

Reviving Active Testing for Reliable Dynamic Networks and Services

July 2023

EXFO



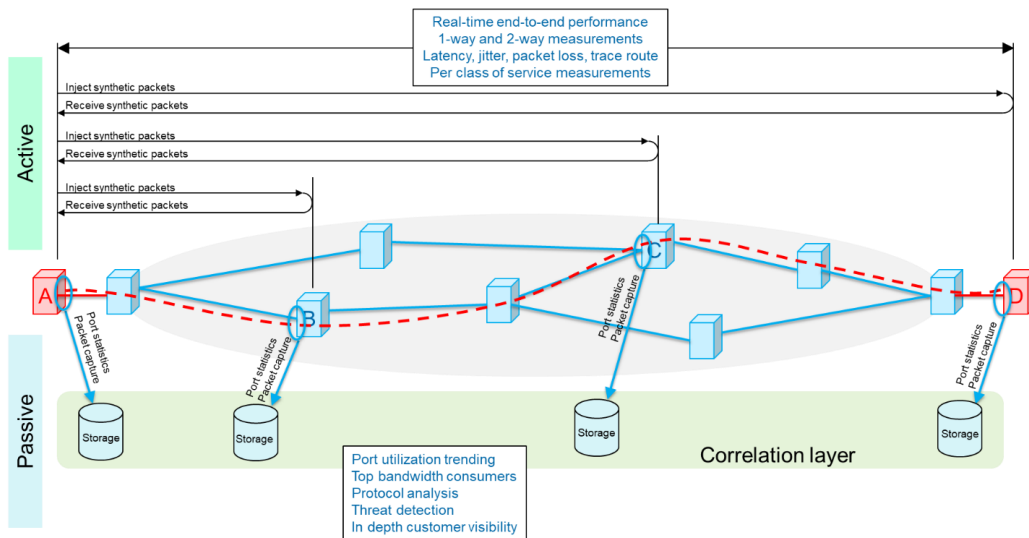
Agenda

- Active Assurance 101
- Overview of EXFO Active IP monitoring
- Case studies
- Demo

Two approaches for assurance

Active monitoring

- ❑ Injecting test traffic into network via verifier or agents
- ❑ Same forwarding criteria as the user traffic (service) being monitored
- ❑ Policing SLAs on SLO
- ❑ KPIs: loss, latency, jitter
- ❑ ICMP, TWAMP, Y.1731 etc.
- ❑ Verifier to Verifier, verifier to router, etc.



Passive monitoring

- ❑ Capturing and analyzing live network traffic, or traffic statistics, at a specific point in the network
- ❑ DPI, netflow, sflow, IPFIX,
- ❑ Post event analysis
- ❑ Root cause determination, signaling protocols
- ❑ Application usage, top bandwidth consumers

Key differences with passive vs. active assurance

	Monitoring and implementation	Performance measurement	Adaptation	Issue Identification
Passive	Monitors specific high-traffic aggregation points in the network; on one end or the other in the deployment.	Measures performance only when the network is active with live customer traffic	Static positions of hardware appliances do not adapt to topology changes in dynamic networks.	Detects major issues and determines how many users are impacted.
Active	Measures performance anywhere on the network using emulated traffic and can be located at either end or any point in between.	Can measure performance with simulated traffic before users are live on the network (for pre-deployment validation).	Automatically mimics the service as networks change to optimize itself without interrupting KPI generation	Identifies minor problems before they become major, customer-impacting issues, avoiding SLA violations.

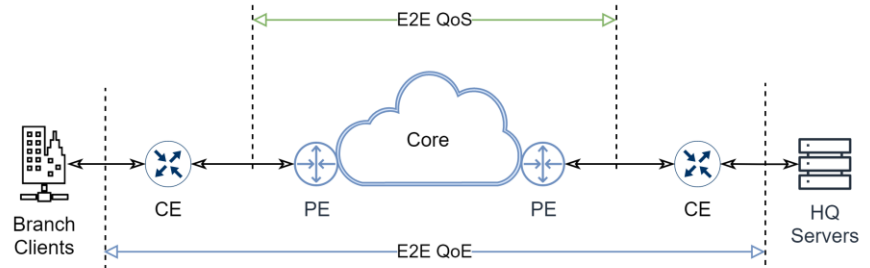
QoS and QoE

Quality of Service (QoS)

- Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of service
- Network-centric approach
 - deploy network infrastructure and guarantee acceptable service levels
- Even if the network provides best QoS a poor content will always lead to poor QoE

Quality of Experience (QoE)

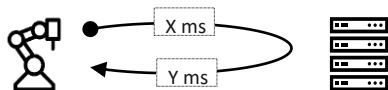
- Degree of delight or annoyance of the user of an application or service. It results from the fulfilment of his or her expectations with respect to the utility and/or enjoyment of the application or service in the light of the user's personality and current state
- User-Centric approach
 - Understand end-to-end quality including human users' point of view



SLA/SLO: Delay, Jitter, Loss, Throughput

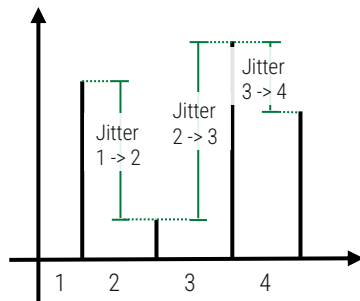
Delay: Roundtrip and One-way

Measured time in milliseconds from the outgoing packet leaves the monitoring server until it returns, and single way



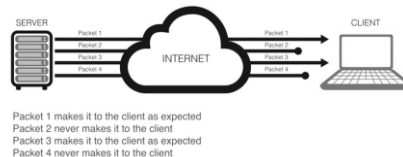
Jitter: Roundtrip and One-way

Jitter is the measured difference in roundtrip time between two adjacent packets.



Packet Loss

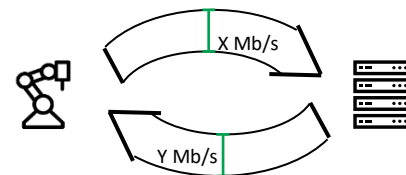
Dropped packets, out-of-order, retransmission timeout or late arrival, etc.



Throughput

Average bandwidth in kbps/Mbps between monitoring server and the device

Scheduling benchmark test during mid-night



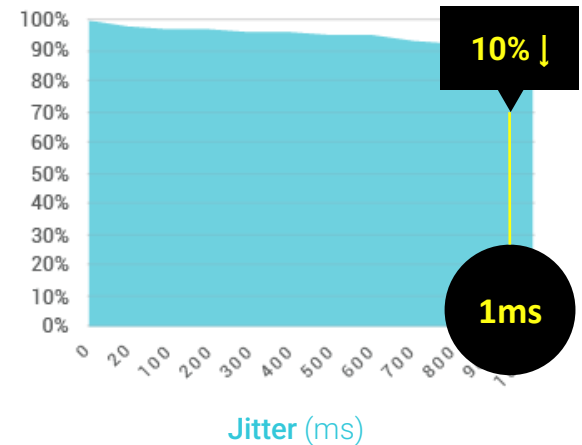
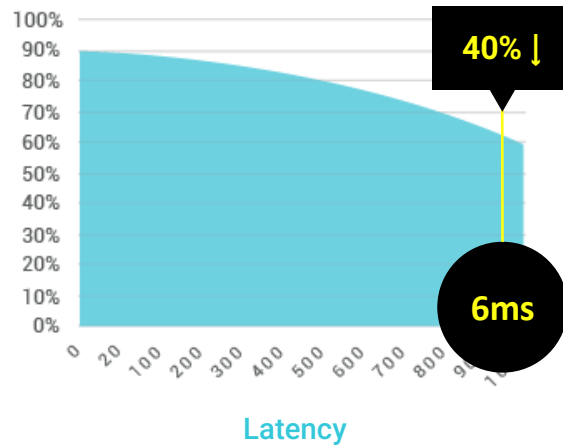
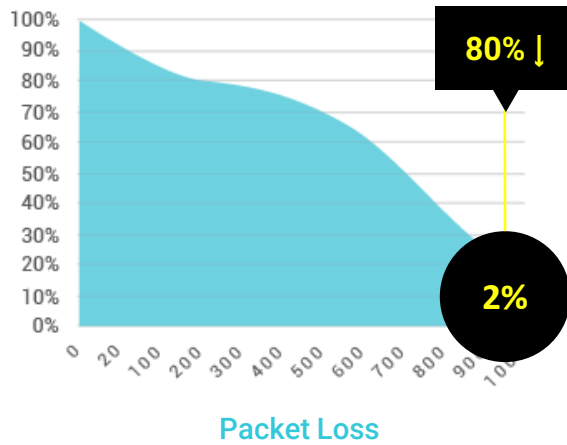
New relationships impacting throughput








