LTE-A & 5G Backhaul Performance Assurance

As mobile networks accelerate towards 5G, the backhaul is changing. We are entering a new level of performance requirements that will change how backhaul is delivered and assured, very soon.

Backhaul Today
Backhaul networks serving 3G and LTE mobile services are typically instrumented with network interface devices (NIDs), that allow providers to meet and report on performance service level agreements (SLAs). Packet loss, jitter, availability, and delay are collected from the network, and reported to show compliance with performance targets.

Often, this is done by polling metrics from multiple vendors’ equipment, where links are monitored using standards-based (Y.1731 OAM, RFC-5357 TWAMP) or proprietary methods (e.g. Cisco IP-SLA). As backhaul networks transform, these techniques will need to be augmented for providers to remain competitive.
Backhaul Tomorrow

Accedian works with nearly all leading mobile network operators, (MNOs) having insight into future trends as they emerge. Leading MNOs in Asia—including SK Telecom—are preparing for pre-5G deployments in 2017, having already launched LTE-Advanced with resounding success. With users already routinely experiencing 1,000 mbps download speeds to their phones, backhaul networks had to transform to support this new level of performance—all within the span of just a few short years.

Amongst the many drivers, VoLTE, virtualization, and exceptional growth in video traffic have all had a role in redefining backhaul networks’ and the limits they must withstand. As North American and European operators embark on the same journey, there are many ways they can benefit from the hard lessons learned by Asia’s early adopters.

Making this transition more difficult, backhaul networks have become more complex, with the introduction of 10 Gbps to the tower, enlarged networks with multiple domains, infrastructure vendors and layers—Ethernet and IP—often stitched together by acquisition, or required by upgrades or vendor consolidation.

**Performance visibility is fragmented:**
- Different levels of precision
- Different granularity
- Uneven measurement support

Along with this diversity comes discontinuous visibility. Different domains are often monitored with varying levels of precision and frequency. Performance may be measured at different layers, with metrics that tell different stories. Consider the difference round trip and one way measurements can make, when troubleshooting issues over multiple network segments.

“Backhaul networks are becoming more complex.”
Transforming Backhaul: LTE-A and 5G

With the breathtaking speed increases introduced by LTE-Advanced and 5G come significantly tighter backhaul requirements on latency, loss, and network uptime. Not only do these key metrics need to meet new levels, but they have also become interdependent. Delay and loss now have a direct impact on each other, as well as on throughput, as coordinated multi-point (CoMP) access and media traffic over the mobile X2 interface become common.

<table>
<thead>
<tr>
<th>Specs Tighten</th>
<th>LTE</th>
<th>LTE-A</th>
<th>5G</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput (Mbps)</td>
<td>10</td>
<td>100</td>
<td>1,000</td>
<td>770 X</td>
</tr>
<tr>
<td>Latency (ms, 1 way)</td>
<td>30</td>
<td>10</td>
<td>⅔</td>
<td>60 X</td>
</tr>
<tr>
<td>Availability (downtime / day)</td>
<td>1.2 min</td>
<td>8 sec</td>
<td>540 X</td>
<td></td>
</tr>
</tbody>
</table>

Compounding this, the rise of TCP traffic—largely from increased over the top (OTT) streaming video consumption—is introducing erratic micro-bursting and loss into the backhaul, similar to traffic patterns found in financial trading networks. The message to MNOs is clear: running backhaul networks at low utilization with overprovisioning is no longer sufficient to ensure QoS.

Transforming Backhaul: VoLTE

VoLTE cannot fail: mobile operators need it to work, flawlessly, to recover spectrum from legacy voice services. VoLTE requires a dedicated, prioritized class of service (VLAN / QCI), very low jitter, latency and packet loss. However, in VoLTE, it’s not just packet loss that matters, but how packets are lost. Even if packet loss is low, on average, if several packets are lost in a row—a loss burst—calls will drop. The ability to detect this type of behavior in the network is new, but critical, in helping mobile operators troubleshoot, monitor and successfully deliver VoLTE services.

Specifications shown relate to the following releases: LTE: GSMA Release 8, LTE-A: Release 10, 5G: evolving 3GPP IMT2020 program. All graphs provided by data from Accedian customers.
Backhaul operators can also benefit from VoLTE QoE monitoring. By knowing that their network performs adequately to support clear call quality, they can help mobile operators locate elusive network issues, becoming a valued partner in their end-to-end network.

Transforming Backhaul: Virtualization

LTE-A & 5G require operators to virtualize the evolved packet core (EPC), and introduce cloud RAN (C-RAN). Because of the added complexity, operators have to be careful how they approach and implement virtualization. As the network is no longer static, unexpected behavior and indirect consequences can emerge from autonomous systems. Performance can suddenly degrade when interaction between virtual functions is impaired.

