EXFO End-to-End Service Experience (Sx)

SOLUTION DESCRIPTION

Version 1.0

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Executive Summary

Throughout its entire history, the telecom industry has been going through major technical and business transformations that provide great opportunities for communications service providers (CSPs) to seek competitive advantages against their rivals.

Key transformations in 2016 to 2017 include network modernization, cloud enablement, network virtualization and data analytics—all of which, when executed successfully, provide increased agility, improved performance and efficiency, and reduced costs in comparison to legacy infrastructure.

EXFO Service Assurance (SA)'s offering is designed to support these transformations, focusing on key drivers, such as speed and agility in new technology and service rollouts, operational efficiency and business assurance. It also takes into account the typical obstacles in adoption of new technologies such as organizational barriers.

EXFO's SA mission is to provide the most comprehensive end-to-end (E2E) visibility into service experience with real-time actionable intelligence. This is achieved by combining data horizontally and vertically across the whole network.

EXFO's E2E solution consists of analytics, active testing, passive monitoring and physical-layer management, with typical use cases covering service, subscriber and network analytics, in addition to data correlation, service modeling, Internet-protocol (IP) infrastructure performance management, wireless infrastructure performance monitoring and quality-of-experience analysis.

The above-listed key transformations are driving EXFO's innovation and bolstering our partnerships with 97% of the top 100 CSPs worldwide, who rely on our support to ensure a smooth and successful transition.

Change Always Brings Opportunity

There are currently four key transformations taking place in the telecom industry: network modernization, cloud enablement, network virtualization and data analytics. While these major transformations each represent a major investment involving a risk that must be managed diligently, they are foremost an opportunity to create a sustainable business advantage in the market.

Network modernization typically means transformation from legacy network technology to new technology, or unifying an existing multitechnlogy infrastrucuture into unified network architecture to meet the future demands of customers. Examples of network modernization projects are fiber-to-the-home (FTTH) or 2G/3G upgrades to long-term evolution (LTE). When successful, network modernization enables CSPs to improve their CAPEX/OPEX in network expansions, operations and maintenance.

Cloud enablement is the process of creating, deploying and operating the CSP's IT infrastructure, software and resources through either the private or external cloud. This encompasses servers, the operating system, and business applications that are typically virtualized and accessed remotely over the Internet. The cloud allows for more efficient use of resources, thus reducing CAPEX and delivering savings in maintenance costs.

Network virtualization, through which hardware/software network resources and network functionality are combined into a single, software-based virtual network, is a potential game-changer for the entire industry. Suddenly, the functionality that was previously only available via intensive capital investments is now readily accessible as a service that can be combined with other virtual functions to provide end-user services. Network functions virtualization (NFV) will increase flexibility and agility durign service creation and improve scalability while keeping costs under control.

Data analytics has now been a hot topic for almost a decade. The expectations have been high—and to some extent, inflated—but there is now clear evidence that the chasm of the hype cycle has been crossed. Public customer cases show that tangible benefits can be achieved in service operations for improved customer experience, quality and workflow automation—and recently, even in the creation of new business, such as the Internet of Things (IoT).

EXFO helps CSPs achieve these goals by providing them with intelligent and automated test platforms, intelligent test systems, network and SA solutions, and real-time E2E analytics. Our goal is to ensure a smooth integration of these new technologies, as well as faster and more efficient technology deployment to accelerate time-to-revenue.

The following chapters will discuss EXFO's SA offering in greater detail, and notably, how it is designed to support these transitions.

Drivers and Obstacles in the Adoption of SA Solutions

There are three key drivers in the market that will be boosting the development and adoption of SA solutions in 2016 to 2017.

Speed and agility in new technology and service rollouts. When it comes to new network technology, such as LTE rollout or network virtualization, the target is to minimize rollout time, ensure a smooth transition and provide good service experience from day one. Consumer behavior is changing rapidly, so the ideal SA solution will be scalable and flexible to meet demands and easily accommodate the assurance of new services such as Voice over LTE (VoLTE), Voice over Wi-Fi (VoWi-Fi), and IPTV.

Operational efficiency. Telecom revenues are declining globally, and CSPs are streamlining their processes to protect their margins. SA solutions accommodate functionality that directly improves operational efficiency in network operations, such as workflow automation and test/assurance orchestration. A good SA solution also offers E2E visbility, thereby improving prioritization and reducing mean time to resolution (MTTR).

Business assurance. Competition for customers' hearts and wallets is tough, and CSPs are not only competing against each other, but also against over-the-top (OTT) providers. Offering outstanding service experience is a proven, effective way to build customer loyalty, and SA solutions are key in this role; together with analytics, they enable CAPEX optimization such as smart investments.

As opposed to drivers, there are also obstacles that may slow down the adoption of SA solutions. To some extent, the impact can be mitigated with a correctly designed SA solution.

Organizational barriers are typically the biggest hurdle. Often, organizations are a collection of silos in which the ownership of systems and processes is distributed to various suborganizations. As a result, the operational processes do not allow for the utilization of new types of solutions that would require cooperation between the silos. Transition from network-oriented operations to customer-oriented operations is a good example. An SA solution can support the redesign of the organization and processes by offering flexibility and a platform for process development such as workflow automation.

New business development. New technologies open new business opportunities for operators, and IoT is a good example of a major revenue opportunity for CSPs. Large business development projects tend to require a lot of attention, thus leaving less resources for SA projects. A flexible and scalable open SA platform is also able to support new business development activities.

EXFO's End-to-End (E2E) Service Experience

EXFO's SA mission is to provide **E2E visibility into service experience** through **real-time** actionable intelligence. Our solution is specially designed to deliver greater operational efficiency and optimized subscriber quality of experience (QoE).