Packet transmission performance



Affect on TCP Throughput



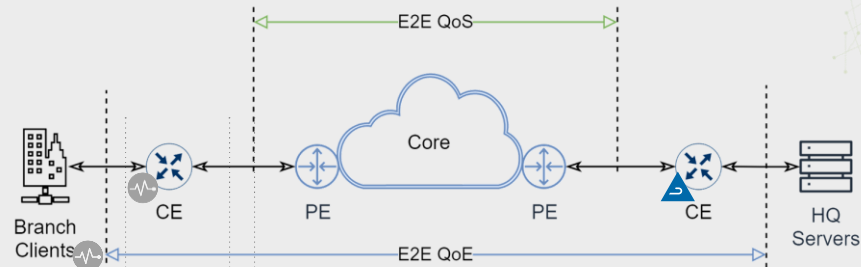
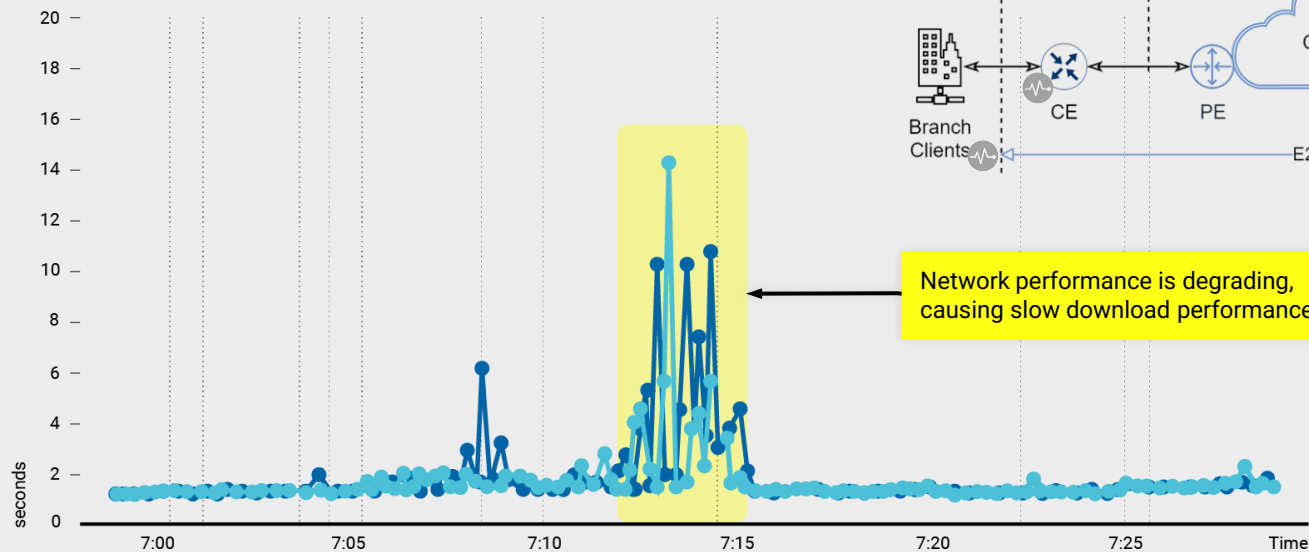
Latency matters in 5G applications

Environment	Use Case	Latency
AR/VR/Gaming 	AR/VR motion-to-photon	7-15ms
	Collaborative gaming	<20ms
Transportation & Logistics 	Time critical sensing	<30ms
	Remote drone operation	10-30ms
	Real-time control for discrete automation	≤1ms
Automotive 	HD Digital map update	100ms
	Remote operation	10-30ms
	Sensor sharing	<20ms
Smart Cities 	Time-critical sensing	<30ms
Industrial 	Mobile robots (machine control)	<10ms
	Mobile robots (video-operated remote control)	10-100ms
	Process automation	50ms
	Mobile control panels (assembly robots, milling)	4-8ms
	AR monitoring	<10ms

QoS issues impacts on Browsing

Issues/Performance

HTTP Active Test



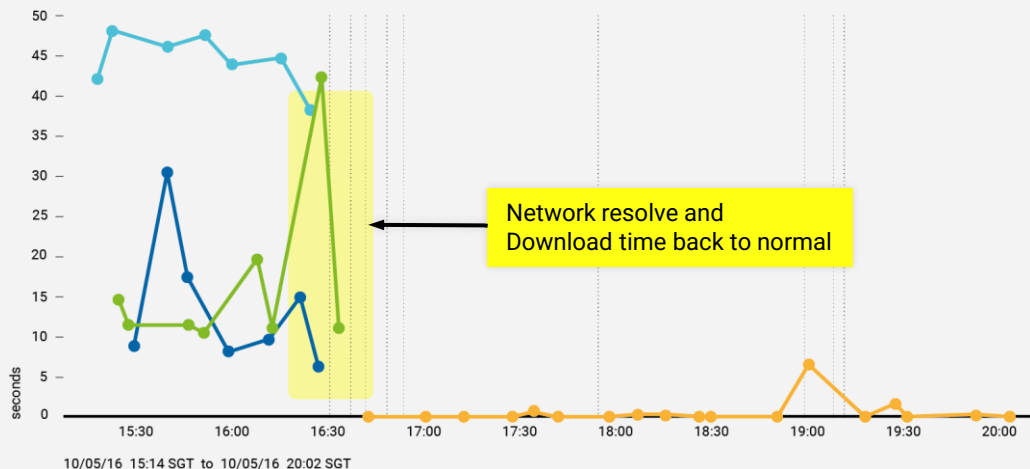
HTTP application test

TWAMP continuous test

QoS issues impacts on Browsing

Network related issue

HTTP Active Test



QoE Test

Data Source	Data Set	Customer SLA	Guaranteed Service	Service Identifier	Verifier	Target
HTTP Active Test	Total Page Download Time	Reliance FTTX Testing	RJIL HTTP ACTIVE Test	RJIL HTTP ACTIVE-NDTV	BV-110-RJCP-1	www.ndtv.com
HTTP Active Test	Total Page Download Time	Reliance FTTX Testing	RJIL HTTP ACTIVE Test	RJIL HTTP ACTIVE-NDTV	BV-110-RJIL2	www.ndtv.com
HTTP Active Test	Total Page Download Time	Reliance FTTX Testing	RJIL HTTP ACTIVE Test	RJIL HTTP ACTIVE-NDTV	BV-110-RJIL3	www.ndtv.com
HTTP Active Test	Total Page Download Time	Reliance FTTX Testing	RJIL HTTP ACTIVE Test	RJIL HTTP ACTIVE-NDTV	BV-110-RJCP-1	www.ndtv.com

