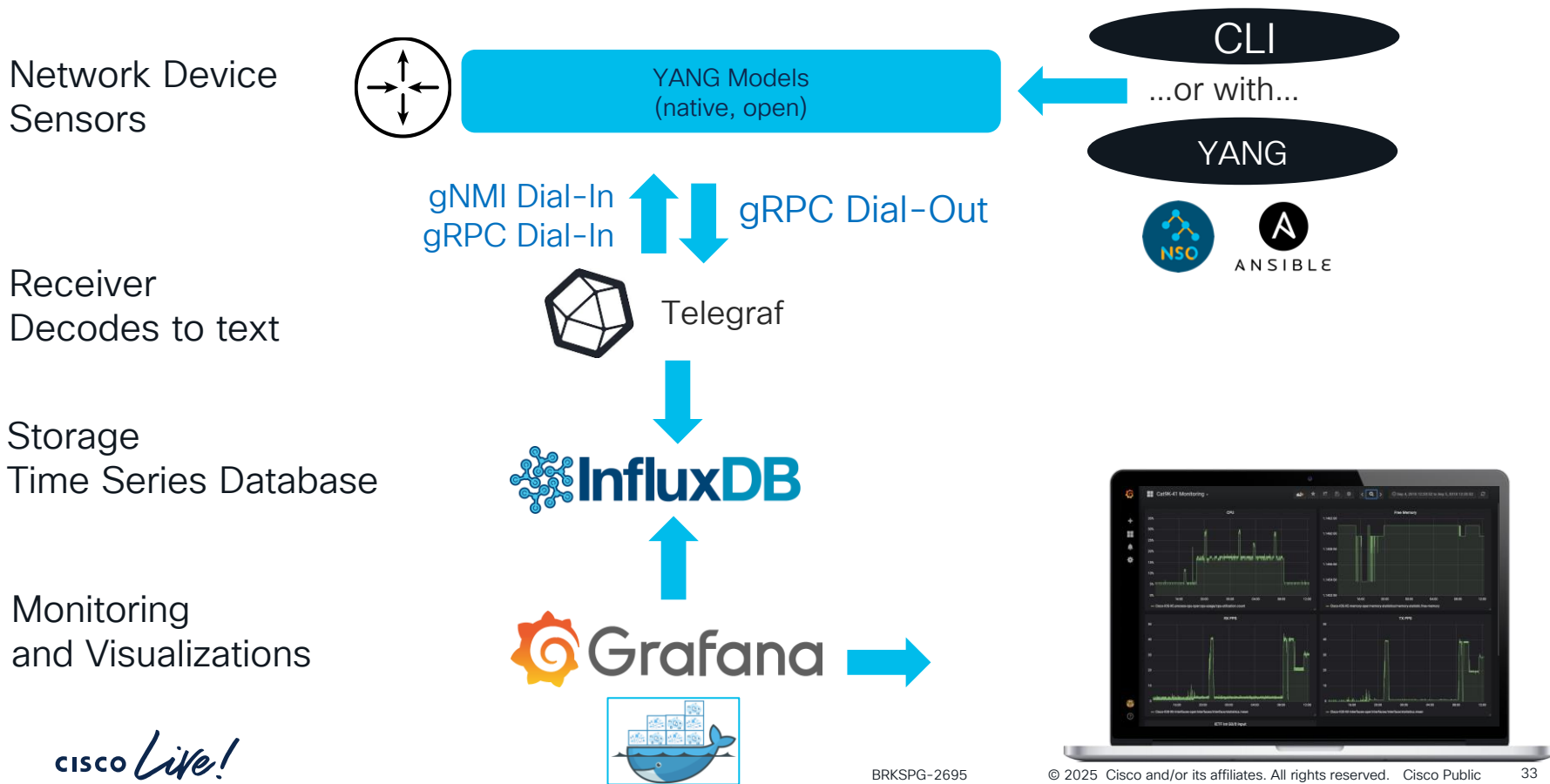
Observability and Telemetry in IOS XR

- Telemetry streamed or on-request:
 - Stats collection via Dial-In and Dial-Out – MDT/gNMI/Open Telemetry can be fed to a multitude of platforms
 - Periodic or event based
 - Customized to recipient – subscribe to any YANG subtree
- Benefits over SNMP:
 - Increased operational data and visibility (far beyond SNMP MIBs)
 - High scale due to push model (versus SNMP pull model) – significantly less CPU intensive
 - Network monitoring cadence reduced from 5mins to seconds
 - Structured data is software friendly – easier to read and automate