EXFO's SA solution provides the most comprehensive visibility into E2E service experience available on the market by combining data horizontally and vertically across the entire network. On a horizontal dimension, the solution covers all parts of the network (e.g., radio, core, IMS backhaul and transmission networks), from the subscriber to the service and back again. On a vertical dimension, the solution covers the user-terminal, user-data, signaling-data, IP-infrastructure and physical-network layer. This principle is illustrated in Figure 1 below.

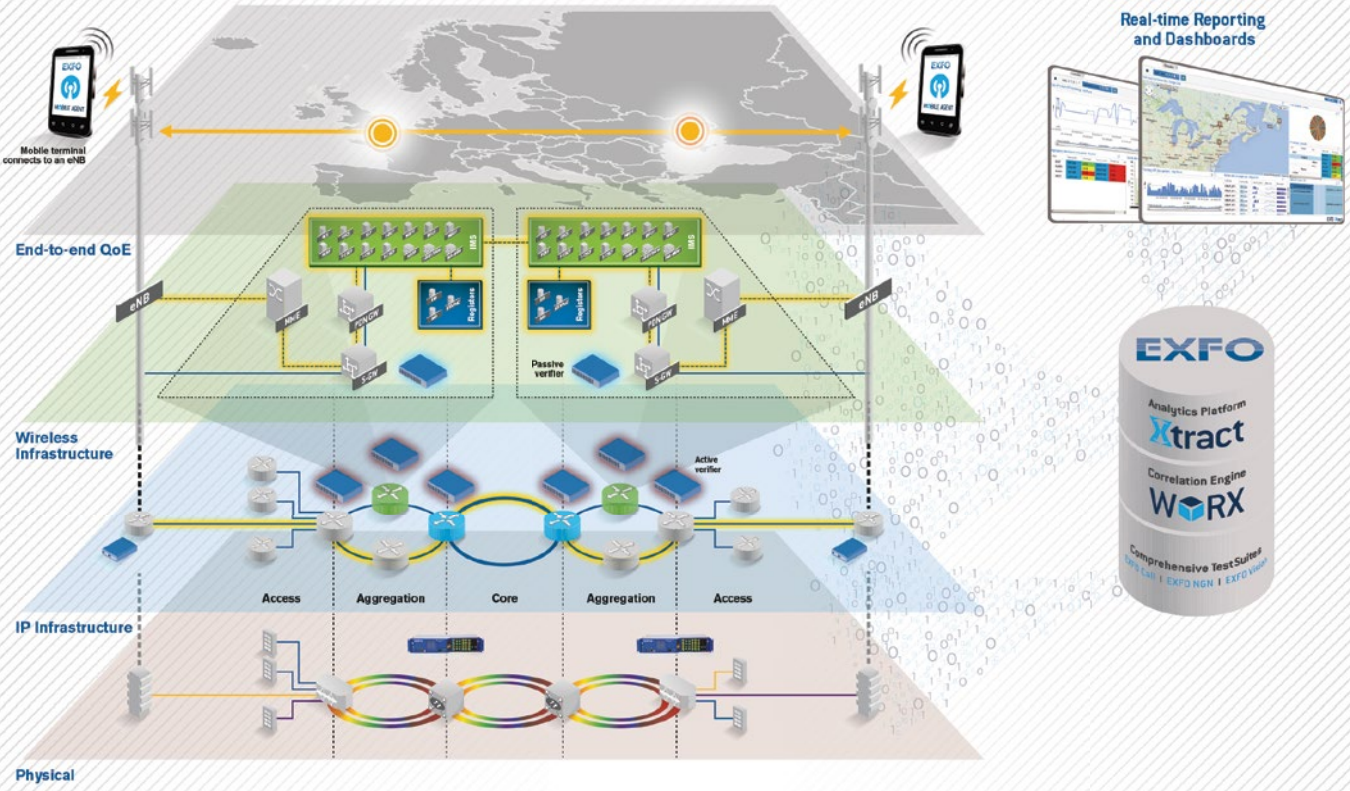

Figure 1. EXFO SA E2E principle

EXFO's SA solution can be divided into three main architectural layers:

- An analytics layer containing data-visualization, analytics, enrichment and threshold/alarm functionality
- A data-correlation and mediation layer containing real-time data correlation and mediation, in addition to detailed drilldown views for troubleshooting purposes
- The source data-fetching and polling layer

The architectural structure of the solution is shown in Figure 2 below.