QoS issues

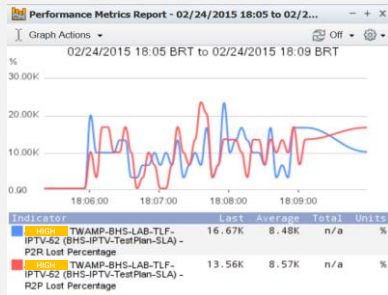
Packet loss

Causes
retransmission
at TCP layer

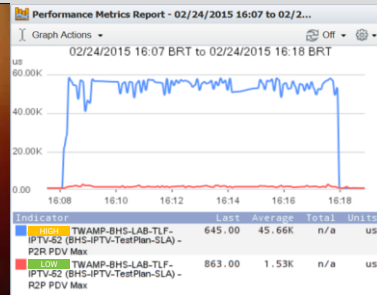
Latency

Impacts
response time

QoS issues impacts on Video QoE

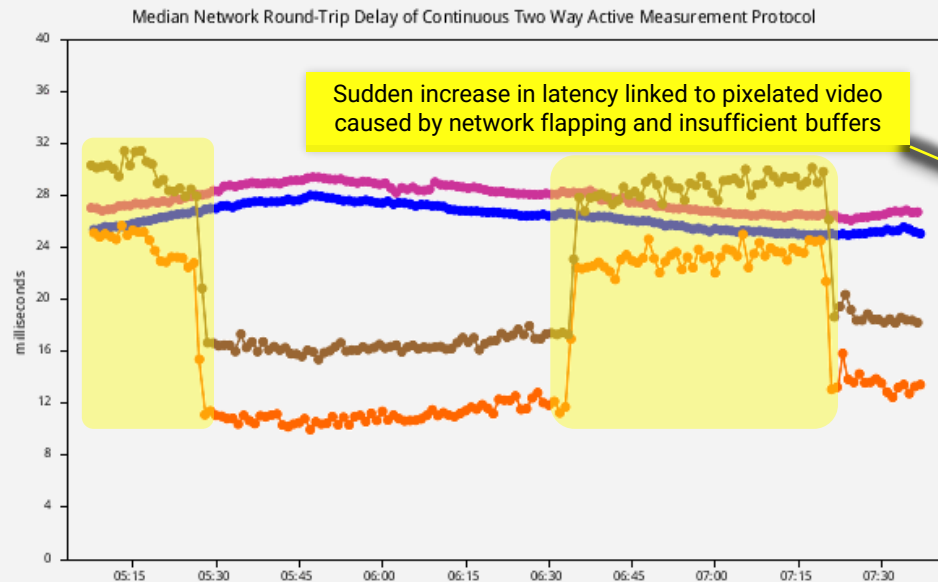


Packet Loss of 1%
Significant Pixilation of Image
Significant Impact



Jitter of 60ms (15% of packets)
Sporadic Pixilation of Image
Noticeable Impact

Jumps in network latency *impact real-time* app performance and user experience



Legend

Location 1 Responder -> UE
Sender (UE DL)

Location 2 Responder -> UE
Sender (UE DL)

UE Sender -> MEC 1 Responder
(UE Upload)

UE Sender -> MEC 2 Responder
(UE Upload)

Good Video with no pixilation – Mobile screen zoomed in

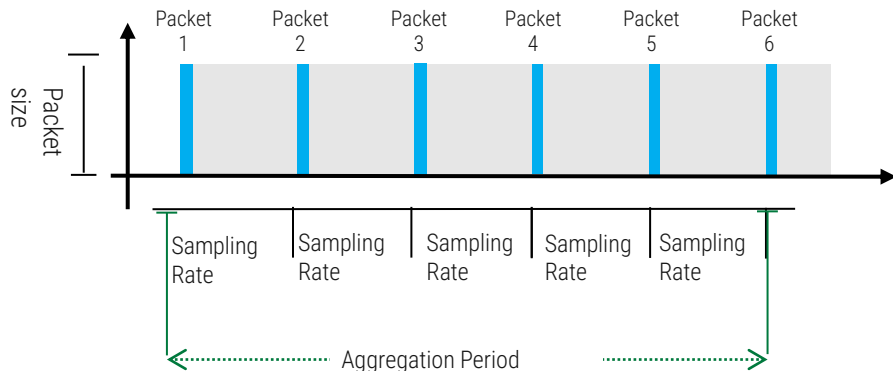


Poor Video with noticeable pixilation – Mobile screen zoomed in

QoS Measurement

Synthetic Active Test

- Active test agents inject synthetic traffic into the network under test at endpoints and various points in between, where performance and quality are assessed at each point
- Responder: active test agents or reflector (ICMP responder, TWAMP lite responder)
- Measurement method: ICMP, TWAMP (full/light), Y.1731 SOAM PM
- Sampling Rate: When and for how long send monitoring requests (pings) to the device?
- Test topology: aligned with network path per service

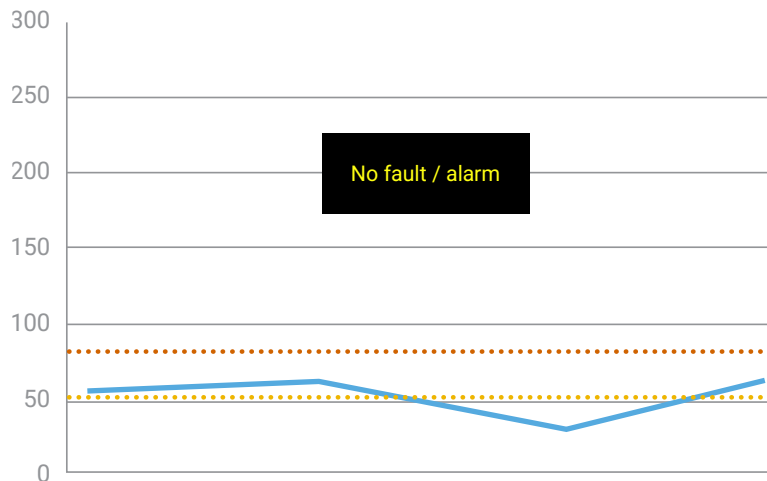


Example:
Packet Size = 115 bytes
Sampling rate = 1000 ms
Aggregation Period = 2500 ms
Timespan = 5500 ms

Granularity reveals transient issues

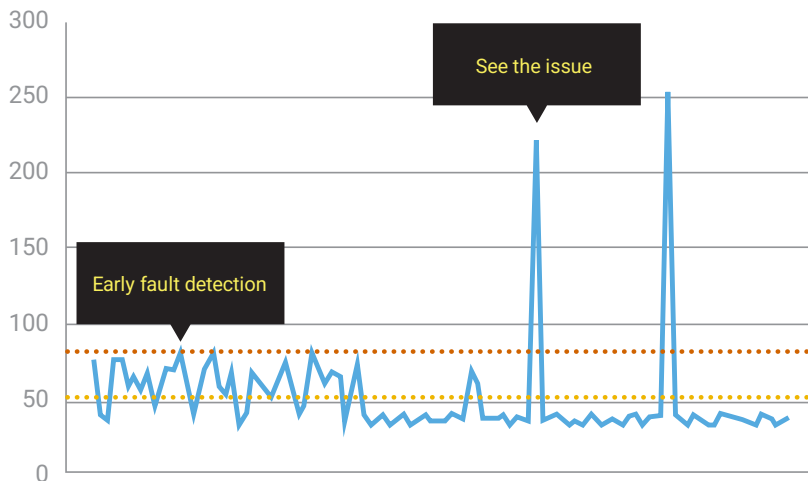
Average Latency – Traditional

- Aggregation Period: 5 minutes
- Periodical mode: 10 packets in 5 minutes, packet interval 1 sec
- Continuous mode: Sampling rate 1 second



Average Latency – Modernized

- Aggregation Period: 1 second
- Continuous mode: Sampling rate 100 ms



Benefit of “Synthetic” Active assurance



Like the **Canary in the coal mine**, Active Assurance is:

- **Proactive detect issues**
- Focused on **degradation** as opposed to **failure**



