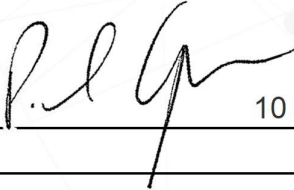


Final Report

The value of network and application performance assurance to delivering the business outcomes that underpinned the investment in 5G

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ABBREVIATIONS

AI/ML	Artificial Intelligence / Machine Learning
API	Application Programming Interface
eMBB	Enhanced Mobile Broadband
KPI	Key Performance Indicator
mMTC	Massive Machine Type Communications
uRLLC	Ultra-Reliable Low Latency Communications

EXECUTIVE SUMMARY

5G-Encode is a £9 million collaborative project partially funded by the Department for Digital, Culture, Media, and Sport (DCMS) with the aim of developing clear business cases for 5G applications in the composites manufacturing industry. Solvay was a partner in the industrial use case evaluating asset tracking of time sensitive materials.

The asset tracking evaluation work package was delivered in collaboration with Plataine Ltd which provided the TPO application and the NCC, Bristol which provided the test bed for the private 5G technology evaluation. The NCC test bed was delivered together with Zeetta Networks, Toshiba, Mativision, Plataine, Siemens, Telefonica, Accedian and the High-Performance Networks Group from the University of Bristol as partners.

Accedian has been a long-standing provider of network and application performance monitoring to both Service Provider and Enterprise markets and they had recognised the new opportunities that 5G would offer to Industry. Research by the [CapGemini](#) Research Institute concluded that “2 out of 3 industrial companies believe that guaranteed quality of service is critical for their digital transformation” and with 5G holding the key to unlocking digital transformation for manufacturers, both in the UK and around the world, monitoring the performance of both the 5G network and the applications driving the 5G use cases of mMTC, eMBB and URLLC, is a critical success factor.

Project Encode provided Accedian with an ideal opportunity to validate the value of its performance monitoring and test generation virtual platform, Skylight Analytics, to in the manufacturing industry by supporting their digital transformation journey and helping companies to realise the performance and reliability benefits of 5G.

Within Project Encode, Skylight was deployed at the National Composites Centre (NCC) and delivered granular and accurate real-time visibility, anomaly detection, and analytics on the performance of 5G-ENCODE's private 5G network and the applications that run over it. Skylight was able to support the project's goal to accelerate the realisation of the benefits of 5G for their key business use cases; in-factory and in-transit asset tracking,

virtual 360-degree video training and closed loop manufacturing in Liquid Resin Infusion.

The key results being:

1. The simplification of fault identification and resolution to enable non technically skilled staff to identify use case impacting issues and also what the issue was and what the possible root cause was.
2. The presentation of highly accurate and granular performance data to enable technical staff to trouble-shoot use case impacting issues to reduce downtime
3. The ability to proactively identify performance degradations that would lead to negative impact on the use cases.

INTRODUCTION

Project Objectives

The prime objective of Accedian within the Encode project was to provide a performance monitoring capability, Skylight, which enables Manufacturers to ensure that the performance benefits promised by 5G live up to expectations and lead to the successful delivery of the use cases that underpinned the business case for investment in Private 5G.

We also wanted to show that Skylight could be used by non-technical people to derive operational value for the organisation.

Purpose of 5G

From Accedian's perspective 5G is just an enabler of the Manufacturing use cases and is no different to a 4G or Wi-Fi network connection or indeed a wired connection, other than that the Encode 5G environment is disaggregated rather than a black box solution.

However, there is a difference when it comes to the value of performance monitoring, which increase with 5G due to the stringent nature of the network performance requirements for some private 5G use cases and applications. These applications have special requirements in terms of latency, packet loss and bandwidth, which make it critical to monitor these performance factors.

The disaggregated nature of the Encode 5G environment also creates challenges with understanding performance across multiple functions and multiple vendors.

Skylight delivers value in three ways; visibility, insight and action:

1. Visibility

Skylight provides the ability to measure the performance of the connectivity in a very accurate and granular way. This is done using sensors. These sensors can be deployed as physical sensors or software sensors, in the form of virtual software or containers to generate a multitude of KPIs that determine the performance of the network connectivity.

We can also deploy capture sensors that provide application delivery performance metrics.

The combination of these sensors means that Skylight can provide complete end to end visibility of both the underlay and overlay network performance, irrespective of whether the network is wireless or wired or whether the applications are hosted in a private or public cloud or indeed a hybrid environment.

2. Insight

However, visibility in itself isn't enough. It's all well and good Identifying that an issue exists is useful, but the real value is knowing what the issue is, where it is and most importantly what its impact is on end user experience.

KPI's on their own may only be useful to users with the appropriate skills and knowledge to analyse them and deduce what they are indicating if there is an issue that will impact end user experience.

Skylight uses metadata to add context to the KPI's and then uses AI/ML methodologies such as anomaly detection and pattern matching to add intelligence to turn them into something meaningful, such as the root cause of the issue. A simple example would be that Skylight could identify an issue with packet loss but using geographic metadata to determine that the issue was in a particular location and then additional metadata would lead us to the exact location of the device

3. Action

With the insights now available, what can a user do with the information? Skylight has very powerful dash-boarding capabilities to enable visualization of performance KPIs and create insights in multiple ways to meet differing requirements of individual user groups, such as Operations or Capacity Planning. These dashboards can provide a high-level view of performance that can indicate specific issues based on threshold breaches. This allows users, based on their role profile, to drill down into the underlying details to determine the root cause.

These dashboard views should not be confused with a similarly named features documented in the single and multi-domain service management report where a 'single plane of glass' feature is used to visualise the network devices.

Additionally, Skylight can feed the created KPIs and insight, via APIs, to other third-party systems to trigger further actions. This could be for something simple like the creation of a trouble ticket, but it could also be part of a more complex closed loop automation process.