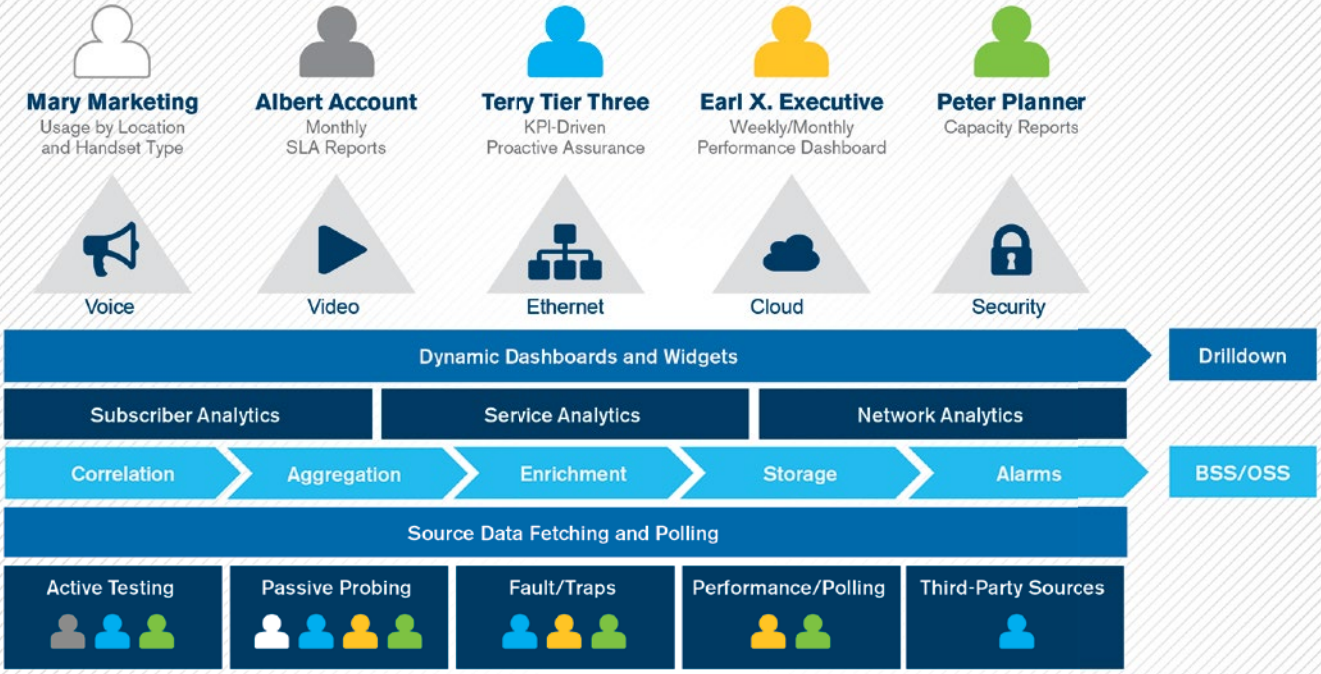

Figure 2. EXFO SA solution architecture

EXFO Xtract E2E Analytics

The essence of EXFO's analytics approach consists in providing CSPs with a comprehensive E2E view from the subscriber, service and network perspectives.

The core functionality of Xtract is retrieving, correlating, aggregating, enriching, storing, analyzing and processing massive volumes of source data in real time to form a consolidated view into service experience.

EXFO Xtract also contains advanced analytics capabilities for service modeling that enable CSPs to automate the linking of any given service with its physical and logical resources. This in turn makes it possible for CSPs to easily recognize network elements, services and subscriber groups that have been impacted by service degradations, and to minimize efforts to keep the service up-to-date.

Profiling identifies and categorizes subscribers based on usage and experience, ranks terminals on QoE, and puts cell sites into priority order based on volume and QoE. This allows CSPs to focus on what matters the most, such as repair of degradations.

EXFO Xtract supports alarm capabilities that keep CSPs up-to-date on the performance metrics of the network being monitored and tested. Thresholds can be manually defined for key performance indicators (KPIs), key quality indicators (KQIs) and indexes, or the system can automatically detect deviations to the normal performance baseline. When a threshold value is crossed, i.e., the monitored performance indicator either exceeds or undercuts the allowed value range, an alarm is immediately generated to alert the operations personnel about the condition.

Finally, visual and intuitive graphical user interfaces (GUIs) ensure that the insight is meaningful and actionable.

EXFO Xtract offers pre-packaged solutions that bundle essential logic designed to help CSPs manage their daily challenges related to service experience. A solution package includes predefined integrations to necessary KPI, KQI and index definitions, data sources, service models, data-processing rules and pre-defined dashboards designed to solve domain-specific use cases in the most efficient way. Solution packages focus on a particular network service or cover multiple services. Packages are offered for subscriber, service and network analytics in VoLTE, VoWi-Fi, mobile data access, OTT, business Ethernet, end-to-end IP and carrier Wi-Fi.

EXFO Xtract is the most comprehensive E2E analytics solution on the market thanks to its ability to collect and combine data from various data sources, including active, passive, network and third-party sources, and from mobile agents. EXFO Xtract can be employed in conjunction with any other technology, network architecture or equipment vendor. CSPs can count on EXFO's industry expertise to leverage data from these sources to rapidly deploy new services, analyze performance baselines and accurately pinpoint service-affecting events. Real-time and historical reports can be viewed for any period of time through charts, grids and maps.

EXFO's total cost of ownership (TCO) is predictable. After the initial investment, operator teams or third-party developers can add their own data sources, analytics logic, dashboards and reports on top of the EXFO Xtract analytics platform. The framework can be easily extended with open, standards-based application programming interfaces (APIs) to ensure that operators avoid expensive lock-ins, and are able to forecast and control the solution's TCO. This platform is designed to be a zero-admin system.

Finally, EXFO Xtract has been developed in conjunction with key CSPs across the globe. **EXFO's SA solution captures the intelligence gathered from hundreds of use cases.** This expertise is also available through EXFO's professional services team, and is offered as part of the solution.

Active Testing and End-User Client Device Monitoring

EXFO is the global market leader for active testing solutions and has deployed the largest live solution, running more than 16-million tests over 250 000 paths per hour.

EXFO is also one of the few players in the industry that are combining active testing with passive monitoring to improve E2E visibility, scalability and the flexibility of the solution.

The principle of active testing is to ensure E2E quality of service (QoS) in multitechnology IP networks by generating synthetic, non-intrusive test events across the network in order to characterize network and application performance on a continuous basis. This is key to effectively assuring services and virtualized infrastructure performance.

Active testing also provides an E2E view of performance and quality without the need to rely on subscriber traffic, acting as virtual users for service providers. By leveraging active testing, providers can monitor and view E2E performance to proactively address degradation rather than reacting to subscriber-impacting failures. When combined with passive monitoring, active testing provides accurate troubleshooting information for services and locations with degraded service quality.

Complementary aspects of active testing and passive monitoring are presented in Figure 3 below.