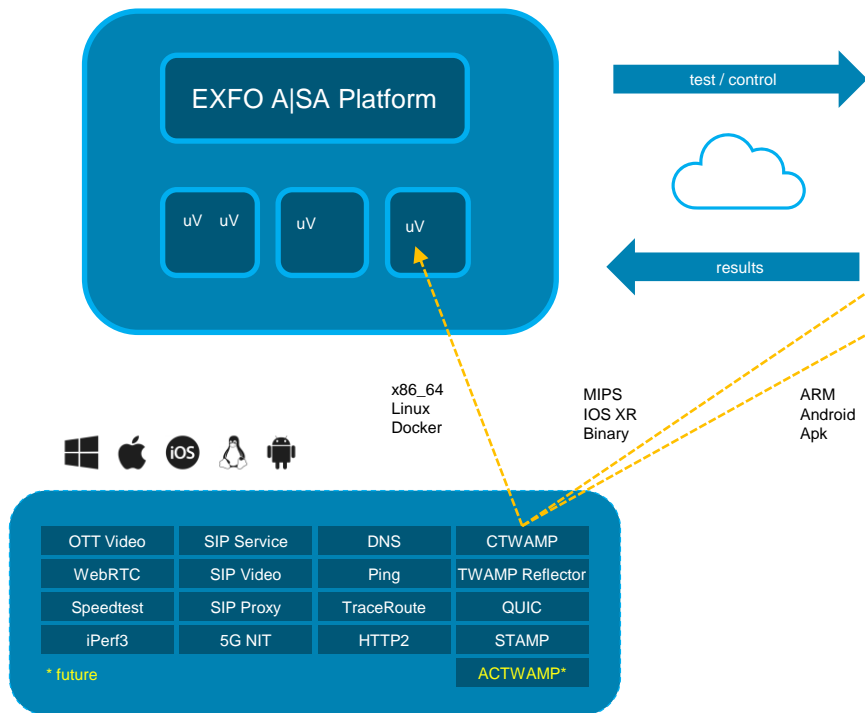
Like the **heart rate monitor**, Active Assurance:

- Measures trends, e2e visibility
- Benchmark quality and identify deviations

Verifier Anywhere

EXFO Active

K8s Orchestrated Solution



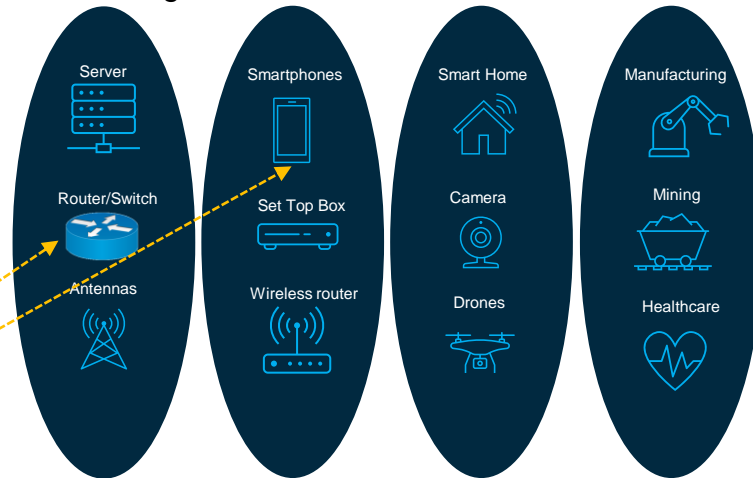
Test libraries already supported

Transport Monitoring

Mobile/FWA

IoT

Industry 4.0



verizon

Transport Segmentation and Performance Monitoring (TSPM) on VCP
Private MEC solution with Mobile Agent integration
5G MIL solution for combat zones deployment

dish

5G cloud network monitoring on AWS

TELUS

SNMP data polling & IoT devices integration

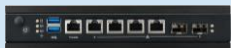
EXFO Active Agent

Physical EXFO Active Agent	Application EXFO Active Agent (EVA)	Virtual EXFO Active Agent (VV)	μ-Verifier
<p>Hardware accelerated physical test probes</p> <p>Physical format</p> <ul style="list-style-type: none"> - Guaranteed FPGA performance - Hardware timestamping with us level accuracy - Full line rate testing (100M to 10G) 	<p>Software agent for non-hypervisor host devices.</p> <p>Available format:</p> <ul style="list-style-type: none"> - Dockers and binary files - Application compiled for Linux/Debian - Can be adapted for different host devices - Also available on NV-10B 	<p>ETSI-compliant VNF for deployment on hypervisor-enabled environments</p> <p>VNF Format:</p> <ul style="list-style-type: none"> - OpenStack Nova - Oracle VirtualBox - VMWare ESXi - KVM/Xen - Also available on NV-20A/ NV40A/ NV-50A/ NV60A 	<p>Containerized independent, orchestratable test agent</p> <p>Microservice based & modular with small footprint on host devices</p> <p>Certified on Ericsson Container platform and RHEL OpenShift</p>

Physical Verifier



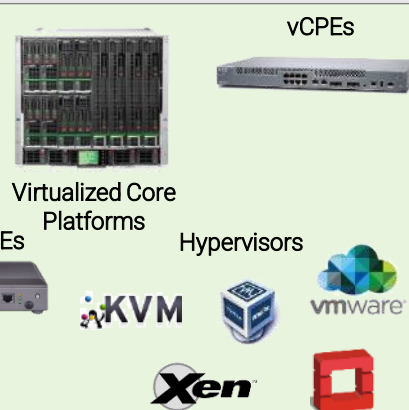
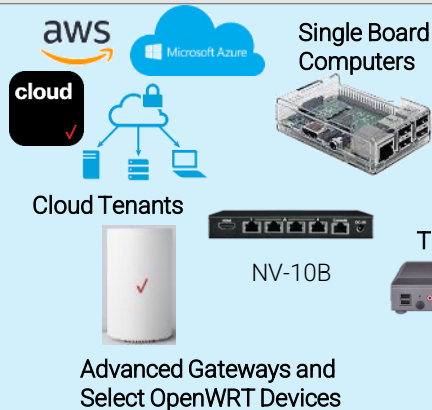
BV-110



NV-20A



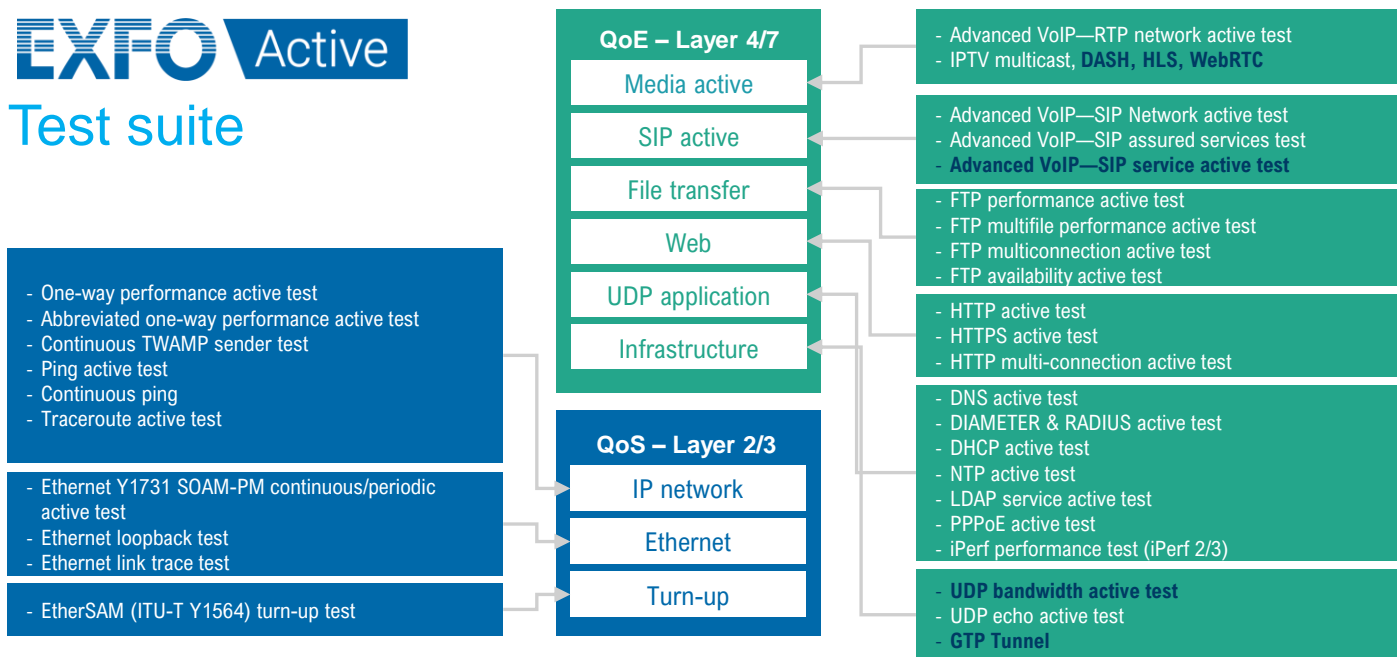
NV-40/50/60



Active Testing and Monitoring Capabilities

Covers all layers from service to network and throughout the underlying cloud infrastructure.