WHAT WAS DEPLOYED

In order to meet the objective described previously we selected the following operational use cases on which to base the solution design:

- End-to-end Slice performance visibility across the 5G private and 5G public networks
- End user QoE monitoring
- Enable SLA compliance across entire infrastructure
- Advanced troubleshooting for operational efficiency
- Accurate performance data feedback loop for automated network orchestration

To deliver the above use cases we also took the following key design decisions:

- To implement both active network testing and passive application monitoring
- To deploy sensors where appropriate to measure the performance across the end-to-end network all the way to end devices and applications and on both sites

The following components were implemented:

- Virtual Machines (on Hyper-V and KVM):
- Sensor Control
- Sensor Capture
- Orchestrator
- Roadrunner
- License Server
- Skylight Analytics (SaaS)
- Sensor Agent x 2 (Docker)
- Roadrunner x 2 (Docker)
- TWAMP reflector agent x 3 (Android)
- Hardware components:
 - SFP-C x 6
 - ANT x 1

Please see figure 1 below, which illustrates the topology of the solution deployed. Figure 2 provides more detail on each component.

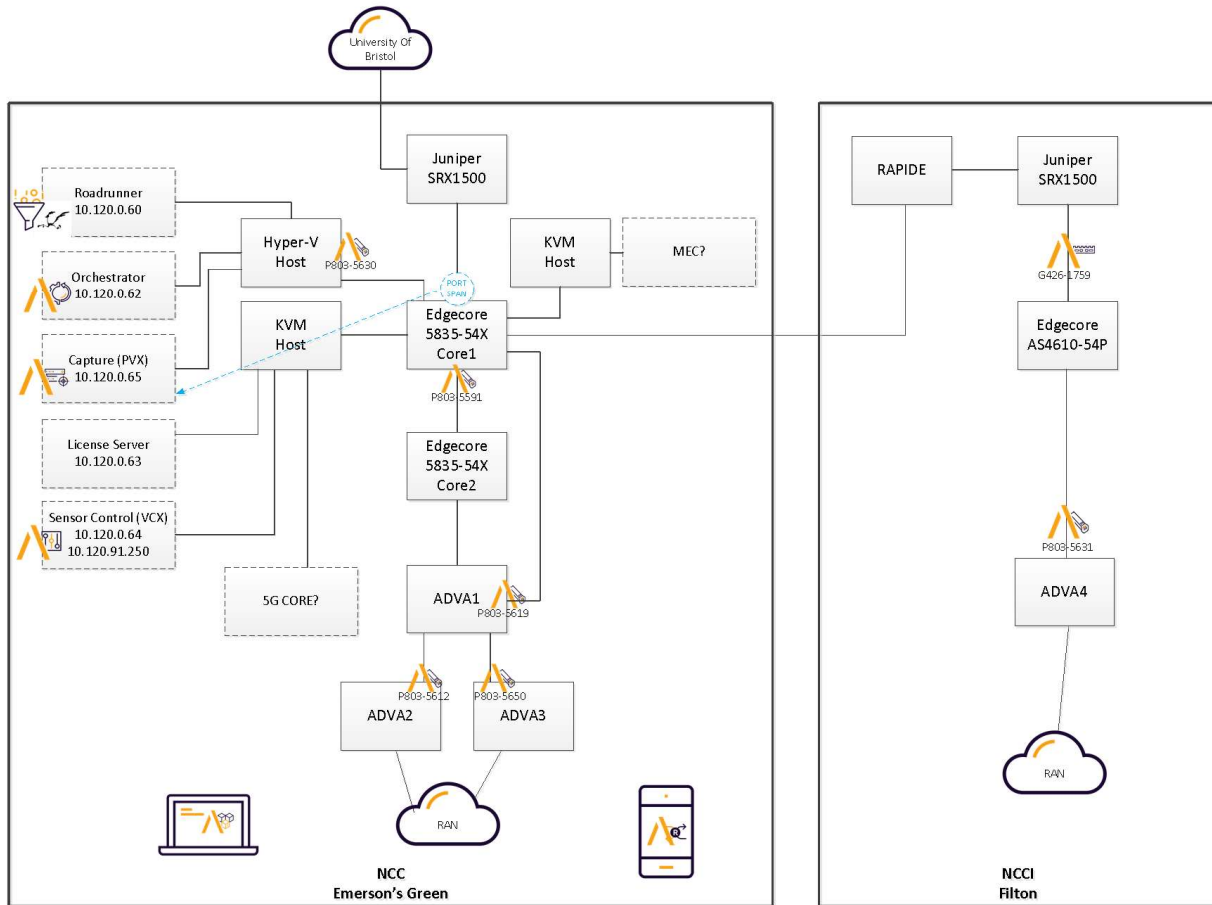


Figure 1: Skylight solution topology showing the position of the solution components

Component	Deployment Target / Scope	Technical Function	Capability
SFP-Compute and ANT modules	Physically installed in or connected to ADVA switches and EdgeCore switches	TWAMP and Flowmeter	Network performance and bandwidth assurance
Sensor Agent	Docker container on workstations	TWAMP	Network performance assurance
TWAMP reflector	App on Android handsets	TWAMP	Network performance assurance
Sensor Capture	Mirror / SPAN feed from Core switch	Wire data analysis	Application delivery assurance
Sensor Control, Orchestrator, Roadrunner, License Server	Virtual Machine on Hyper-V and KVM	Module discovery, configuration, management, data collection, APIs	Network performance and bandwidth assurance with full orchestration
Analytics	SaaS	Data visualization portal / APIs	Network performance, application delivery and bandwidth assurance with visualization, AI/ML data processing & 3 rd party ingestion

Figure 2: Explanation of the role of each of the components

IMPACT ON ENCODE USE CASES

In general terms, there are three generic use cases for 5G and they are mMTC, eMBB and URLLC. Skylight enables organizations to understand how the 5G network is impacting the delivery of these use cases by providing ultra-granular visibility of network performance (the underlay) as well as visibility of the performance of the applications (the overlay) that run over the network to drive these use cases. Skylight was used in the Liquid Resin Infusion (LRI) use case report to validate network traffic estimated with network traffic passed by the transported network. The data was not of high volume but needed to be delivered with minimal latency for valve and oven controls used during the infusion process to execute correctly.