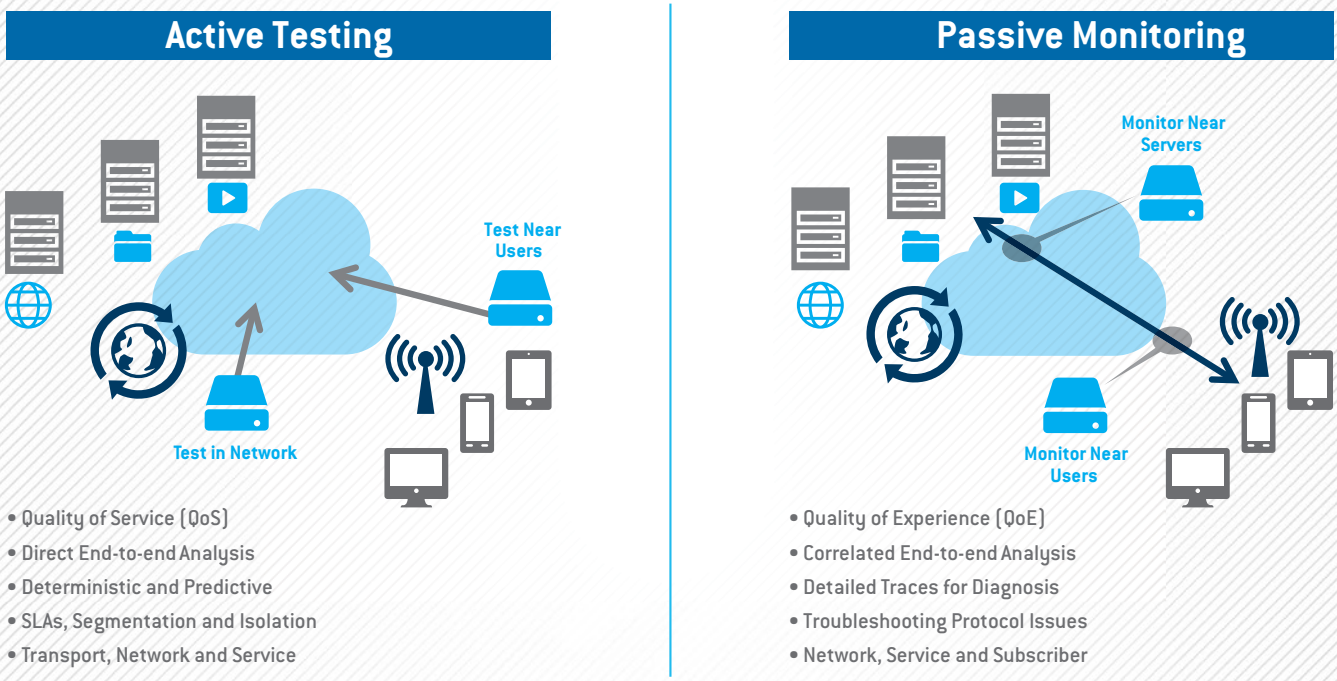

Figure 3. Complementary aspects of active testing and passive monitoring

EXFO's active testing solution consists of distributed verifiers, centralized test suites and data-correlation and reporting engines, and can be scaled to support the largest tier-1 network infrastructure (physical and virtualized).

EXFO Active Verifiers are designed to provide E2E SA coverage of the most complex and demanding networks. Comprised of a full array of hardware appliances and leveraging standards-based in-network devices wherever possible, EXFO Verifiers offer maximum deployment flexibility and support any combination of IP services with proactive and live traffic monitoring solutions for mobile 2G/3G/LTE networks, VoIP/IMS, IP video, data, VPN, Ethernet, network-infrastructure and network-performance testing.

EXFO Active Verifiers are also offered in a variety of platforms to meet various needs and scenarios, including hardware-optimized platforms with highly accurate timestamping and proven high scalability for the most demanding networks, where highly precise transport metrics are required, a software version that can be deployed on compliant x86 COTS host platforms for deployments flexibility, and an NFV-compliant software application that can be dynamically instanciated by hypervisors for agile networks. All flavors of verifiers are managed by the same EXFO Worx system and provide equal feature sets.

EXFO Worx packages different active test suites for mobile backhaul, small cell and IP services, as well as VoLTE, VoIP and IPTV.

In addition to test suites, EXFO Worx provides two main functions: remote test orchestration to autonomously run and execute desired tests, and results warehousing for storage, analysis and reporting of results. Correlated results are also forwarded to Xtract where they are correlated and further enriched with other collected data.

The solutions are easy to deploy throughout the network at low cost. Active monitoring is suitable for all network segments, from the core to the edge, and therefore effectively supports a well-segmented approach to problem-solving.

Typical use cases for EXFO's active testing solution include E2E verification of IP transport, measurement of SLA business services, and service activation testing.

An active E2E testing scenario for the IP transport network is shown in Figure 4 below.