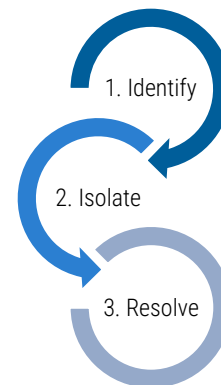
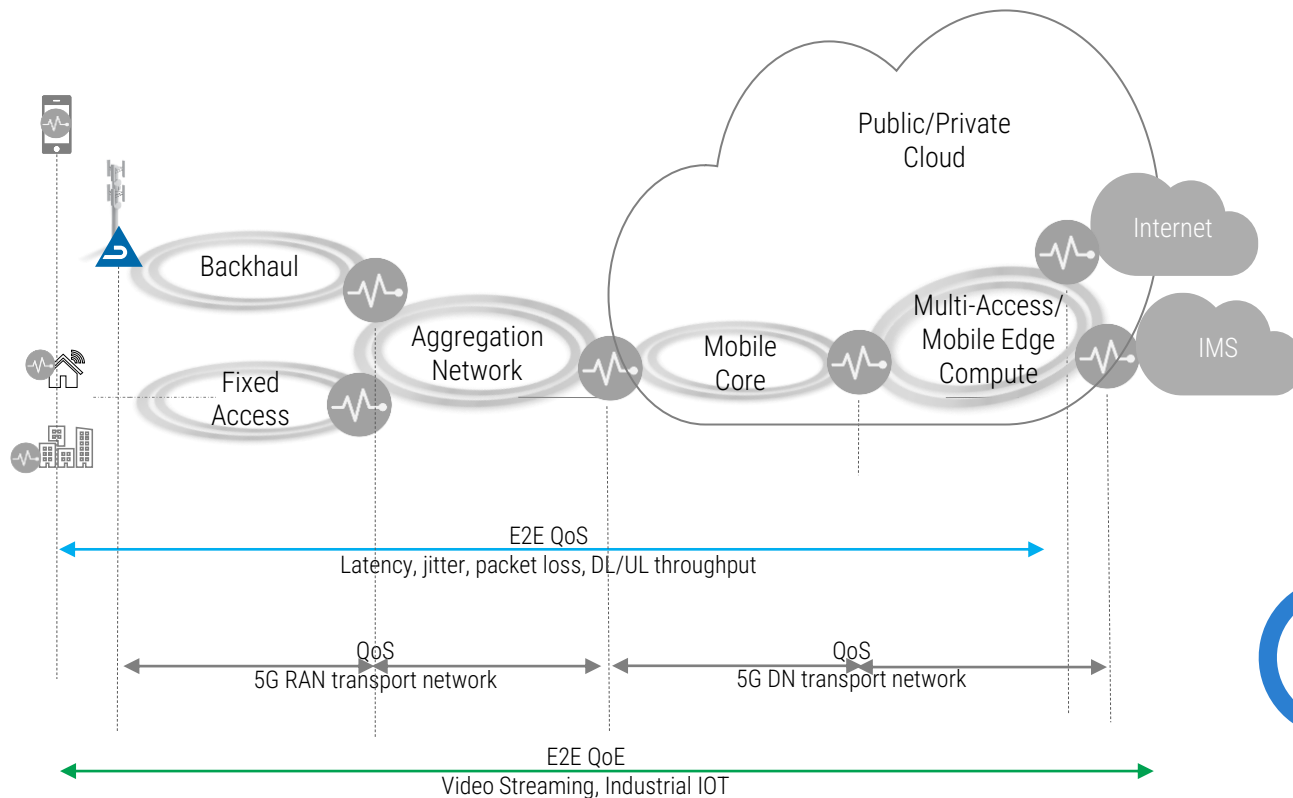
EXFO Active Test suite



100+ tests
1/3rd for QoE

End-to-End & Segmented Visibility

- Virtual or containerized agents
- Run on Cloud, dedicated HW, Routers, NIDs, CPE, IOT, mobile
- Connect as needed on any interface
- Emulates the control and data application traffic from subscribers like HTTP, VoLTE, VoNR
- Execute network layer tests like ICMP, Traceroute, TWAMP, Y.1731, Y.1564, etc.





Reveal the invisible

SLA, QoE



4G-5G
core, RAN



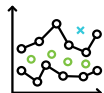
Cloud
observability



Compute
observability



**Continuously
analyzes data
sources**



**Learns what's
normal
and detects
anomalies**



**Classifies,
groups and
diagnoses
events**



**Visualizes
events and
customer
impact**

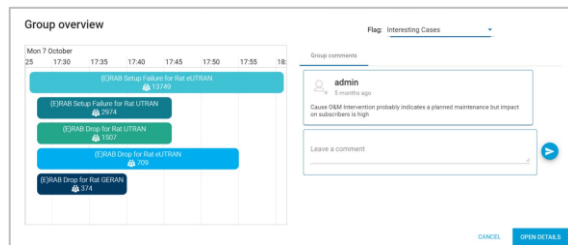


**Automated
root
cause analysis**

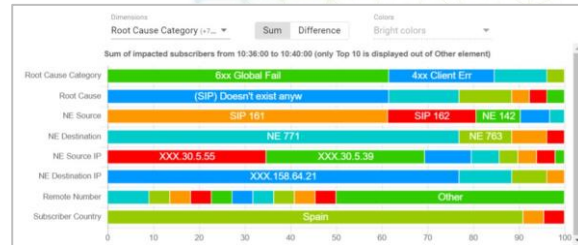


**Analytics
B/OSS
Orchestration
Automation**

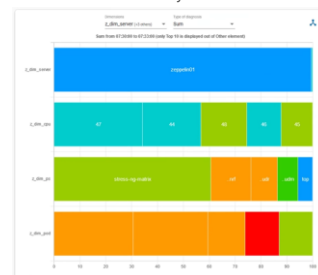
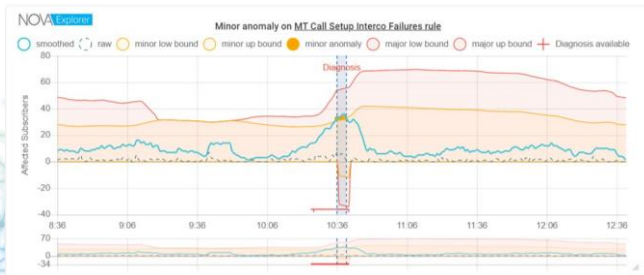
Correlated cases (enriched alarms)
based on telecom KPI rules



Root cause analysis
based on telecom KPI rules dimensions



Correlated cases (enriched alarms)
based on telecom KPI rules



Topology-aware transport assurance

Like a medical professional, EXFO provides operators with a **complete picture of the state of their network and services** to optimize service performance and generate new revenue from advanced services with strict SLAs.