A recent report from Analysys Mason (Analysys Mason Private 5G enterprise survey) says that reliability and security are the most important 5G requirements for the manufacturing sector. Support for low-latency time-critical applications is important to manufacturers, along with high network bandwidth and throughput and support for a wide range of endpoint devices.

High reliability 82%

Highly secure 78%

Support for low-latency, time-critical apps 75%

High bandwidth/throughput 73%

Diversity of endpoint devices supported 73%

Specifically, to Encode, the key impact that Skylight will have on the four use cases are as follows:

1. Skylight enable NCC users to proactively identify both stability and performance issues that will impact the successful delivery of the various use cases and provide insight into what the root cause is so that the appropriate action can be taken.
2. Reduces the technical skills required to identify issues and their root cause through the use of thresholds and alerts and also visualizations

3. Provides a single, agnostic, view of network and application performance irrespective of the vendors implemented in the network or whether a private, public or hybrid cloud environment is being used.

To support the above we have provided example screen shots and labels in the Appendices to demonstrate how Skylight enables non-technical resources to identify issues and their root causes.

IDENTIFIED LIMITATIONS

As a result of the project, we identified a number of limitations in the current Skylight product that we can now address moving forward:

1. User Equipment (UE) TWAMP endpoint capability currently limited to Android phones and workstations capable of running Docker
2. Android reflector is not currently GA
3. Android reflector reflects TWAMP from Sensor Agent only (and cannot reflect from SFP-C) due to callback requirement
4. Capture Sensor does not dissect MQTT or LLRP L7 transactions

There were also a number of constraints within the NCC environment that impacted the expected deliverables:

1. LLDP messaging caused issues in the 5G network, LLDP had to be configured as a pass-through in the SFP-C modules, so the probe was not detected as a network device
2. Un-supported hypervisors (Hyper-V) were used to host some VMs due to hardware capacity
3. Time constraints and 5G network stability did not allow for the addition of enhanced features such as closed loop automation
4. No end device or connectivity available for measuring over private-public-private 5G to validate "splicing" technology.
5. Very low latency in 5G core platform which may not be representative of production Private 5G deployment. Limitation on "realism" of data displayed in Skylight

FUTURE DEVELOPMENTS

The key areas of focus for development to support 5G Private Network use cases is our sensor agent program. Our objective, as seen in Figure 3 below, is to enable ubiquitous coverage by creating agents to sit in any environment.

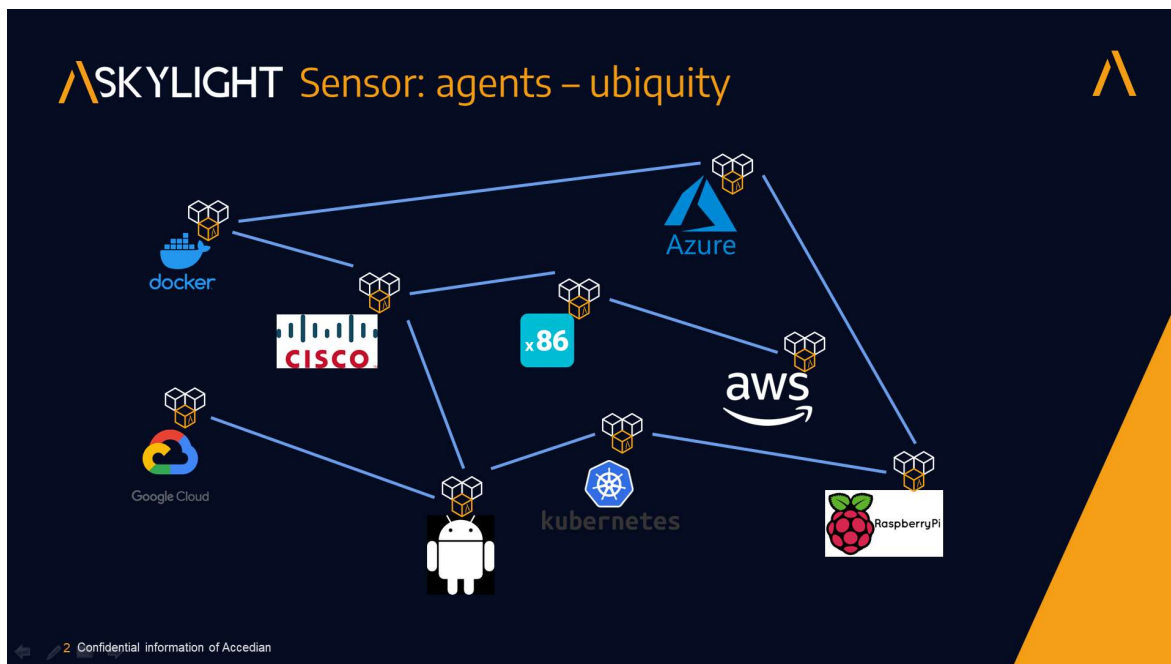


Figure 3: Illustration of proposed sensor agents

Skylight Sensor Agents – Current

- 21.06 GA
 - Actuate: RFC5337 TWAMP sender, reflector
 - Throughput: RFC6349 TCP agent, limited
- Demo / PoC versions:
 - ARMv8 actuate and throughput
 - Reflect: PM reflection binary x86 and ARMv8
 - Trace: path tracing, limited
 - Android reflector