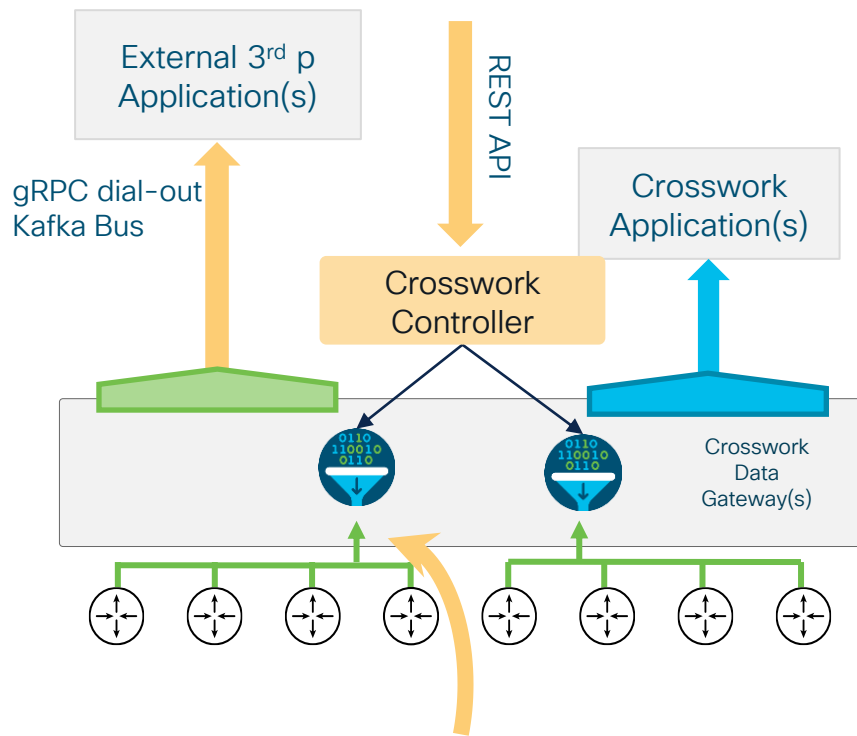
IOS XR Programmability



Telemetry Data - Open-Source Application Stack



Telemetry Collector: Crosswork Data Gateway



- Crosswork Data Gateway is part of the Crosswork Automation platform
- Crosswork Data Gateway provides a simple **secure** gateway between the network and applications to **collect data** even for applications in the cloud
- It is designed to be **multi-vendor**, **multi-protocol**, to reduce the need for multiple collection points
- By scaling horizontally and offloading application logic into it, Data Gateway can help applications achieve **mass scale** deployments to the network

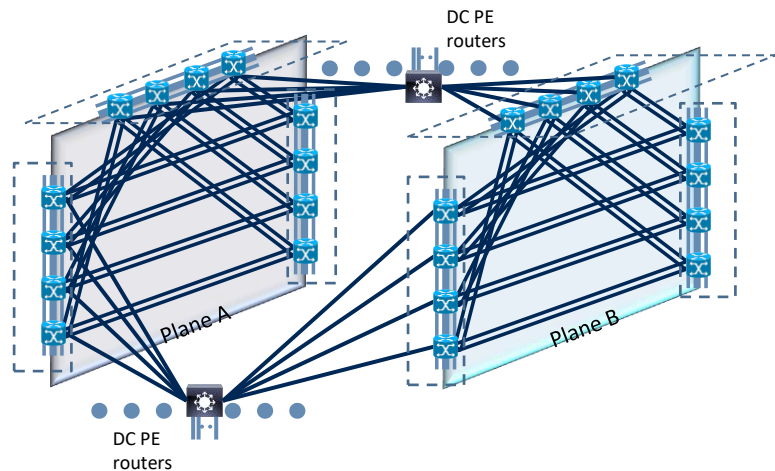
AI Driven Telemetry

Sensor-Group	Destination-Group	Subscription
"What/Which" Data Models	"Where/How"	"How Often"