Sensor data



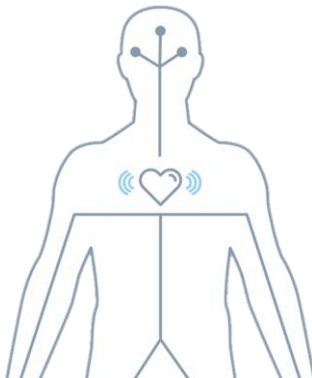
E2E topology



Anomaly detection

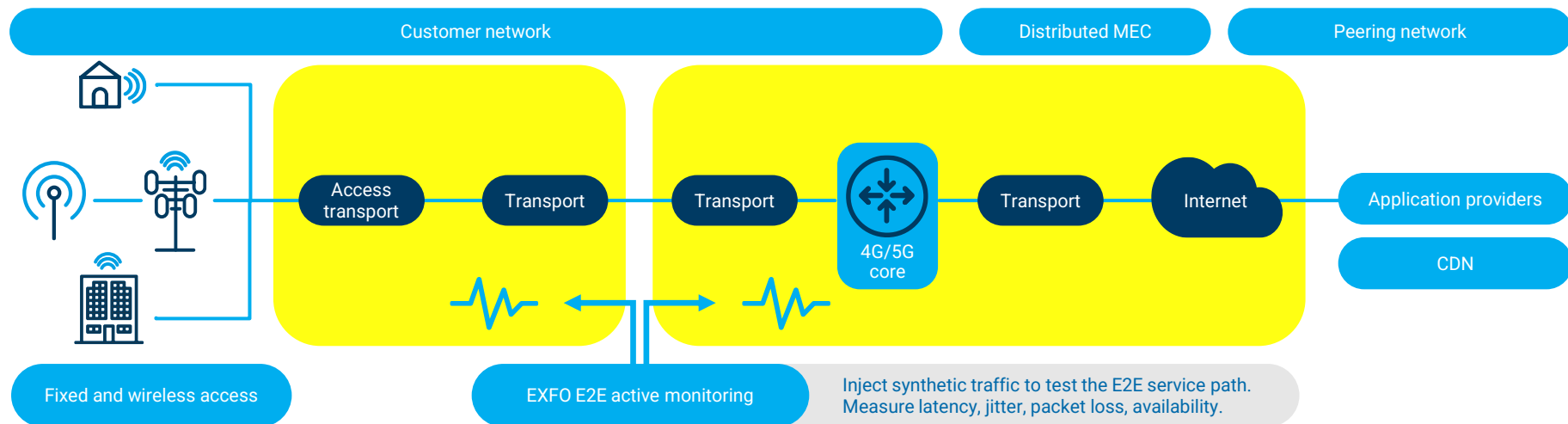
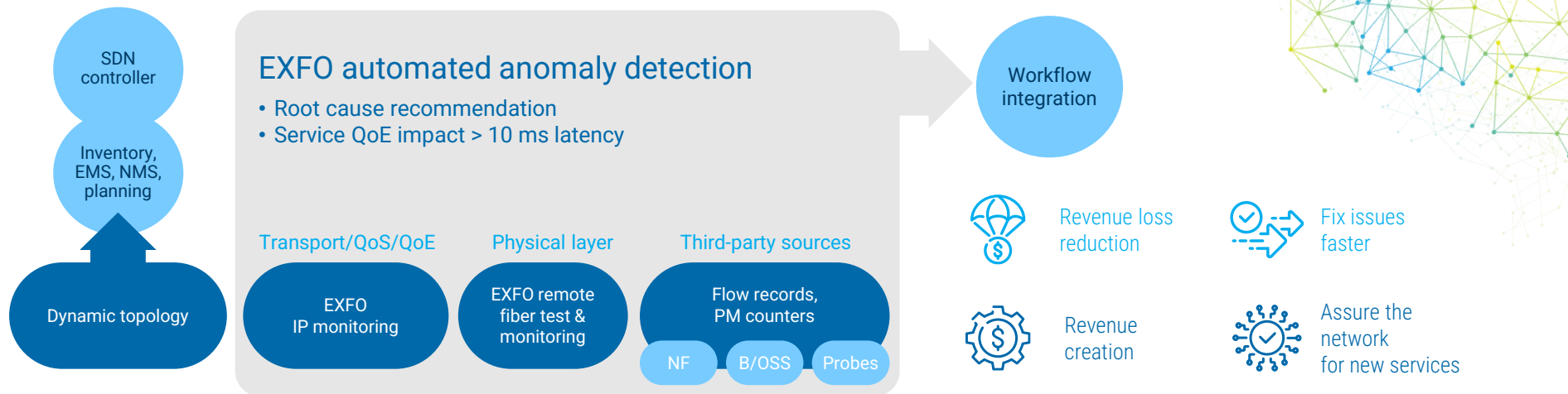


Multi-domain knowledge



Solution

- EXFO provides a complete topology-aware solution **to assure the E2E transport network, to optimize services and meet strict latency targets**
- **EXFO sensors actively monitor** and measure performance in each segment of the network for E2E visibility
- **Service and network topology data on service paths, configuration and subscribers** is correlated together with network performance data to add valuable contextual insight
- **Anomalies are detected and analyzed** together with topology data to diagnose issues, determine root causes and optimize service performance



Benefits

- Validate Service Path by injecting low amount of syntactic traffic
- Go the same root as the customer traffic is going
- Reduce mean time to repair (MTTR) by getting end-to-end visibility
- Identify and detect issues impacting the access & core transport network
- Provide meaningful SLA reports

USP – Mobile Core

1. Only in the market simulating and testing GTP Tunnel through packet core
2. Support of TWAMP 1s reporting interval
3. Support of application tests (OTT, DNS, HTTP)

USP – Backhaul

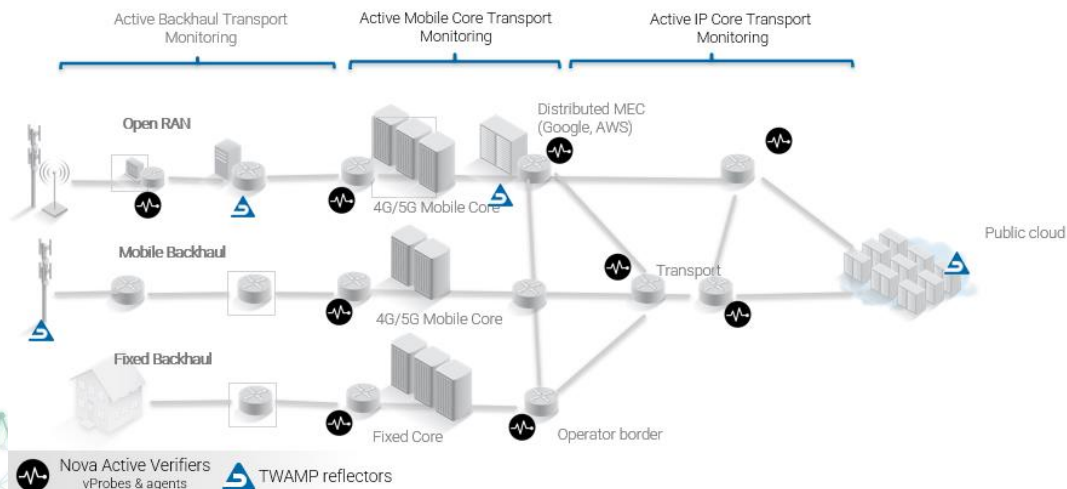
1. High performance sensor data (15,000 End Points)
2. 1 min reporting interval
3. High accurate test results
4. Automated configuration

USP – Open RAN

1. High performance sensor data (15,000 End Points) against CU
2. Micro verifier to test between CU and DU to meet low latency requirements
3. Automated configuration

USP – Fixed backhaul

1. High performance sensor data (15,000 End Points) against customer CPE
2. Unique cooperation with CPE vendor
3. Automated configuration