Skylight Sensor Agents – Up-and-coming Enhancements

- 21.12 (in final SQA)
 - Actuate: added support for UDP echo and ICMP echo session types
 - Throughput: added support for baseline results and multiple test definitions
 - Reflect: simple unmanaged binary reflector app for linux 64bit (x86)
 - VRF support for deployment on Cisco
 - post-GA validation of performance on Cisco HW platforms (5500 and 540)
- 22.04
 - Throughput: new visualization of TCP tests in Analytics
 - Actuate: adding roundtrip metric support, TWAMP-control NAT support
 - Trace: multi-test support and configuration loops (scheduling) – no new visualization
 - ARMv8 (64-bit) GA for throughput, actuate, trace and reflect
 - Domain: demo version for DNS testing

CONCLUSIONS

5G technology will revolutionize manufacturing not only with much needed additional security for critical applications, but also by delivery of dedicated resources with assigned guaranteed quality of service.

In response to a 2021 IDC global survey, 50% of manufacturers cited lack of automation and analytics to optimize their environment as a top barrier to building a resilient digital infrastructure.

In the same survey over 40% of manufacturers reported problems with performance, security, and connectivity with mission-critical workloads and 43% saying that having difficulty with finding the staff/training/skills to meet the needs of evolving network requirements, is one of their organization's biggest business challenges.

The Analysys Mason Private 5G enterprise survey points out that "The network will need tools to monitor each application's performance and ensure that those metrics are in line with the KPIs."

Our involvement in the 5G-ENCODE project, enabled us to take a step closer to delivering a solution that enables organizations to realise the value of 5G through the visibility and assurance of the performance of the network and critical applications and of the end user experience. A particular example where Skylight was able to identify how a network outage impacted the LRI use case has been highlighted in their report.

Also, asset tracking is a low data volume solution that is not reliant of ultra-low latency, however, coverage is key so NCC used Skylight to look for rhythmic transmission of small bursts of data. In the samples taken no issues were detected but please refer to figures 7,8 & 9 in the Appendices.

In addition, we have provided sample screen shots from the Skylight solution implemented for Encode in Appendix A to demonstrate how Skylight enables non-technical resources to identify issues and their root causes. I've also attached the IDC snapshot report in Appendix B.

APPENDIX A

Skylight dashboards

This section provides information regarding the dashboard views configured for the 5G-Encode Project and associated use cases. The red text provides annotation of capabilities provided.

The final 2 screenshots present information provided to a specific 5G-Encode use case owner in order to understand the traffic activity in their own environment.