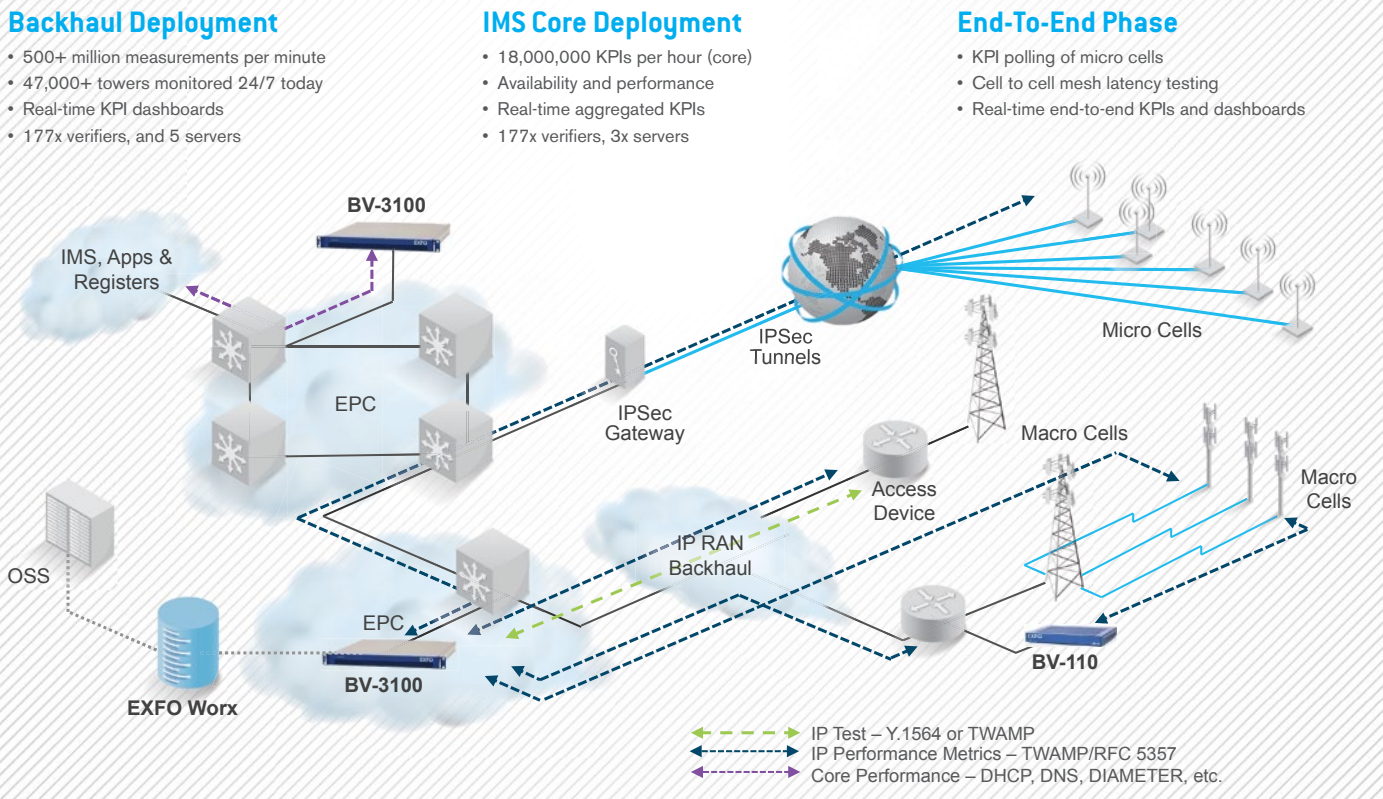

Figure 4. Active testing scenario for the E2E IP transport network

More active testing use cases are presented in the next chapter.

EXFO Mobile Agent (EMA) is an application for smart devices (e.g., smartphones, tablets) that provides manual and automatic (remote control) validation modes for 24/7 monitoring of voice and data services across wireless networks. Aided by zero-touch provisioning to support large-scale deployments, EMA collects service-experience data from end-user devices along with radio signal data to help analyze the deployed QoS and QoE.

An overview of EMA test scenarios are presented in Figure 5 below.

