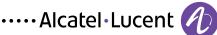# SERVICE-AWARE MANAGEMENT FOR END TO END LTE

APPLICATION NOTE

ABSTRACT

As mobile and IP technologies converge, network management has become increasingly complex. This transformation poses significant operational challenges to mobile service providers. Traditional element and network management solutions do not allow service providers to keep pace with the volume and complexity of today's mobile services. Manual processes are too slow and error prone. Reactive problem detection leads to longer outages and dissatisfied customers. And integration with existing systems and processes is expensive and time-consuming.

Maintaining a high-quality subscriber experience within an LTE network requires operators to respond quickly to the dynamic nature of today's mobile services and demands a new approach to network management.

This application note details how advanced assurance and provisioning capabilities help wireless service providers to efficiently manage the complexities of LTE, from the RAN, across backhaul, to the packet core. Offering rapid provisioning and proactive troubleshooting that spans physical, routing, and service topologies, the Alcatel-Lucent 5620 Service Aware Manager (SAM) portfolio also provides fast and simple integration into existing operational environments and processes resulting in unmatched operational flexibility.

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1. INTRODUCTION

As mobile and IP technologies converge, network management has become increasingly complex. This transformation poses significant operational challenges to mobile service providers. Maintaining a high-quality subscriber experience within an all-IP network requires operators to respond quickly to the dynamic nature of today's mobile services and demands a new approach to network management.

Traditional element and network management solutions do not allow service providers to keep pace with the volume and complexity of today's mobile services. Manual processes are too slow and error prone. Reactive problem detection leads to longer outages and dissatisfied customers. And integration with existing systems and processes is expensive and time-consuming.

What mobile service providers need is service-aware end-to-end management that provides a unified view of all network domains from LTE RAN, across backhaul, to the packet core.

The Alcatel-Lucent 5620 Service Aware Manager (SAM) frees mobile service providers from the traditional boundaries of element and network management, offering advanced assurance and provisioning capabilities designed for the complexities of LTE.

The 5620 SAM provides mobile service providers with:
- Unified, end-to-end management for LTE data and control plane, including RAN, backhaul and packet core
- Automated configuration and flexible provisioning tools to minimize operator error and decrease time to market
- Proactive assurance capabilities that integrate physical, network routing, and service topologies, simplifying management tasks
- A flexible, open architecture that ensures faster and cost-effective integration with existing operational processes and systems
- Full integration with the Alcatel-Lucent 9753 lightRadio™ Management System (LMS) for the management of converged, multi-technology RAN deployments
- Proven solution with more than 400 deployments globally

This document outlines the features and benefits of service-aware network management with 5620 SAM, including:
- Advanced configuration and provisioning capabilities including automation, bulk provisioning, and policy audits
- End-to-end assurance with multi-layer fault correlation and root cause analysis, further easing fault isolation and resolution
- Visualization of the interdomain relationships, enabling operators to both understand the interactions between layers and easily isolate/resolve network issues
- Multi-layer performance management enables troubleshooting, optimization and planning
- Comprehensive Service Level Agreement (SLA) monitoring that proactively detects and isolates SLA violations within any layer of the network
- Management of multiple backhaul technologies for both LTE and 2G/3G mobile environments
- A single GUI, simplifying service introduction and reducing training requirements
- Coordinated security infrastructure, providing operator scope and span of control
- 3GPP- and XML-based northbound interfaces, facilitating integration with higher level OSS/BSS systems

2. RAPID PROVISIONING

The 5620 SAM GUI-based interface provides access to all network elements from a single management point in the network. Intuitive forms support configuration of all aspects of the network elements and simplify provisioning. The 5620 SAM allows for increased automation through work orders, provisioning templates and policies that significantly accelerate provisioning while greatly reducing provisioning errors.

2.1 Control plane bearer deployment

Figure 1 illustrates the 5620 SAM multi-platform capabilities — in this case, defining the behavior of S5 paths between multiple Serving and PDN gateways (SGW and PGW).

Figure 1. 5650 SAM control plane configuration

The configuration forms shown in Figure 1 define global policies on the 5620 SAM that control the behavior of the GPRS Tunneling Protocol (GTP) running over S5 paths between Serving and PDN gateways. After the definition is set, the policy is dispatched to an operator-defined set of gateway nodes and applied locally to the S5 path endpoints on the target nodes. If the operator subsequently changes one or more parameters in the global policy, this change is automatically dispatched to the network elements using this policy, updating local copies of the policy. Using policies to define configuration parameters speeds network turn-up and ensures consistent behavior across a desired set of network elements.
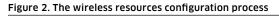
2.2 Configuration policy audits