VoLTE QoE Monitoring

- Accurately estimate user experience with R-factor, MOS score
- Localize VoLTE issues: in backhaul or not?
- One-way metrics identify directional issues

“It can hear you, can you hear me?”

Transforming Backhaul: Virtualization

Traditional Networks
Predictable cause & effect

Virtualized Networks
...interact across additional dimensions, often delivering unexpected outcomes.

Transforming Backhaul: Virtualization

Tier-1 example: THROUGHPUT VS LATENCY

It’s critical that backhaul operators are prepared to support this transition with ‘eyes wide open’, as they will need real-time monitoring of exceptional granularity and precision to isolate issues that can unexpectedly propagate across their networks.

In the example shown here, identifying a tight coupling between backhaul throughput and sub-millisecond latency spikes allowed the operator to avoid continued, systematic packet loss—something that would be invisible without sub-second latency monitoring with microsecond accuracy.

The New NOC

Operations teams already have their work cut out for them, keeping the backhaul running at peak performance. But with tightening specs and thresholds, they will soon face a barrage of alarms that will overwhelm their efforts to understand where problems originate. Monitoring systems need to become actionable, guiding operators, and helping them focus on unique events, probable root causes, and correlations that point to problem spots.
The combination of statistical metrics—minimum, average, maximum, percentiles, and standard deviation—for standard measures like packet loss, latency and jitter, provide a diversity of filtering and viewpoints that can cut out alarm noise, and highlight outliers and exceptional events. Combined with Boolean alarms that sound only when a combination of conditions exist and persist, engineers can benefit from intelligent indicators that help them zoom in on events that impair QoS, and the end customer experience.

Obtaining this new level of visibility is now possible, thanks to advances in virtualized instrumentation, in concert with the widespread support for monitoring standards in network elements.

Prevalence of TWAMP, Y.1731 means a new level of visibility is now possible, without adding hardware to the network.

Virtualized instrumentation: Visibility Without Compromise

Until recently, scalable, precise network performance monitoring solutions relied on purpose-built hardware probes. Software solutions, although low-cost and easy to install, are unable to achieve the same level of performance.

Accedian’s virtualized instrumentation closes this divide, delivering ease of deployment, exceptional economics, and open integration, without sacrificing accuracy or granularity. With this visibility centralized in data centers shared with SDN control and big data analytics, providers have an integrated foundation to deliver a new level of customer experience.
Virtualized instrumentation harmonizes the entire backhaul network with uniform visibility to eliminate:

- Multi-vendor, silo systems
- Metrics at different layers
- Varying precision & coverage
- Consolidating data from multiple systems to troubleshoot & report
- Custom code and integration

It provides a single view into network performance that allows the operator to manage its entire network together, as a single entity. By providing uniform, high definition monitoring to all layers and locations, each network element contributes actionable information to optimize the network state, and ensure reliability is never compromised.

**Transforming Visibility: Viewpoint Diversity**

Accedian’s Network State+ metrics provide the most complete view of QoS. Statistical KPIs are calculated on the fly—as quickly as every 5 seconds—to ensure alarm management, SDN control and performance assurance systems have the feedback they need, as it happens. Packet stats provide insight into network configuration issues, including persistence or loss of service marking, packet prioritization, micro bursts, and RF link packet transmission irregularities.

This diversity of perspectives provides the resolution required to precisely detect network issues, QoE impairments, and trends that can predict failures and capacity issues before they impact users. When combined with logical alarms, operators will be notified if—and only if—there is an issue warranting their attention.

<table>
<thead>
<tr>
<th>Packet Statistics</th>
</tr>
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<tbody>
<tr>
<td>- Packets received • lost • % lost</td>
</tr>
<tr>
<td>- Bytes received • lost • % lost</td>
</tr>
<tr>
<td>- Loss bursts • longest • shortest</td>
</tr>
<tr>
<td>- Reordered packets • ratio %</td>
</tr>
<tr>
<td>- Packets duplicated • ratio (%)</td>
</tr>
<tr>
<td>- CoS / DSCP Preservation (TX/RX)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Meta Metrics</th>
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<tbody>
<tr>
<td>- Session ID</td>
</tr>
<tr>
<td>- Interval sequence number</td>
</tr>
<tr>
<td>- Interval timestamp (UTC)</td>
</tr>
<tr>
<td>- Interval length (Custom)</td>
</tr>
</tbody>
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Transforming Visibility: High Granularity

Like counting cars on a highway, if you only glance every 15 minutes, you’re unlikely to see anything exceptional—like a pink bus, or a group of touring motorcycles, or a squirrel crossing the highway. But if you increase your observation frequency to once a minute, you’d be rewarded with more insight, and might sometimes be alarmed.