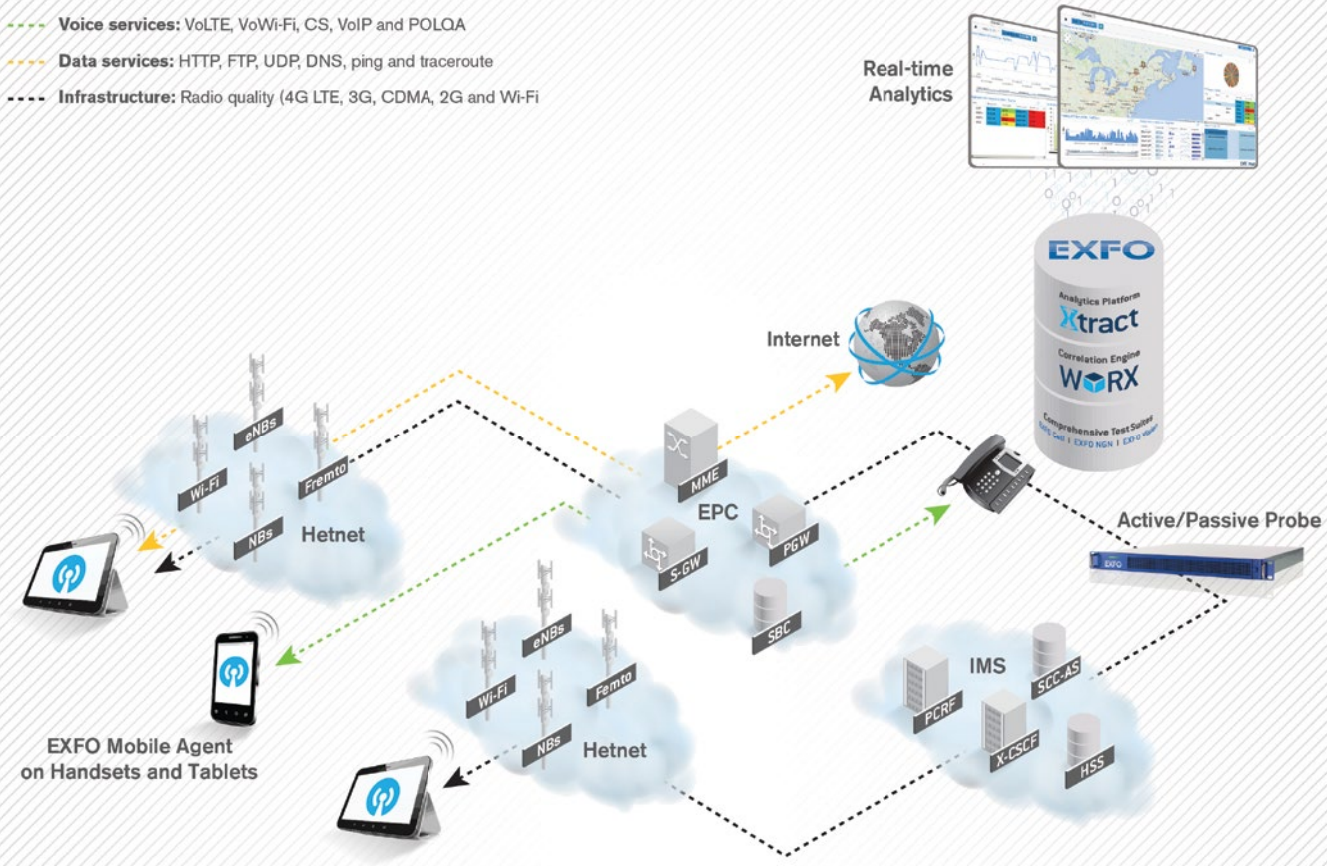

Figure 5. Overview of EMA test scenarios

EMA provides the collected data to Xtract analytics, which correlates it with corresponding signaling data, in practice extending the scope of E2E analysis to also cover subscribers' terminals.

End-user client-device monitoring provides service-quality measurements of the last mile. The fact that the measurements are carried out from end-user devices guarantees a true customer-experience view.

The challenges can be effectively addressed with correlated data from passive monitoring of the IMS core, EPC signaling and RTP media streams. This provides the following advantages:

- Full real-time coverage of the entire network and subscriber base
- Detailed view into problem cases through signaling analysis (LTE and SIP)
- Call-quality analysis with the capability to pinpoint where call quality is degrading
- Information on subscribers, handsets, locations and network elements with all call records, which provides a multidimensional view of QoE
- EMA passive voice call monitoring will capture all user-generated voice-call events along with radio metrics, thereby helping to analyze calls (no POLQA) for call drops, SRVCC mobility and radio coverage gaps. The industry's first E2E ladder diagram can be built using EMA and passive data-correlation analytics.

EXFO Passive Monitoring

The EXFO passive monitoring solution enables continuous 24/7 real-time monitoring of VoLTE, fixed VoIP, IMS rich-media, video-calling traffic, mobile circuit-switched calls and mobile broadband data connections over all key 3GPP interfaces.

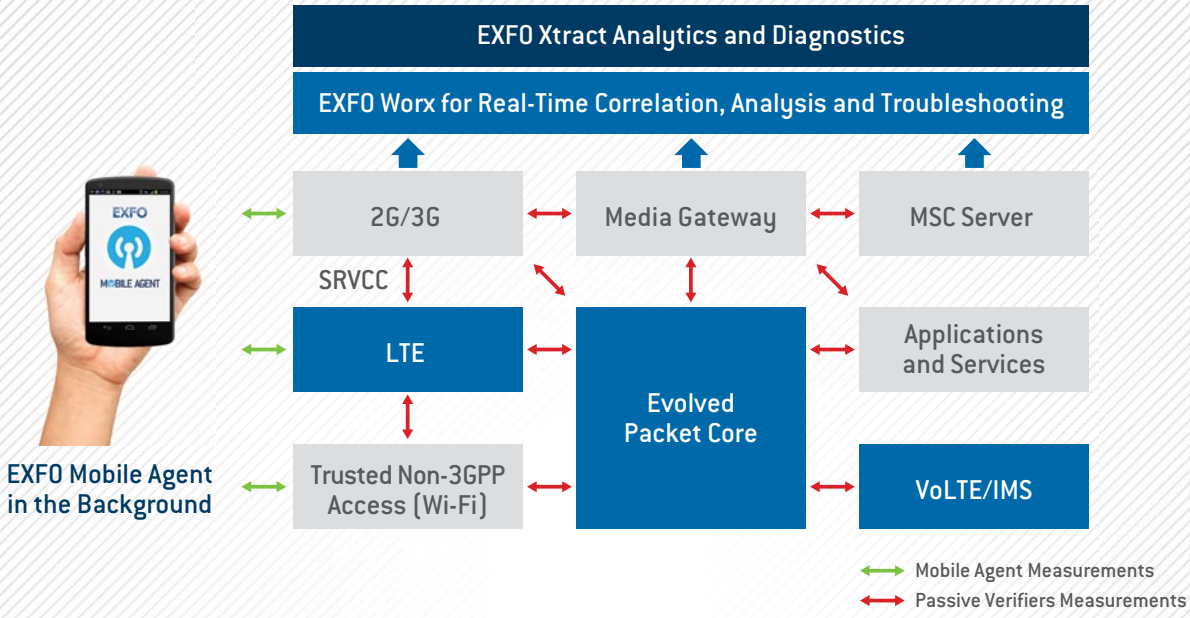

Figure 6. EXFO Passive monitoring solution interface coverage

The EXFO passive monitoring solution enables continuous 24/7 real-time monitoring of VoLTE, fixed VoIP, IMS rich-media, video-calling traffic, mobile circuit-switched calls and mobile broadband data connections over all key 3GPP interfaces. Passive monitoring is the key for understanding individual subscriber service experience and troubleshooting specific user sessions.

The solution supports LTE, 3G and 2G access networks, untrusted Wi-Fi, and fixed network access for operators' VoIP, IMS rich- media and video-calling services. It can be seamlessly integrated with active assurance results for combined layer 1 to 7 visibility.