Network, service E2E
topology

Anomaly detection

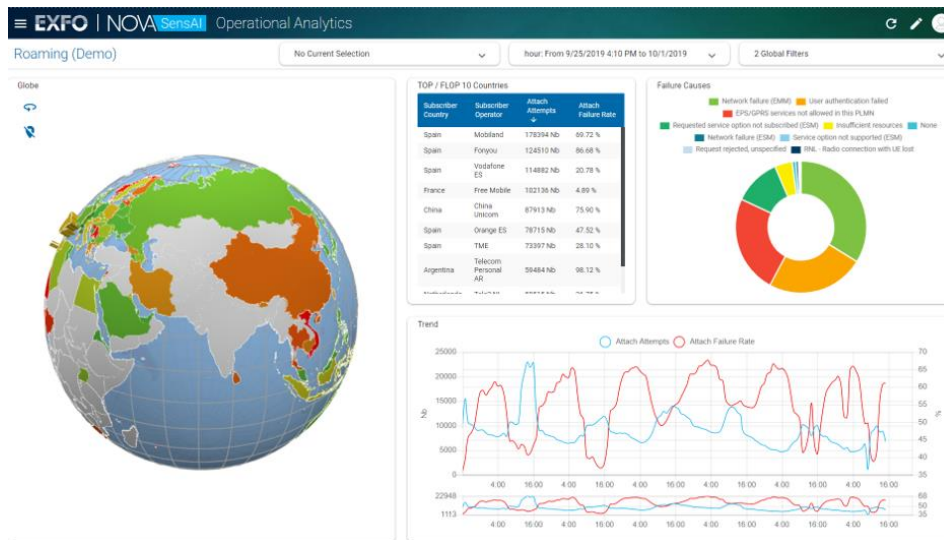
Operational analytics

Transport path sensor data

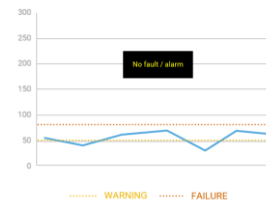
Transport path sensor data

Benefits

- Low granularity KPI storage and analysis (1 min)
- Self-service User interface including data export
- Data export to aggregate data to higher exporting intervals (big data systems)
- Strong troubleshooting capabilities to understand systems and root cause
- Learning database to optimize machine learning algorithm for Anomaly Detection Application



Average Latency - 15 min interval



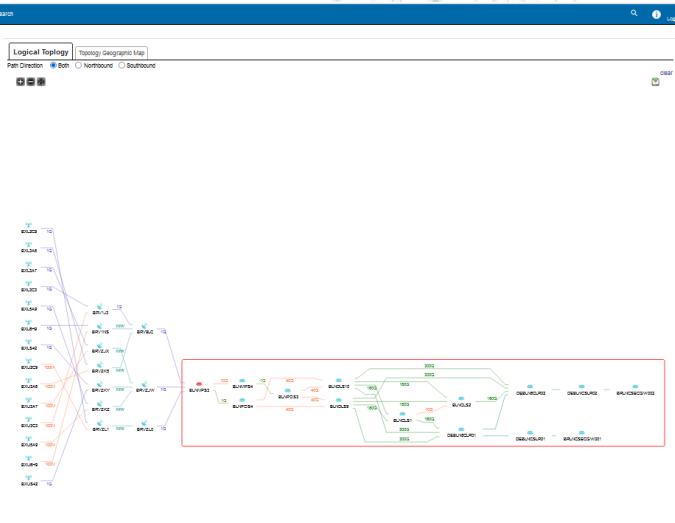
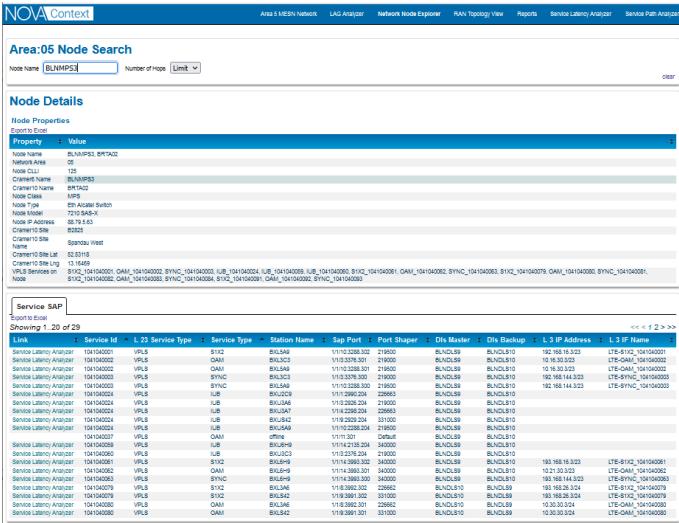
Average Latency

30 gbps sampling, 1 min reporting



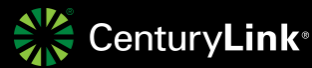
Benefits

- Automation relies heavily on an accurate representation of data
- Provide an accurate view of the network topology from multiple sources inventory, NMS, planning data site
- Overlay alarms, customer tickets, KPI with network topology
- Graph databases enabling flexible models specifically adept at combining siloed sources of data across networks, services and customers
- Enables our DevOps teams to innovate and build capability (Improve NPS score)





Best Practices



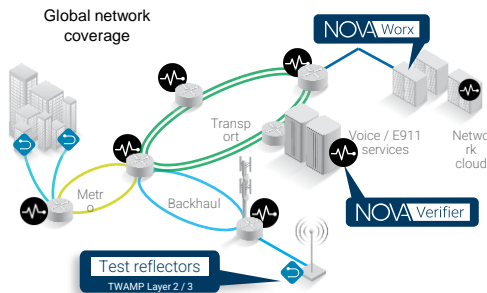
Active Probes	600	2,519	3 under expansion	32+
Type	Physical + Virtual	Physical	Physical + Virtual	Virtual
Sessions / hour	16 Million	10 Million	10,800	24 Million
Endpoints tested	67,300	66,907	900 5,100 – next expansion	500,000 +200,000 by 2023
Coverage	Nationwide	Nationwide	Regional initial deployment	Nationwide
Network and Applications	L2 and L3 TWAMP x 4 QoS	TWAMP, Ping, UDP echo, SIP, iPerf	L3 TWAMP and EtherSAM	L3 TWAMP x 2 QoS
Networks	4G EBH & Backbone, VZ Business links, 5G	Wireline	Wireline, broadband, IPTV	3G, 4G, 5G
Highlights	Deployed over 10 years. Mobile backhaul: 60k cell sites, 270k tests/min minute. Used for SLA claw-back and troubleshooting. Backbone: Core, distribution, access segments of OTNGN network.	Deployed and scaled over 5 years	Multiservice, multi-network testing for 4G and 5G	Fully virtual solution. Single platform managing all tests and results India-wide.
Why EXFO?	High reliability, stability, scale and open integration capabilities.	Combined voice and full-mesh network testing for multiple CoS from edge-to-core, nationwide.	Flexible, Open API for NMS and 3rd party controller. Fully compatible with other vendors TWAMP reflectors	Scalability, VNF onboarding speed, ability to test future 5G infrastructure.

Active
Done Right



Customer
highlights

Use case: Verizon



EXFO Active deployed in:

Wireline network

Mobile backhaul

4G mobile core

Optical Transport Network (OTN)

Outcome

- Verizon Wireless has near 100% integrated performance visibility of all cell sites and wireless transport, from the core to the edge.
- Optimized bandwidth and active network monitoring of throughput, latency and voice quality (MOS) in near real time.
- Nova Active powers the latency tool that enterprises use to check the Verizon network route performance.

Why EXFO

- EXFO has a broad service assurance portfolio with deep expertise that few companies can match.
- Nova Active provides all of Verizon's active performance testing and monitoring, from turn-up to executive planning and data scientist KPI needs.
- Nova Active has proven scale with 10 million tests per minute running 24 x 7 x 365.
- EXFO customer for **12+ years**

Business impact

- Verizon differentiates its network services based on performance and QoE.
- Savings \$\$ on SLA penalties
- Reduced truck rolls and OpEx with on-demand remote troubleshooting.