Consider the effect of sampling speed in this 3-minute packet loss (network outage) that occurred in a production mobile network in Asia. Sampling at five minute intervals allowed 60% packet loss to go unnoticed by the monitoring provided at the base station. Accedian’s sub-second monitoring captured not only the loss, but showed how the impairment differed in the up and downlink directions (15% vs. 60% loss).

Detecting Transient Issues  Sampling Speed Changes Everything
Transforming Visibility: High Precision

Granularity is also essential. Synthetic packet loss measurements conducted by active test relies on having a statistically significant number of samples to converge on a true view of actual loss. Over the period of a minute, sampling 10 times a second leads to a 1.2% loss accuracy—larger than many thresholds set in next generation backhaul networks, where even 0.1% packet loss can significantly impact throughput. Sampling 500 times per second is required to achieve this level of precision, permitting accurate SLA reporting, as well as the resolution required to detect micro issues, trends, and correlate loss with other key metrics.

In the example above, a relationship between loss and latency was revealed, and a ring switching issue was resolved to the benefit of hundreds of thousands of subscribers, who experienced systematic VoLTE call drops every 14 minutes. It was only possible to detect this relationship using exceptionally precise latency measurements. Standard sub-millisecond accuracy was not enough to expose the subtle changes in delay that occurred each time the network path switched from one side of the ring to the other. Microsecond-precise measurements captured the issue clearly. The combination of highly granular packet loss and latency measurements, each with sufficient precision, together provided the information required to determine root cause, that would otherwise remain invisible.

Actionable Insight, Tangible Benefits

Accedian’s virtualized instrumentation had a transformative impact on performance and capacity for one leading Tier-1 Korean mobile network operator. Despite being one of the world’s best LTE-Advanced networks, the SkyLIGHT solution’s exceptional resolution and granularity revealed actionable areas of improvement that lead to nearly 90% more network capacity and speed within the first 30 days—simply by allowing the MNO to optimize what they already had in place. The figures in the table below were provided by the MNO, as part of an internal study and white paper assessing the efficacy of the Accedian solution.

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While mobile operators constantly strive to acquire new spectrum, the scarcity of it means that making most efficient use of existing assets is not only a practical and economic choice, it may be the only way to increase network capacity in the near term. Recovering captive and wasted capacity is necessary not only to address future traffic demand, but also to transition to VoLTE, and introduce new revenue opportunities like broadcast media, fixed line internet replacement, and 4K video streaming.

Backhaul providers have an important role to play, noting that the significant improvements in capacity recorded here mainly relied on improvements, reconfiguration, and optimization of fixed line access networks. The new relationships between loss, jitter and throughput introduced by LTE-A and 5G have shifted attention to improving what is often considered the least problematic part of a mobile network, as backhaul performance now has an increasingly important role in realizing the benefits of next generation radio access network (RAN) technology.

Virtualized Instrumentation: A New Level of Visibility
With the level of impact early adopters have proven at scale, virtualized instrumentation is a new necessity. Its combined cost efficiency, completeness of coverage, exceptional precision and diverse perspectives are the perfect complement to support software defined networks, and analytics systems, and are foundational to a performance-assured transition to virtualized infrastructure.

Providers can instrument their networks in weeks, to gain visibility into all applications, layers, and sections of their network. They can take control, and differentiate themselves with a new level of performance, assurance, and customer experience.
Virtualized Instrumentation: Real-Time Reporting

As LTE-A, 5G, VoLTE and multimedia services continue to deploy and scale, the way SLAs are reported also needs to change. Maintaining peak performance over virtualized networks is a delicate balance, requiring insightful, real-time information that can be acted upon in an instant. Backhaul providers will need to provide this level of real-time reporting to operators, to help them isolate network and quality of experience impairments.

Waiting for monthly SLA reports will no longer be sufficient proof that a backhaul provider is delivering sufficient QoS. Next generation mobile network requirements elevate access vendors to partners who can transparently share their network insight, and work with the MNO to resolve issues that will quickly become too complex to troubleshoot using traditional methods.

Real-time, secure, hosted portals that provide a diversity of view points, guided visualization, customized report generation on demand, and sophisticated, multi-metric and statistical dashboards fill an important role. Accedian’s SkyLIGHT Analytics platform includes VisionMETRIX™, a software-as-a-service offering tailored to providing a real-time lens into backhaul operations, for both the access provider and mobile operator.

Easy to learn without formal training—and easy to install without involving IT—the modern visualization suite can scale to report every service and circuit in nationwide networks, while also integrating metrics from third party systems. Visual correlation between sites, circuits and services accelerate troubleshooting and reveal complex trends that enable surgical capacity planning.
Deployment Example: Wholesale Backhaul

Backhaul providers deploying SkyLIGHT achieve a harmonized, unified view of multi-domain, multi-vendor networks operating over diverse geographies, all from a single system. The entire network can be easily managed from this single source of insight, providing new performance possibilities, while simplifying operations and probing requirements. Mobile operators deploy these systems before their transition to LTE-A, and 5G, to ensure they have the visibility required to detect and eliminate any sources of QoE impairment their new networks will introduce.