- ADT is available from IOS-XR 7.3.1 onwards and it simplifies the filtering of Model-Driven-Telemetry (MDT) right on the router
- Automatic detection and description of significant state-changes of the router
 - Online/streaming Method
 - Unsupervised
 - Multi-variate, taking a very large number of features into account
 - Right on the router itself
 - Automatically calibrated to the available resources of the router
- Easy on-ramp to adopt MDT: Minimal configuration only
- <https://www.cisco.com/c/en/us/td/docs/iosxr/cisco8000/telemetry/73x/b-telemetry-cg-8000-73x/AI-driven-telemetry.html>

Performance Measurement

- Delay, Loss and Liveness measurements based on TWAMP light/STAMP
- Supported on various IOS XR platforms: NCS5500, ASR9000 and Cisco 8000
- Silicon One Integrated Performance Management provides 14M probes/sec



ECMP Measurements a challenge

Router(config)# **performance-measurement**

xpaths supported for Event Driven Telemetry EDT are:

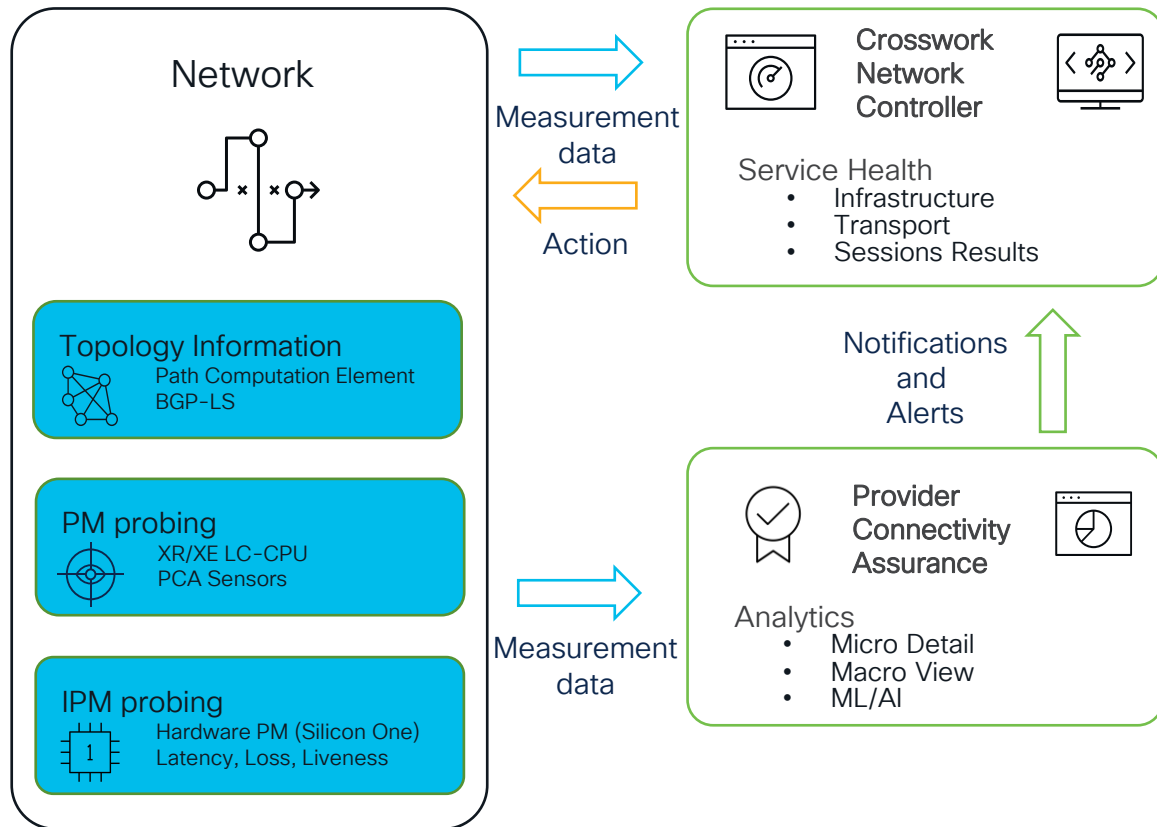
Cisco-IOS-XR-perf-meas-oper:performance-measurement/nodes/node/interfaces/interface-delay/*