EXFO's passive monitoring is a scalable solution that serves multivendor networks. The solution scales efficiently even for very large deployments—both in terms of monitoring endpoints and the number of users. The number of passive probes can be easily scaled up in the system as required. Data can also be gathered and correlated from passive verifiers residing at multiple physical network sites. The solution is vendor-agnostic and can be leveraged in multivendor networks to provide impartial and unbiased information on service performance and subscriber experience.

The EXFO passive monitoring solution provides comprehensive protocol coverage for mobile, wireless and fixed networks. All probes act together in synchronization. A unique differentiator of the solution is its continuous real-time correlation of all signaling and call data retrieved from multiple verifiers along the connection path. Call quality records are provided for both in-progress and completed calls within seconds, not minutes, which dramatically speed up mean time to resolution (MTTR).

Continuous Correlation of E2E Session Flows

"EXFO Worx passive monitoring has the best real-time E2E session trace capability by far compared to other vendors." *Northem American CSP*

"Similar traces from our other vendor's system take two hours to assemble" (as compared to seconds with EXFO Worx)." *Nothem American CSP*

Figure 7. **Continuous real-time correlation in EXFO's passive monitoring solution**

EXFO Worx's passive monitoring solution, combined with EXFO Xtract, offers the fastest troubleshooting functionality in the market, saving OPEX and directly improving operational efficiency and service experience.

This scalable solution supports multi-site and multi-user configurations and allows operators to optimize their capital investments in network monitoring.

Fiber Network Monitoring

Fiber Guardian and Fiber Test Insight (FG + FTI) is EXFO's 24/7 network monitoring solution with remote test units for the physical layer that helps CSPs ensure the integrity of their fiber optical network at all times.

The added value of physical layer network management in E2E analytics is the ability to map layer 1 errors to problems on higher layers of OSI stack. With the help of service and subscriber analytics and service modeling features in EXFO Xtract, EXFO's E2E solution can map physical-layer problems, such as fiber cuts or degraded performance directly, to impacted services and subscribers.

The FG+FTI solution is designed for core, metro and FTTx/access network requirements. It provides both remote real-time testing features and centralized surveillance of the network.

A typical NQMSfiber setup is presented in Figure 8 below.

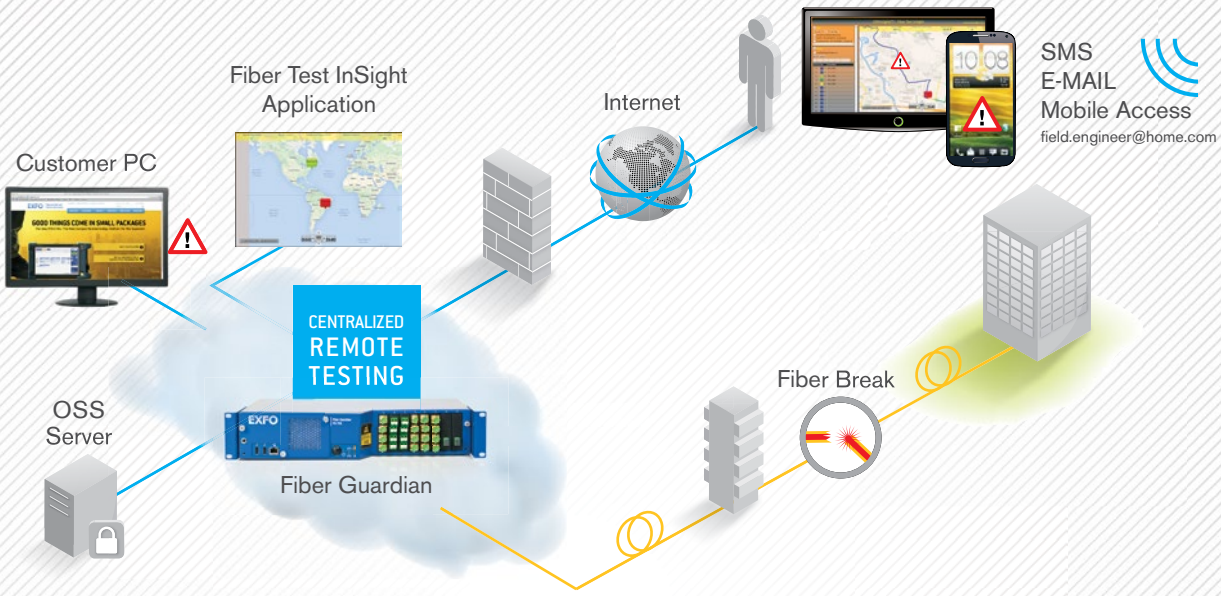

Figure 8. Typical Set-up of NQMSfiber.

The key features of EXFO's FG+FTI solution includes 24/7 detection, location and tracking of fiber degradations, automatic discovery and provisioning capabilities, proactive maintenance that allows deeper characterization of fiber routes, and trending data for future analysis and historical tracking, It is a unique solution in the market that provides accurate optical and geographical correlation within the same box. It also features e-mail alerts (running on all tablets and smartphones) with a URL/hyperlink to Google Maps, export/import fiber-route capabilities, color coding, multilingual Web UI, and much more.

The FG+FTI solution reduces CSPs' operational costs with optimized fault detection and location, allowing prioritized dispatches of the most appropriate repair teams. It can locate cuts on the network as they occur. Moreover, the solution supports SLA management and improved network documentation. It provides low cost of ownership, thanks to minimal maintenance and a high level of automation.

Network Data

EXFO's SA solution includes features for infrastructure monitoring and network reporting. The EXFO Xtract platform uses a combination of patented software engines to collect, analyze, correlate, and report on current and historical events in a network.