Backhaul providers can differentiate their offerings by proactively establishing best-in-class monitoring, performance assurance, and real-time reporting, showing their commitment to delivering the best possible service under the strain of tighter specs, virtualization, and new traffic patterns.

Meeting Next Generation Backhaul SLAs

Delivering next generation backhaul, and meeting performance objectives that will arrive in the form of more sophisticated SLAs, means covering all the bases this transition will introduce. From the backhaul operator perspective, simplicity, ease of deployment, and the ability to uplift the measurements from existing infrastructure are significant benefits of virtualized instrumentation, where cost is optimized, and operational integration is easily achieved. The SkyLIGHT performance platform was purposely developed to meet these objectives, and stands in a class of its own with its disruptively straightforward approach.

<table>
<thead>
<tr>
<th>New Dimension</th>
<th>Effect</th>
<th>Solution</th>
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<tbody>
<tr>
<td><strong>L2, Multivendor</strong></td>
<td><strong>Discontinuous</strong></td>
<td>• Uniform measurements: all layers and locations</td>
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<tr>
<td>Networks**</td>
<td><strong>Visibility</strong></td>
<td></td>
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<tr>
<td><strong>Alarm Fatigue</strong></td>
<td><strong>Sea of Red, Long MTTR</strong></td>
<td>• Percentile, statistical and boolean alarms - actionable and predictive indicators</td>
</tr>
<tr>
<td><strong>LTE-A / 5G</strong></td>
<td><strong>Tighter Specs</strong></td>
<td>• μs precision, fine granularity</td>
</tr>
<tr>
<td><strong>VoLTE</strong></td>
<td><strong>Loss sensitivity</strong></td>
<td>• Loss burst &amp; min/max loss metrics</td>
</tr>
<tr>
<td><strong>1 way issues</strong></td>
<td><strong>1-way &amp; segmented metrics</strong></td>
<td>• MOS score</td>
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<tr>
<td><strong>QoE Validation</strong></td>
<td></td>
<td>• Multi-CoS KPIs &amp; CoS validation</td>
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<tr>
<td><strong>Dedicated CoS</strong></td>
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<tr>
<td><strong>Virtualization</strong></td>
<td><strong>Multi-Metric interaction</strong></td>
<td>• Wider array of metrics for root cause analysis</td>
</tr>
<tr>
<td><strong>10G Backhaul</strong></td>
<td><strong>NID Cost</strong></td>
<td>• Virtualized instrumentation eliminates hardware</td>
</tr>
<tr>
<td><strong>Short-Term Events</strong></td>
<td><strong>Real-Time Reporting</strong></td>
<td>• Real-time metrics* &amp; real-time portals</td>
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</tbody>
</table>

* sub-second granularity, reported as quickly as every 5 seconds
Virtualized instrumentation: Extending Possibilities

The concentrated power of optimized hardware has its place in virtualized performance assurance. Throughput testing and bandwidth monitoring, distributed packet capture, and full-mesh performance assurance require precise processing in remote locations. Virtualization reduces hardware to the minimum required, to enable capabilities that software alone cannot deliver. The SkyLIGHT performance platform works seamlessly to orchestrate tests and performance assurance functions across hybrid infrastructure, enabling new forms of analysis, QoE assurance and troubleshooting that were never before possible—with or without x86 infrastructure widely deployed.

Virtualized capacities can be extended where hardware is irreplaceable:

- **Full line-rate test traffic generation**
  - turn up & service activation testing

- **Remote QoS & QoE probing**
  - test from—and between—remote sites

- **Remote packet capture & time-stamping**
  - distributed packet brokering

- **Bandwidth Metering**
  - utilization & microburst monitoring

Accedian Network Performance Modules: “reducing hardware to the minimum”

Virtualized Instrumentation: Conclusion

SkyLIGHT virtualized instrumentation prepares mobile backhaul operators for next generation requirements, and sets them apart to successfully embrace new business driven by the requirements of LTE-A, 5G and services like VoLTE. It establishes an integrated, complete view of performance over a multi-vendor infrastructure, by enhancing the monitoring capabilities of existing NIDs, extending these measurements to any network element, and seamlessly monitoring core, aggregation and access networks from a single system.

This complete visibility means faster problem detection, isolation, and time to root cause and repair, it means assured compliance with next generation SLAs, it means business. It also means an optimized network based on proactive fault avoidance, and performance optimized, prioritized traffic.

Learn more about the SkyLIGHT performance platform, its role in the march to 5G, and the operators that use it at Accedian.com. Visit our library for a wide range of related resources.