Encode Overview dashboard – Network Performance Assurance section

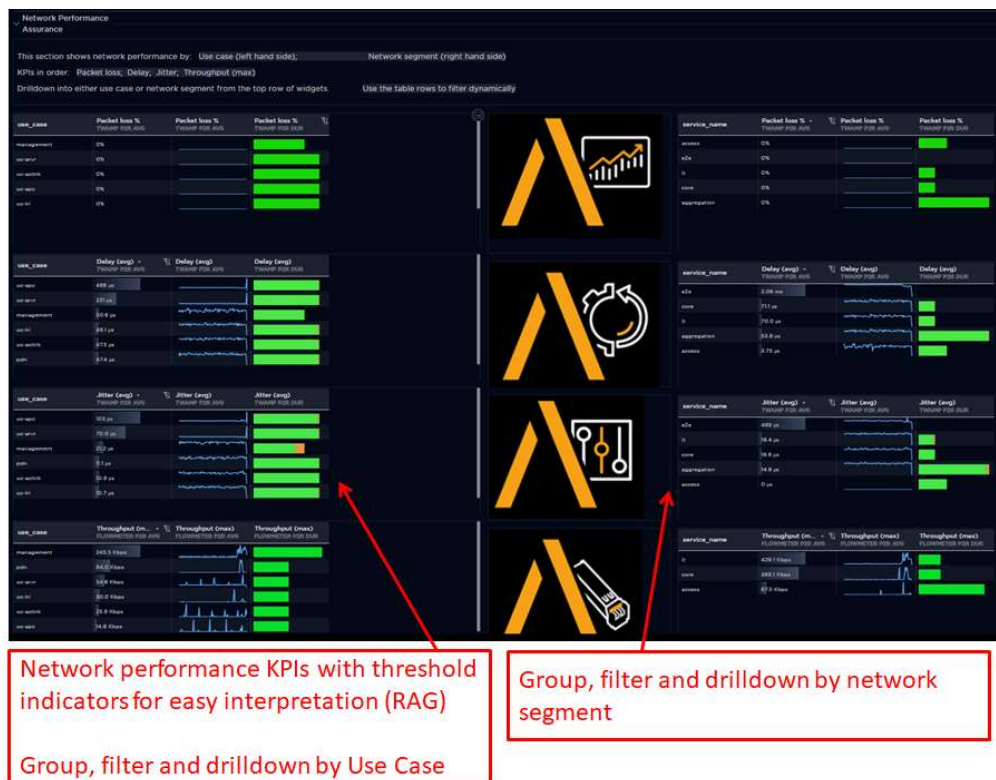


Figure 4: Network Performance Assurance

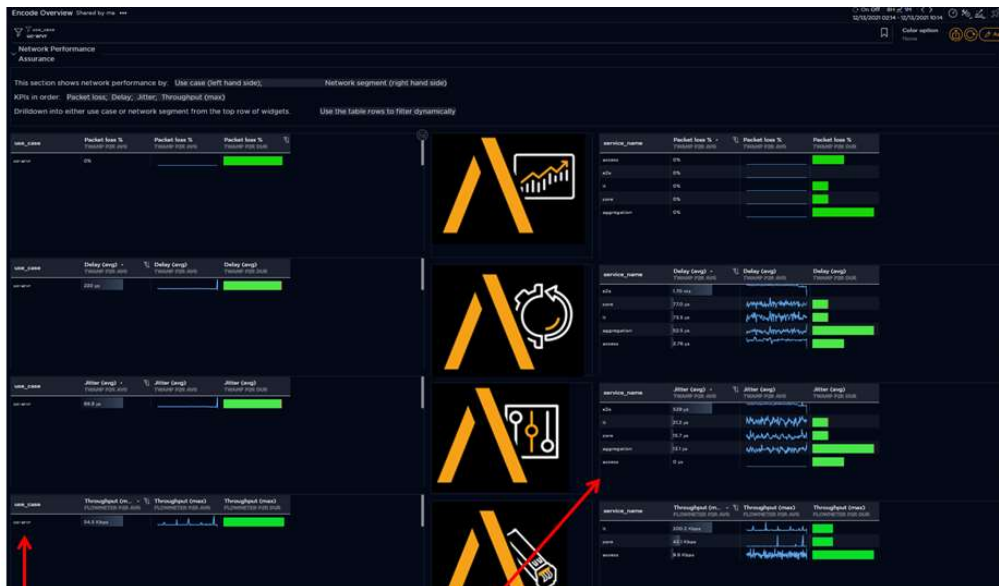


Figure 5: Filtering network segments

Aggregation Segment dashboard

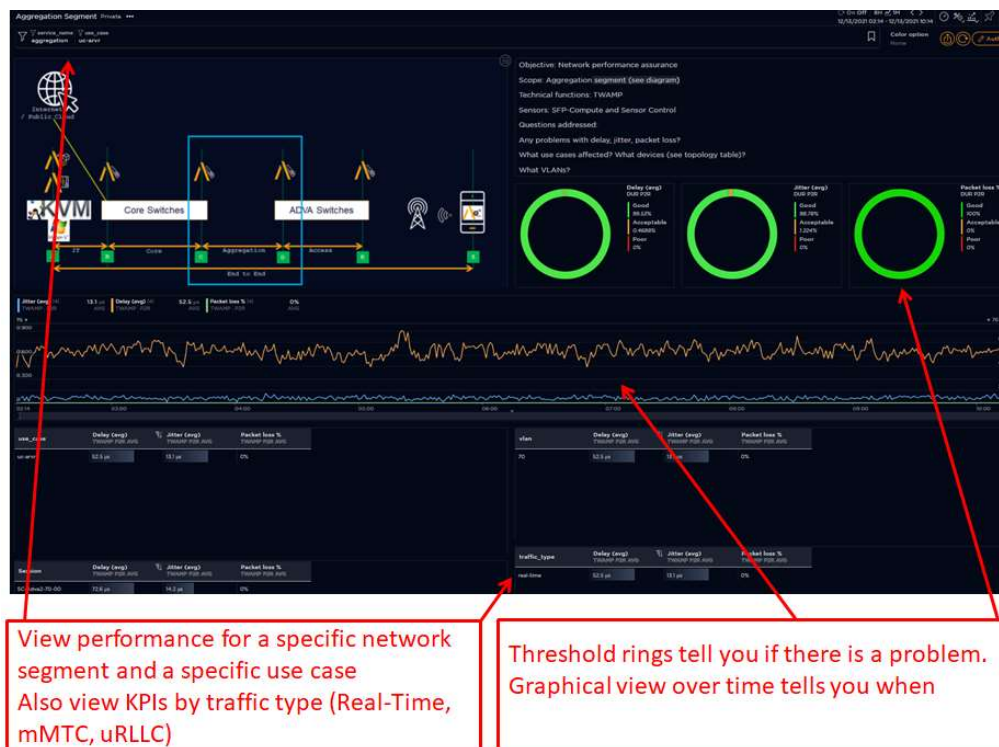
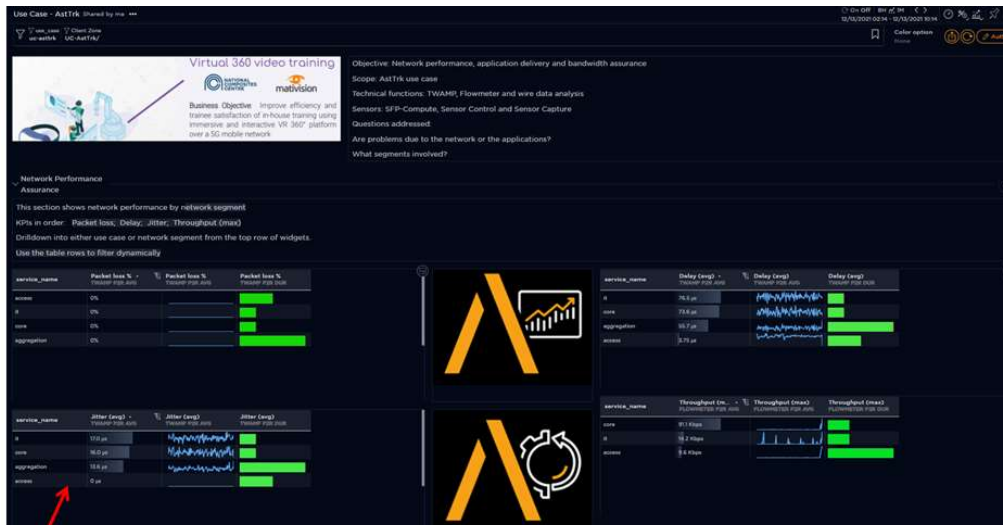