Cisco-IOS-XR-perf-meas-oper:performance-measurement/nodes/node/interfaces/interface-loss/*

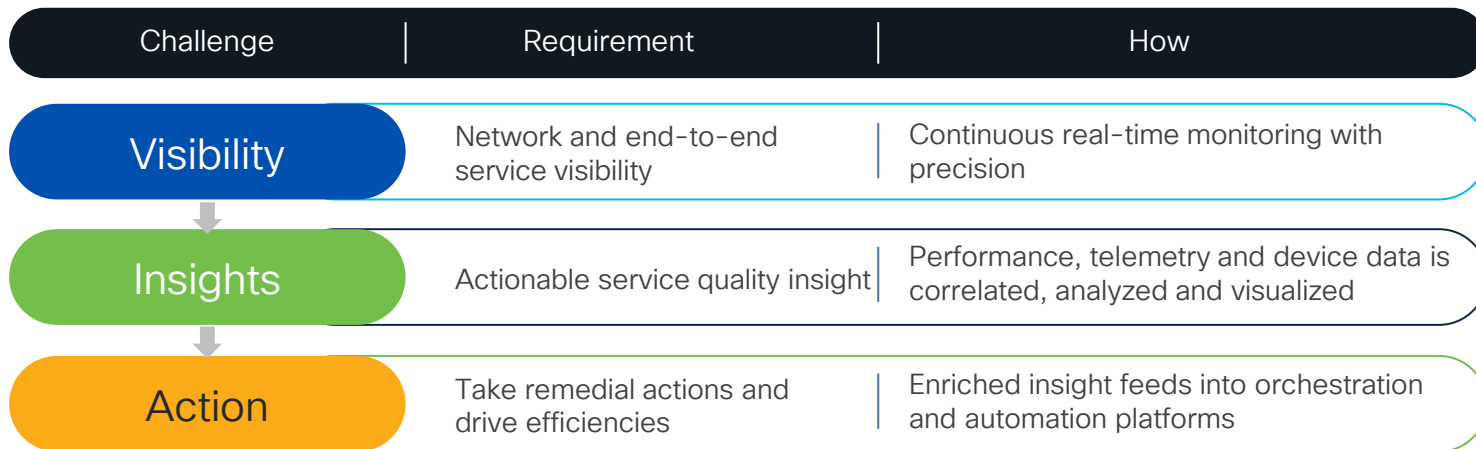
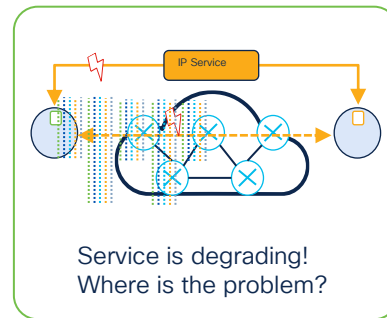
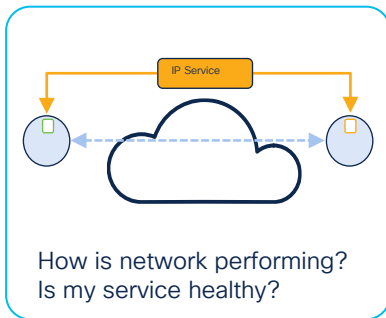
Automated Assurance

Integrated Performance Measurement

- Service Assurance is dependent on the Insights
- Performance data collected is analyzed in PCA and reported to CNC
- CNC correlation use Path Computation Element and BGP-LS data