The solution also features out-of-the-box certified MIBs and supports over 11,000 known events with associated rules.

Furthermore, EXFO's SA solution has a comprehensive fault management functionality with advanced rule-based engine for trap deduplication, filtering and forwarding, and data aggregation and grouping.

E2E Service Assurance Use Cases Enabled By EXFO

E2E Service Experience Assurance For VoLTE

CSPs have a complete view of VoLTE from both service and subscriber perspectives. EXFO enables CSPs to have this view across all network domains, including IMS, support servers, policy and charging rules function (PCRF), the underlying transport service, session initiation protocol (SIP) signaling, real-time transport protocol (RTP) media, and subscribers. Having a complete view is the only way to ensure that the above-mentioned issues are recognized and associated with the right service elements with accuracy and speed. The subscriber perspective ensures that the impact of these issues on key subscribers can be recognized, analyzed and acted upon.

Streaming Video/IPTV and OTT Usage Insight and Service Experience

EXFO provides CSPs with a comprehensive insight into OTT application usage and customer experience by using both active testing and passive monitoring components in connection with analytics. Analyses are initiated from the big picture and cover subscribers, services, mobile terminals and locations. Typical findings include a video or VoIP application consuming a majority of network bandwidth, a sudden degradation in QoE amongst VIP users, low streaming video / IPTV delivery quality, service availability issues in a certain mobile terminal, or a network location with an error spike affecting high-value subscribers. When potential issues are identified, a drill-down to the network and element levels is provided to pinpoint the root causes.

Proactive Monitoring of Business Service SLAs

EXFO presents a complete and accurate view of customer experience and service health for CSPs' subscribers. This view is consolidated from service performance, infrastructure health, and bandwidth utilization. By having this holistic view, CSPs pinpoint exactly where an issue lies, regardless of network equipment manufacturer constraints or network architectures. For example, packet loss between two customer locations can be correlated to poor bandwidth provisioning in one or more segments along the circuit path.

This enables CSPs to guarantee SLAs with their corporate customers. The network operations center (NOC) can proactively address network and service issues before they become critical. These issues are ranked in order of priority based on impacted customers, services and SLAs. CSPs also view trends on collected data, along with deep granularity on data related to customer SLAs and contributing service-level objectives (SLOs). This enables the NOC to drill down into details as needed. Users can also view detailed events for service degradation or non-compliance on an E2E or segment-by-segment basis.

E2E IP Network Service Experience Assurance

CSPs can now have a holistic and segmented view of their IP networks for troubleshooting purposes. For instance, in the case of VoLTE, CSPs can obtain a full and segmented view into how VoLTE performs from a subscriber's device to a radio network, from an eNodeB to a serving gateway (SGW), from a SGW to a packet data network gateway (PGW), and from a PGW to an IMS. Having this critical information helps CSPs understand which network segments contribute to degradations. This insight is used to repair issues with speed and accuracy.

Conclusion and Benefits of EXFO's SA Offering

EXFO's vision in service assurance is to provide **E2E service experience visibility** of network and service performance with **real-time** actionable intelligence. We focus on delivering greater operational efficiency and optimized subscriber QoE.

The main characteristics and benefits of EXFO SA offering can be summarized as follows.

Real-time E2E Analytics That Cover Service, Subscriber and Network Aspects

EXFO captures and assesses data from all elements and across all network layers, including physical, transport and service layers and across all mobile (i.e. UE, RAN, EPC and TDM voice) and IMS/USP domains to provide an accurate and unified view of network and service delivery performance.

This has proven to improve CSPs' operational efficiency, increase customer satisfaction and decrease the time to market for new services and solutions.

High-performance Solutions

EXFO provides true **real-time** cross-domain E2E visibility, not only determining what the problems are or who/what is affected but most importantly pin-pointing the root cause of those problems.

EXFO's analytics engine offers **real-time service modeling** and the **capacity to correlate** huge amounts of data from different layers to effectively identify and address customer-impacting issues.

EXFO's innovative and comprehensive solution can **easily scale** to **support the largest T1 network infrastructures, both physical and virtualized.** CSPs get the required capacity and functionality to seamlessly **transition to a virtualized infrastructure without having to upgrade their service assurance solution.**

Unique Expertise in Combining Active Testing, Passive Monitoring, Network Data and Physical Layer Management

By **combining** our leading **expertise** and deep **understanding** of **active testing, passive monitoring, network performance and fault data collection** and **physical layer management**, we can integrate and present contextually relevant analytics enabling CSPs to make **well-informed** decisions.

A vendor-agnostic/impartial solution can be l**everaged in multi-vendor networks** to provide **unbiased information** on network and service performance.

EXFO can support CSPs during the transition from network-oriented monitoring into customer- and service-oriented monitoring practice, and ultimately helping CSPs to differentiate themselves from the competition.

30 Years of Experience with the Largest Worldwide CSPs

EXFO has proven leadership, expertise, value and scalability in key transformation projects. EXFO has 97 out of 100 world's largest operators as its customers. We ensure the service quality and provide expertise for leading Tier 1 operators, such as, but not limited to, Verizon Wireless, Vodafone, Orange and China Telecom. Our solutions capture key learnings gathered from hundreds of use cases that we have learned over the years. Our expertise will ensure speed and agility in the deployment of any new technology and services.

Other interesting EXFO E2E-related reading:

- **EXFO Mobile Agent:** EXFO Service Experience (Sx) Test Drive report and Pope Crawl Report
- **Active Sx Analysis with Analytics and Active Verifiers**: Assuring the Quality of Mobile Network with Active Testing
- **E2E Sx Analysis for LTE with Analytics and Passive**: How To Make LTE Network Faster and More Reliable

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