Figure 6: Network Segment Performance

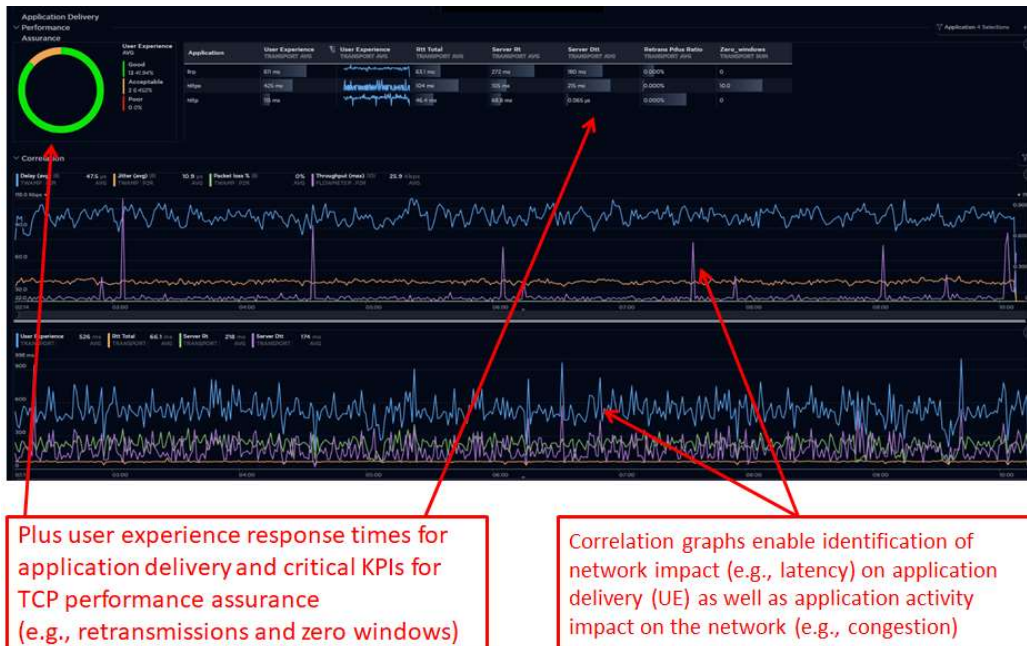
Asset Tracking Use Case dashboard – Network Performance Assurance section



Use Case dashboard also provides breakout of KPIs by network segment

Figure 7: Asset Tracking Use Case Dashboard

Asset Tracking Use Case dashboard – Application Delivery Assurance section



Plus user experience response times for application delivery and critical KPIs for TCP performance assurance (e.g., retransmissions and zero windows)

Correlation graphs enable identification of network impact (e.g., latency) on application delivery (UE) as well as application activity impact on the network (e.g., congestion)