From Data to Action



Incidents and Recovery



Incident Response – Be Prepared

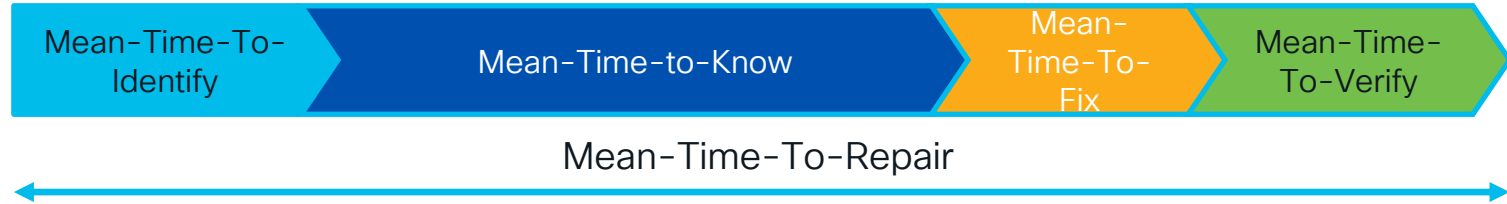
Continuous Preparation:

- Create “network down” incident response playbooks and conduct simulations / fire drills to prepare for potential failure scenarios
- Create applicable remote access “accounts” in advance / proactively and “enable” on-demand only when required
 - Vendors, 3rd parties shall have quick and timely access thus avoiding losing time during the incidents

During critical events:

- Ticketing system should automate notifications and escalations to get resources to start troubleshooting as quickly as possible
- Open vendor case(s) and/or engage all applicable vendors without delay
- Establish a troubleshooting group for mitigation procedures and RCA.
- Establish a business leaders, decision group – this group should ideally not distract the troubleshooting group

Incident: How it goes?



- Identification – Shall be fast and tool based – raising the alarm
- Know – What it is / What is not? Any recent changes?
- Fixing – Service Restoration, Workarounds or Fixes
- Verify – Document the change, update the design

All the changes performed during an incident should be **coordinated** and **documented**. Log all the outputs for the later analysis.

Root Cause Analysis and Periodic Audits

- Every network event necessitates a **Root Cause Analysis** (RCA) and suggestions for future mitigation measures (i.e., continuous improvement)
- **Audit your network** at regular intervals taking into the consideration the initial design, the changes in the deployment, scale, age and requirements that were accommodated on the fly
- The results of the audit should be incorporated in the design, tested and standardized for the whole deployment
- Today, audits come into play when the damage was done
- **Close the loop, not the door**

Next Steps



Autonomous network in standards

From architectures to operation practices and benchmarks

tmforum

Level Definition	L0: Manual Operation & Maintenance	L1: Assisted Operation & Maintenance	L2: Partial Autonomous Network	L3: Conditional Autonomous Network	L4: High Autonomous Network	L5: Full Autonomous Network
Execution	P	P/S	S	S	S	S
Awareness	P	P	P/S	S	S	S
Analysis	P	P	P	P/S	S	S
Decision	P	P	P	P/S	S	S
Intent/ Experience	P	P	P	P	P/S	S
Applicability	N/A	Select scenario				All scenarios

P-Human Operation assisted by Systems

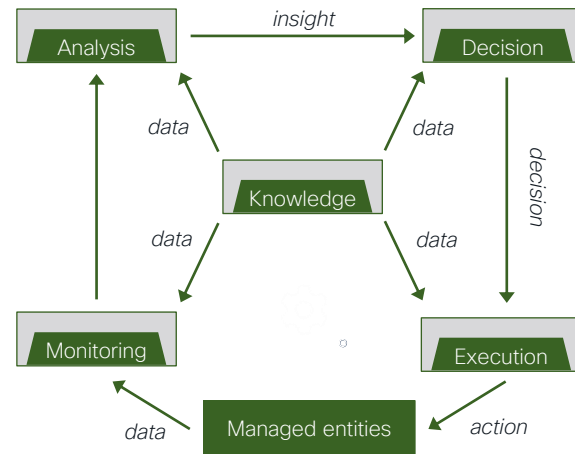


S-Systems Operation assisted by Humans

The big Disruption.



Zero-touch Network and Service Mgmt.