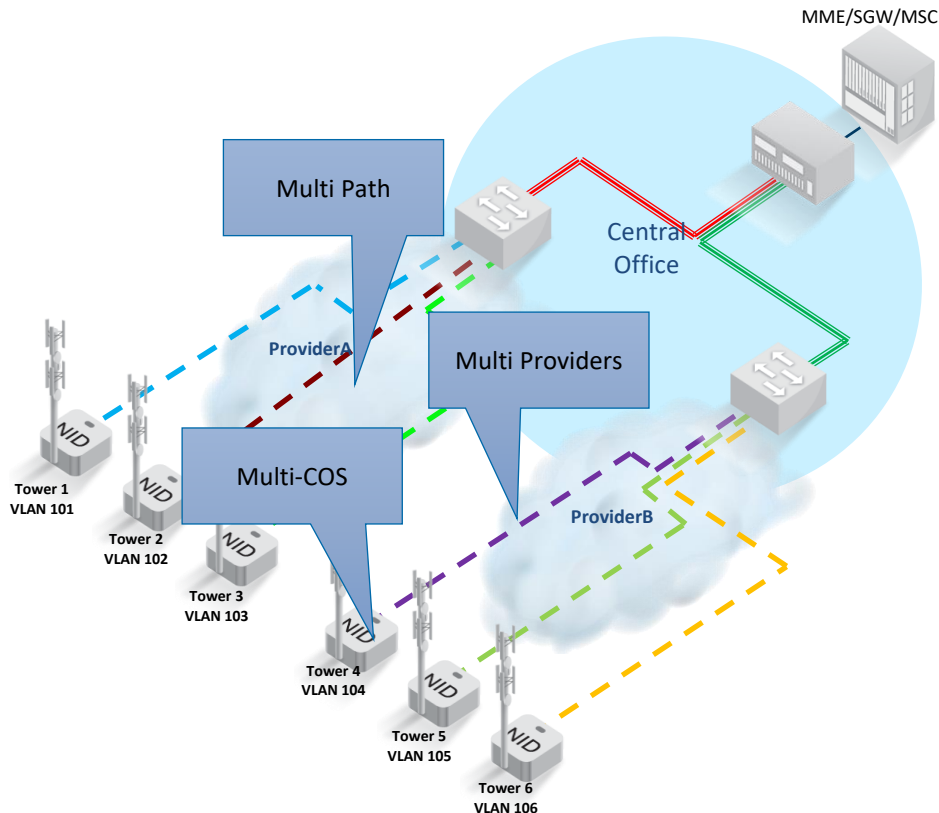
Verizon 4G: Challenge on leased backhaul

Business Challenge:

- Assure SLA compliance 24/7
- Multi-providers environment
- Multi CoS to assure
- Multi Paths to assure/compare
- Scale to 20+ thousands endpoint

Technical Challenge

- No additional hardware at endpoints
- Limited rack/space at head-ends
- Report hundreds of measurement per second per session
- Scalability

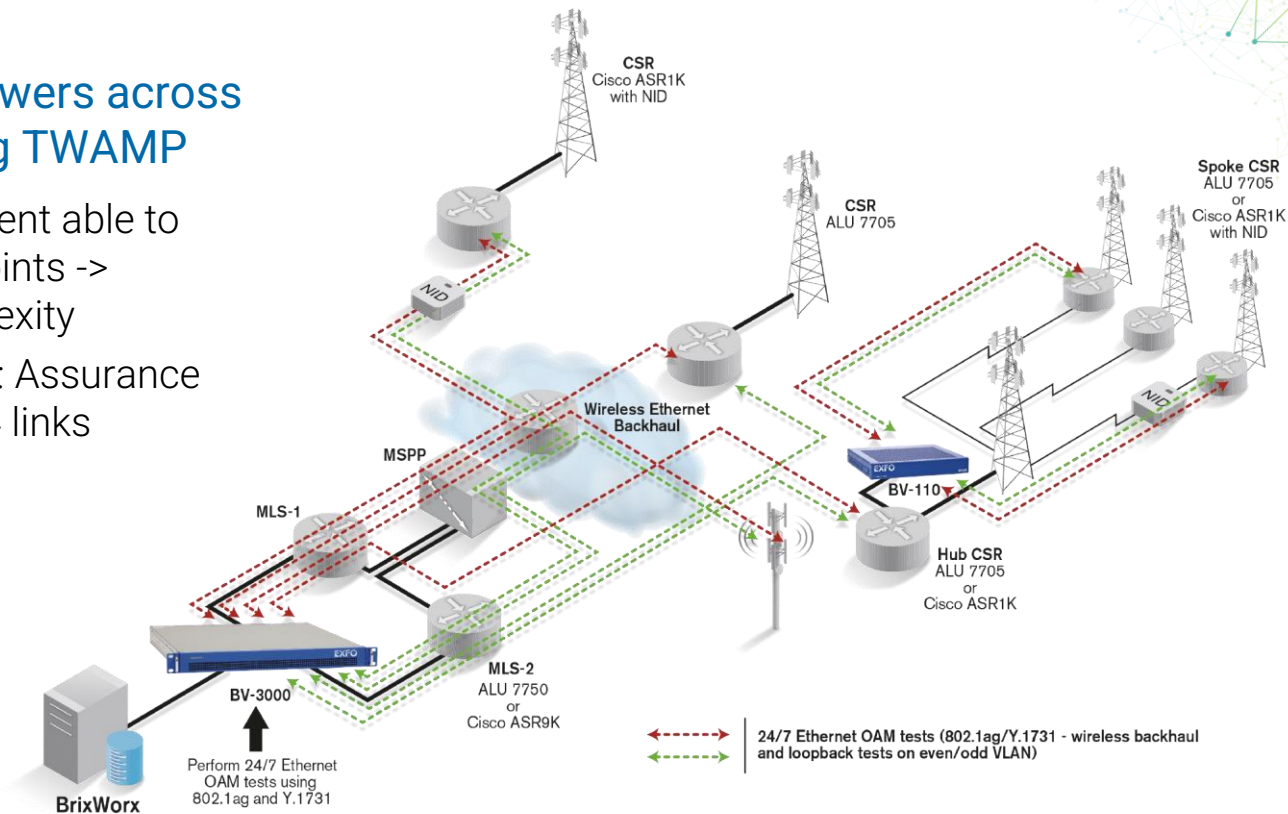


Verizon 4G: Backhaul Network QOS tests using TWAMP

24/7 Monitoring all towers across multiple Circuits using TWAMP

- Single Probe deployment able to support >1000s of endpoints -> Reduce costs and complexity
- TWAMP deployments: Assurance performance across IPv4 links

- TWAMP standard in CSRs: Reduced deployment costs
- Hardware timestamping: Accurate delay measurements
- Round-Trip and One-way results (with sync)
- Low utilization in network, per CoS/DSCP visibility



Market
leader

Data source agnostic
Orchestrated
Cost effective

Public private hybrid models
Predictive-Preventative
Assurance as a Service

Quality of experience management
AI/ML driven workflows
Correlated contextually aware insights
Edge-to-core infrastructure-to-service

The adaptive multi-cloud assurance platform for service provider operations

Integrated ecosystem
Solution focused
Open
Easily deployable

Massively scalable
Multi-domain
Built by telecom experts for telecom environments

Cross-functional
Data democratization
Full-stack

Fiber

IP Monitoring

Mobile

Topology




Enterprise

EXFO Adaptive Service Assurance Platform




LAUNCHPAD

SSO User Profiles



Monitoring

-  Anomaly Detection
-  SLA / SLO Monitoring
-  Alerts, Alarms & Notifications




Troubleshooting

-  Raw Data Analysis
-  Ladder Diagrams
-  On-demand Capture
-  Protocol Analysis



Analytics

-  Network/ Service
-  VIPs
-  Devices
-  Dashboards

Advanced Maps

-  Geo-location
-  Layered
-  Interactive
-  Multidimensional

Topology

-  Graph-based Topology
-  Simple Topology

Specialist Tools

-  ML Workbench
-  Workflow Automation

Source Agnostic Ingestion

-  Stream
-  Batch
-  Decode

Configuration & Data Management

-  Filter
-  Enrich
-  Metric Streams
-  Data Stitch
-  Create
-  KPI KQI Rules

Platform Services

-  Security
-  Encryption
-  Privacy

Observability

-  System Management
-  Log
-  System Management

License Mgmt

-  License Keys

Integration

-  Data Export
-  APIs

EXFO Sources

Fiber Testing
Synthetic Testing
Passive Probing

3rd Party Sources

Performance Management data
Telemetry data
Other e.g. weather data

Summary



Adaptive service assurance will keep pace with the tidal wave of monitoring data



Contextualized data along with **fault correlation and ML/AI** will remove blind spots – **Right Data, Right Time, in Context**



EXFO Adaptive Service Assurance gives Service Providers the confidence to **deliver a better 5G experience to more revenue-generating markets & verticals**

Cảm ơn

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