Figure 8: Asset Tracking Use Case Application Assurance charting

Conversations dashboard – filtered for Asset Tracking Use Case

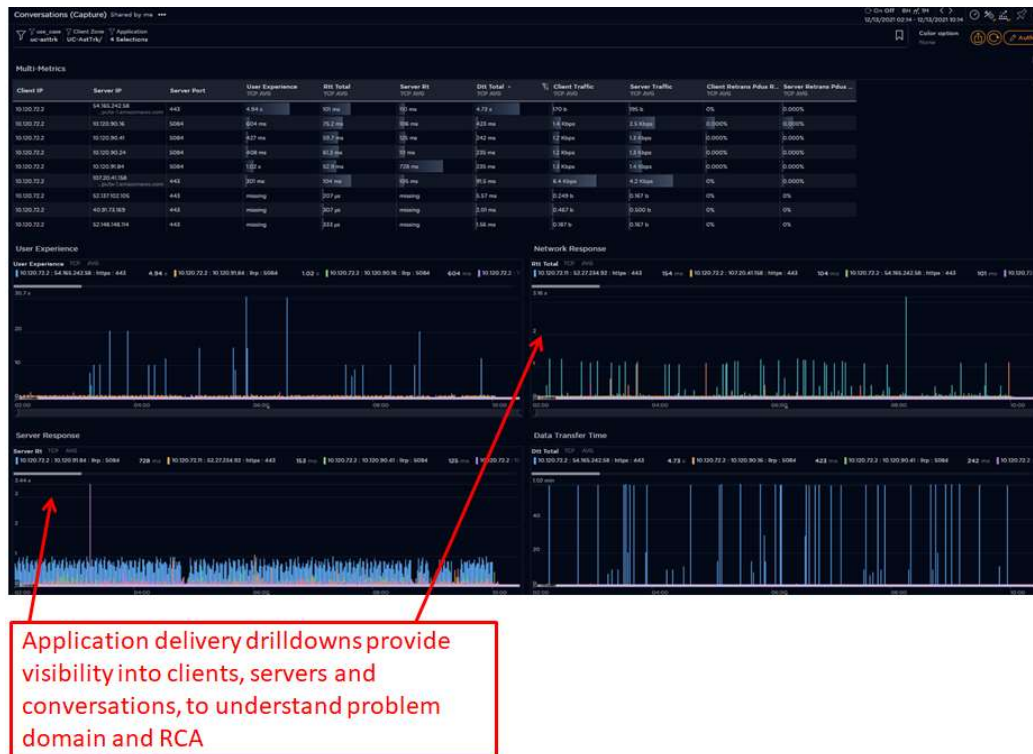


Figure 9: Asset Tracking Use Case filtered data

Bandwidth Usage dashboard

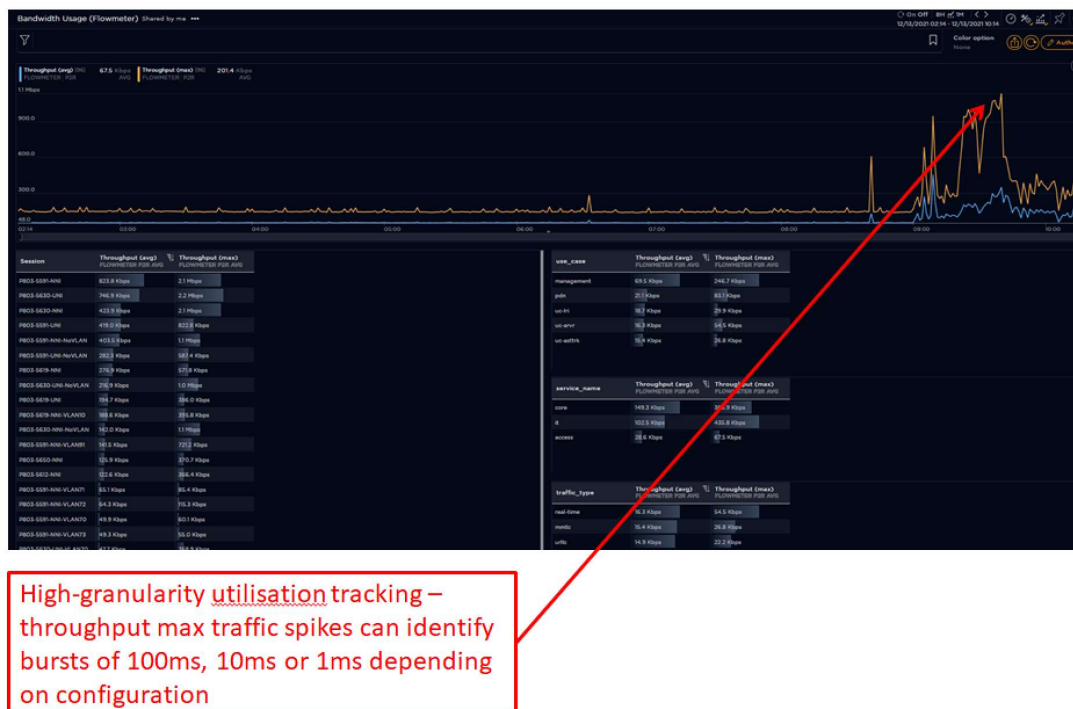


Figure 10: Asset Tracking Bandwidth Usage visualization

Analysis mode on selected data set



Figure 11: Dataset analysis for issue determination

Conversation's dashboard filtered for LRI MEC server and exported as PDF

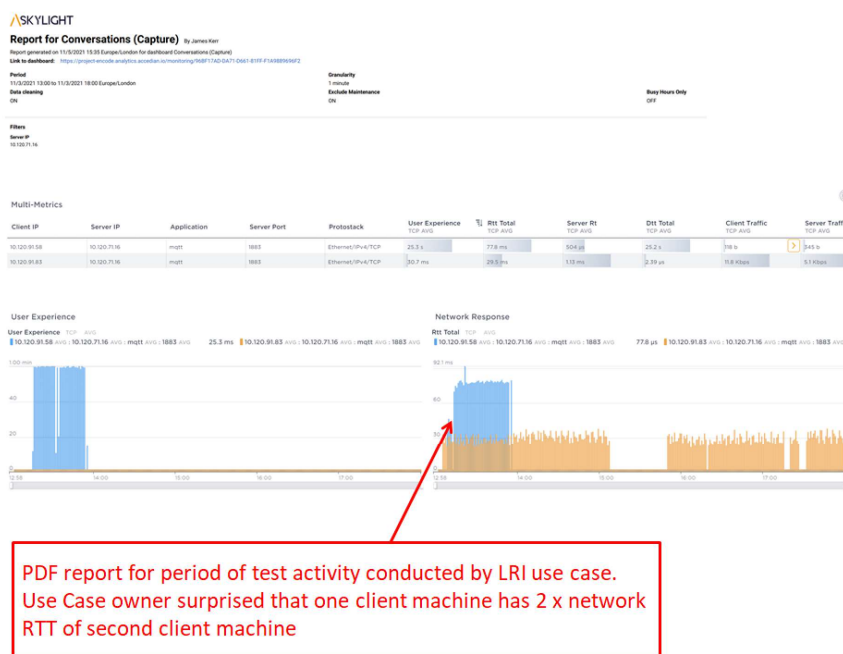
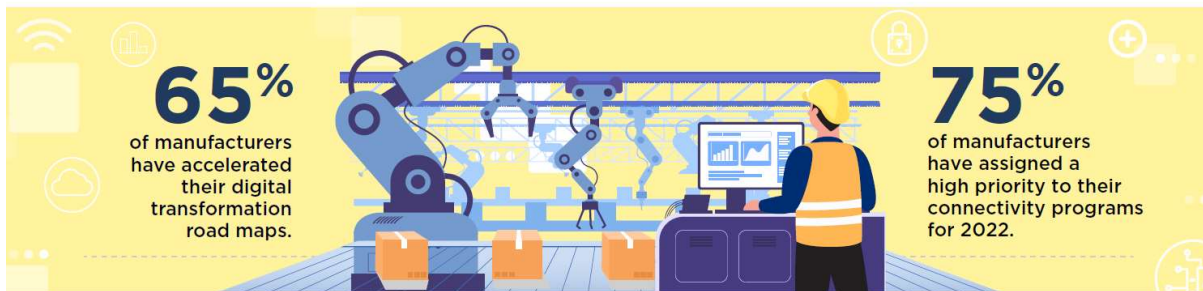


Figure 12: PDF export of conversations data

APPENDIX B

The Network in Manufacturing: 2022 and Beyond Critical to Innovation, Efficiency, and Productivity