The Journey towards Autonomous Networks

Common Telco Use-Cases

Operator Augmentation

LLM UI + Accuracy AI trained with SP Knowledge Base (federated / custom trained assistant)

Multilayer Optimization

Global Topology and Multilayer (including tenant service) Optimization to SLO

Automated RCA / Remediation

Reaching causality – especially on uncharacterized issues.
Recommendation/action taken

Closed Loop

AI action taken on network configuration, performance to optimize and reduce MTTR

Configuration / MoP Optimization

Review of network device configurations, documented procedures to align with intent and current state of network

Traffic Characterization & Management

Characterize encrypted flows for congestion management, endpoint capabilities, optimization of fiber and spectrum resources

AI Advisory

What goes on prem, cloud. What models to use, governance, operations, infra selection and tuning

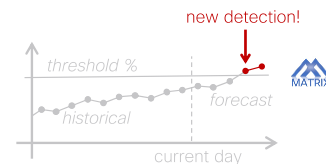
Today

Future

Capacity Management

(1) Perception and Prediction

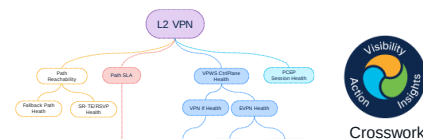
e.g. LSTM-based traffic forecast



Event Correlation

(2) Detection and Identification

e.g. service assurance graph accelerating RCA



Resource Optimization

(3) Control Optimization

e.g. maximize resource utilization
Energy Proportional Networking



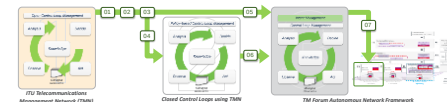
Anomaly Detection

(4) Process Optimization

e.g. Predictive Maintenance



Closed Loop Evolution



By prioritizing proactive measures, leveraging automation, and fostering collaboration, we can build resilient networks that are adaptable to the evolving technological landscape.

Related Sessions

Code	Title
BRKSPG-2695	Architectural Best Practices for Ensuring High Availability in Service Provider IP/MPLS Backbone Networks
BRKOPT-2016	Building Transport-Grade Packet-Based Networks with Routed Optical Networking
BRKSPG-1180	Impact of AI Traffic in Transport Networks
BRKSPG-1583	5G Non-Terrestrial Networking using Cisco Converged SDN Transport
BRKSPG-2029	Designing Routed Optical Networks: IP/MPLS Considerations
BRKSPG-2063	Modernizing Private WAN Architecture for Critical Networks Infrastructure
BRKSPG-2203	Introduction to SRv6 uSID Technology
BRKSPG-2227	Design, Deployment, and Management of Next-Generation Network Fabrics
BRKSPG-2643	Differentiating B2B Services and Transport with QoE and Proactive Service Assurance
BRKSPG-2944	Cisco 8000 Technical Update: Powered by Silicon One and IOS XR
BRKSP-2133	SP Architectural & Service Evolution with the Cisco SP NaaS framework
BRKSP-2551	Introduction to Segment Routing
LTRSPG-2140	Mastering BGP with Recent Features and Troubleshooting Techniques on IOS XR
LTRSP-1216	IOS XR Model-Driven Telemetry and Operations: This Is the Way
LABOPS-1507	Automating Services with NSO

Acknowledgements

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Webex App

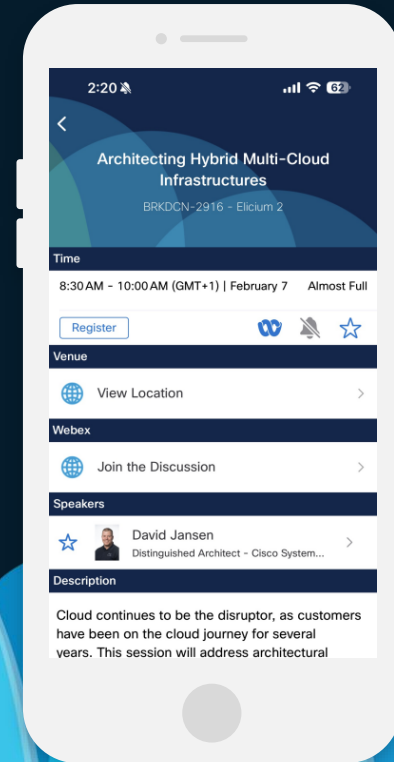
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(from 11:30 on Thursday, while supplies last)