- Over 40% of manufacturers reported problems with performance, security, and connectivity with mission-critical workloads.
- 43% of manufacturers cited difficulty in finding staff, training, and skills as their biggest business challenges related to managing the network.



n=167 Source: IDC's Future Enterprise Resiliency & Spending Survey, Wave 7, August
n=159 Source: IDC's Future Enterprise Resiliency & Spending Survey, Wave 4, May

Manufacturing organizations face the challenge of advancing along multiple digital business fronts while operating with already tight budgets driven by a difficult 2020–2021 economic environment. In a series of recent IDC surveys, manufacturers consistently ranked the following as top business priorities: digital innovation, operational efficiency, and employee productivity. It is no coincidence that further IDC research in 2021 indicates that **65% of manufacturers have accelerated their digital transformation road maps** by more than 25% as they move toward 2022 — with almost half of those companies accelerating their DX road maps by more than 50%!

Manufacturers recognize the importance of the network infrastructure to digital success. A 2021 global IDC survey indicated that **75% of manufacturers have assigned a high priority to their connectivity programs for 2022**. A network that provides for consistent, high-quality, and resilient services — and protects connected resources, users, devices, and information — is an absolute necessity in today's hyperconnected manufacturing environment, where data in motion is central to success.

Critical Focal Points for Network Management in Manufacturing

Comprehensive end-to-end network intelligence and insights enable the continuous monitoring and proactive management necessary to meet the evolving demands associated with top digital business priorities. From private network and public cloud services to end-user experiences and smart device exchanges, complete visibility and control assures consistent network service levels, a strong security posture, cost-effective resource use, and ready digital rollouts.



Digital innovation

IDC research indicates that **48% of manufacturers are increasing investment in Internet of Things (IoT) solutions over previously planned levels**. This raises network connections, traffic volumes, and potential vulnerabilities dramatically. At the same time, the global supply chain problems seen across all industries have manufacturers reforming their partner ecosystems. Here, heightened connectivity and interactions with both supply and distribution partners raise external networking and security requirements. Network visibility and control are vital to innovation, whether focused on internal or external systems, services, and processes.



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Operational efficiency

Pervasive secure connectivity and high-impact exchanges among critical manufacturing systems, workers, facilities, and partners guarantee all work in concert, providing for maximum return and resiliency. Network access, threat protection, high performance, and resource (e.g., budget, systems, and services) optimization are prime determinants of success. Here, visibility and control are paramount to network integrity and cost-effective connectivity and operations — no matter the location or demand or endpoint.



Workforce productivity

IT staff shortages, limited cross-IT teamwork, and IT/OT convergence are driving major technical workforce reformation for manufacturing organizations. Digital pressures keep rising, while IT/networking budgets and staffing levels are constrained. Detailed network intelligence and insights boost networking staff productivity and impact in such key areas as problem resolution and network optimization. In addition, improved network visibility and control bolster the effectiveness of other IT teams (e.g., SecOps, DevOps) and promote teamwork across IT through shared network data, views, and toolsets.

While driving forward movement along top business priorities, it is also important to note that heightened network visibility and control help manufacturing organizations overcome significant barriers. In response to a 2021 IDC global survey, **50% of manufacturers cited lack of automation and analytics to optimize their environment as a top barrier to building a resilient digital infrastructure.** In this same survey, other top barriers included cost-effective cloud services management (47%) and performance and security issues with many critical workloads (41%).

The Impact of Network Analytics in Manufacturing

Improved network visibility and control drive significant tactical and strategic benefits to manufacturing organizations. Network analytics solutions stand front and centre in delivering end-to-end visibility and control across the network infrastructure. When done right, network analytics deliver the following key benefits:



Reduction of downtime, slowdowns, and security threats:

Over 40% of manufacturers reported problems with performance, security, and connectivity with mission-critical workloads. Detailed network data and associated analysis of that data provide early warnings based on traffic behaviour for developing problems and threats and direct precise corrective actions. Gains in infrastructure integrity, application performance, data availability, and connected automation heighten operational efficiency, workforce productivity, and product output and quality — critical to customer satisfaction and business profitability.



Acceleration of digital transformation and innovation:

As manufacturers undergo digital transformation, it is critical for the network — and network monitoring and management systems — to readily adapt to dramatic increases in smart devices and machinery, data collection and distribution, new and dynamic workflows, remote work activity, and supply and distribution partner interactions. Complete visibility and control over network components, connected resources, data in motion, and even developing threats drive more predictable results and positive returns from new network technologies, connections, and exchanges.



Improved IT/OT staff productivity and teamwork:

Manufacturers are having difficulty finding the staff/training/skills to meet the needs of evolving network requirements, with 43% saying it was their organization's biggest business challenge related to managing the network. Getting the most from not only the network staff but also the broader IT staff and, increasingly, the OT staff is a critical success factor for manufacturers. Offering a single source of network intelligence and in-depth insights across NetOps, SecOps, DevOps, and OT groups boosts technology worker productivity and impact, which in turn boosts digital infrastructure resiliency and readiness.



Enabling reliable real-time communications and collaboration:

Remote work, partner interactions, customer exchanges, IoT solutions, and data in motion are all accelerating out of the pandemic. End users and smart end devices all require consistent network service to meet the rising expectations of the time-sensitive, highly interactive, and ever-more-virtual digital manufacturing environment. Detailed end-to-end and core-to-client network visibility and control enable the delivery of the best possible digital experience for all — users and machines.

Message from the Sponsor

Driving digital transformation of manufacturing processes and increasing productivity depends on managing and securing applications running locally and in multiple clouds, devices, and networks. Accedian Skylight empowers IT teams to take control of digital experiences for their end users and customers by providing real time business and security insights to assure application and network performance.

Learn more at accedian.com/manufacturing

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