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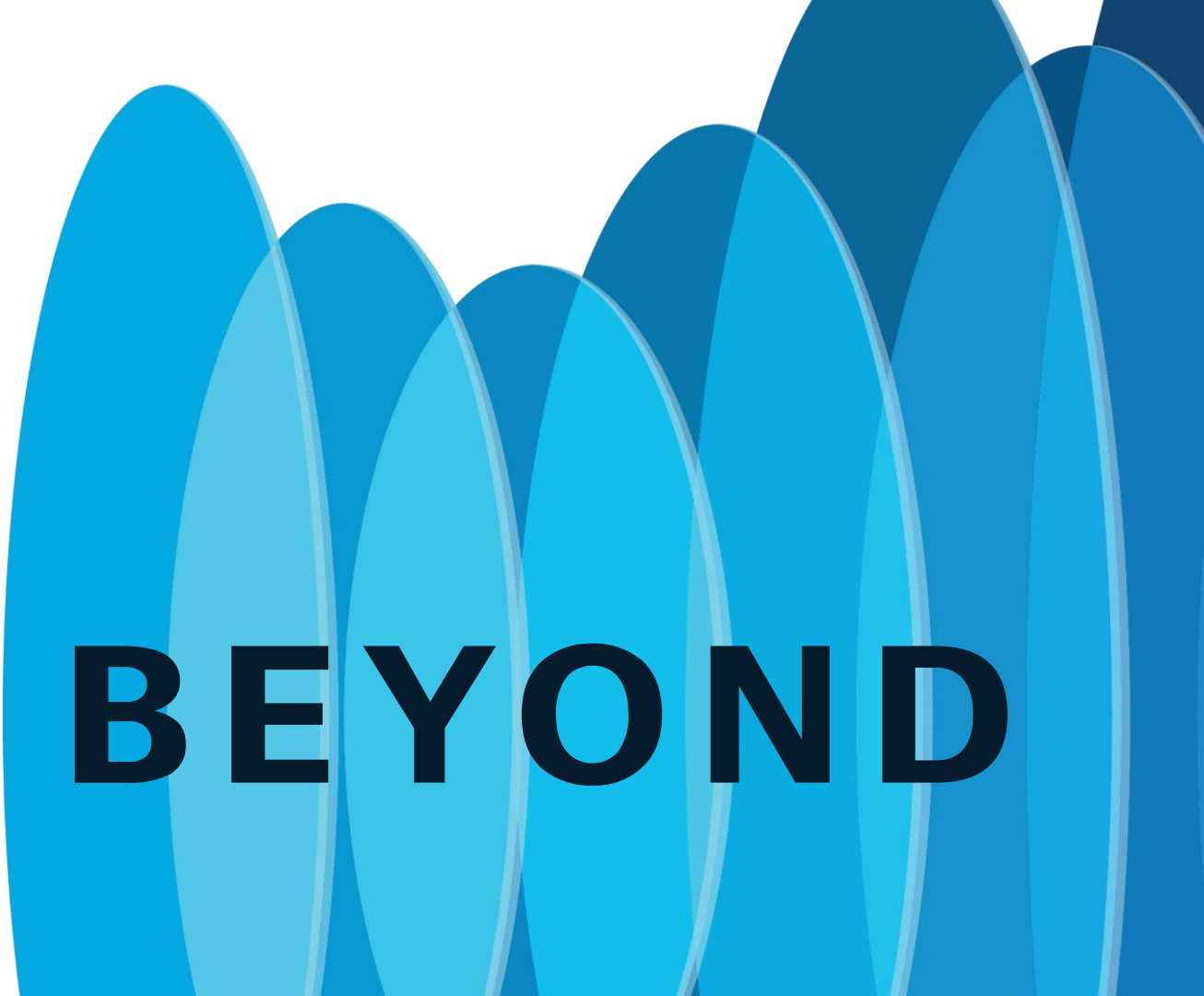
Thank you

CISCO *Live!*



CISCO *Live!*

GO BEYOND

The background of the slide features a series of overlapping, teardrop-shaped elements in various shades of blue, ranging from light sky blue to deep navy blue. These shapes are arranged in a way that creates a sense of depth and movement, resembling a stylized mountain range or a series of waves. The overall aesthetic is clean and modern.