The 5620 SAM provides a configuration policy audit capability, which allows operators to verify deployed configurations in the network against configurations defined by 5620 SAM policies. The 5620 SAM compares the master configuration rules stored in its database with the configuration deployed on managed network elements, identifying discrepancies, and allowing operators to correct (or accept) the discrepancy.
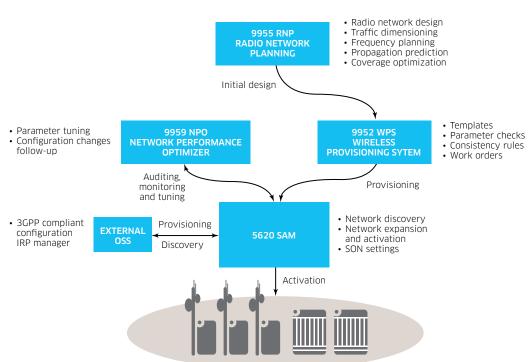
2.3 Radio resources provisioning

Wireless networks have a number of particular constraints that often require the setup of specific processes, including:

• Very high number of network elements (coverage, capacity)

• Continuous evolution of the topology (traffic increase, densification)

• Permanent optimization (changing traffic conditions, new network features or handsets, hardware and software evolutions)

As these processes are key to the efficiency of the rollout and maintenance, the 5620 SAM provides a set of interfaces that help integrate seamlessly and cost effectively within the service provider's own information systems. Alcatel-Lucent optionally delivers a range of powerful products that can carry out part or all of the configuration and provisioning processes, as depicted in Figure 2.

Figure 2. The wireless resources configuration process

2.4 Bulk configuration changes

The Radio Access domain of wireless networks typically contains thousands of base stations, making rapid and secure deployment of new sites in a continuously changing environment a challenge. For that reason, the 5620 SAM provides an additional capability for simultaneous provisioning of large numbers of parameters. This is a key requirement when changing many parameters at the same time or making significant extensions to the RAN.

These changes are usually decided by the network planning teams or are the result of optimization processes. For this reason, and to further increase the integration with the other operational processes, the 5620 SAM offers a tight coupling with a number of products for radio network planning and optimization.

The creation of work orders is supported with a wizard-driven optional Alcatel-Lucent 9952 Wireless Provisioning System (WPS), which addresses the inherent complexity of configuring radio resources. For example, it can autonomously assign the value of 60 percent to 90 percent of parameters, and ensures consistency of network changes. Additional features increase productivity and ensure consistent processes, such as allowing several users to concurrently and securely perform configuration changes on the network.

An activation manager distributes changes to the network elements, ensuring that operators remain in control of subsequent network impacts. As an example, multiple work orders from several operators can be combined to minimize impacts on the traffic. Figure 3 represents a typical change request for a set of cell-related parameters on an eNodeB.

Figure 3. 5620 SAM parameter change over a set of eNodeB cells

Note that the Alcatel-Lucent eNodeB implements Self-Optimizing Networks (SON) features, allowing a subset of its parameters to be autonomously set based on internal algorithms and radio environment monitoring. This will be discovered by the 5620 SAM.

The 5620 SAM northbound interface allows OSS access to all configurable items of the wireless end-to-end network elements, enabling optional flow-through provisioning.

3. PROACTIVE SERVICE ASSURANCE

The 5620 SAM provides a complete fault management solution for all network layers, including:

- Intelligent alarm creation based on events generated by the network elements. These alarms are stored in a central alarm log and are also associated with the 'alarmed' object — for example, a S5 control plane bearer — held within the 5620 SAM, allowing operators easy access to an object's alarm state.
- An alarm correlation function which relates alarms and events to transport layer and dependent Evolved Packet System (EPS) paths in the mobile service layer (EPC and e-UTRAN), allowing operators to quickly and easily understand the root cause of a fault in the network

These capabilities allow operators to quickly identify in which network layer the fault occurred, isolate what physical and logical elements were affected, and determine the cause of the fault and how to resolve it.

Alarms generated by the 5620 SAM are passed to OSS systems through the 5620 SAM northbound interface.

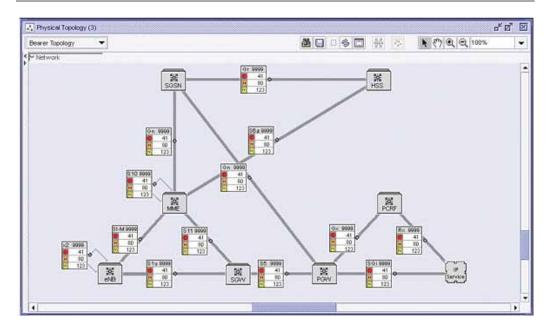## 3.1 Mobile and Transport Layer assurance

The 5620 SAM employs a multi-layer approach for mobile service and transport layer assurance. Its assurance tools enable operators to view and test each network layer end to end, including interlayer integration, allowing operators to easily understand cause and effect between network layers. This multi-layer assurance capability can be applied to both user plane and control plane bearers in the mobile layer, as well as in the underlying IP/MPLS transport layers.

The 5620 SAM assurance tools include:
- EPS path visualization
- EPS path test using the 5620 SAM service test management capability
- Dynamic mobile-to-IP/MPLS transport layer correlation
- IP reachability monitoring (proactive and on demand)
- LTE logical cell service status
- LTE logical interface status, that is, S1, x2
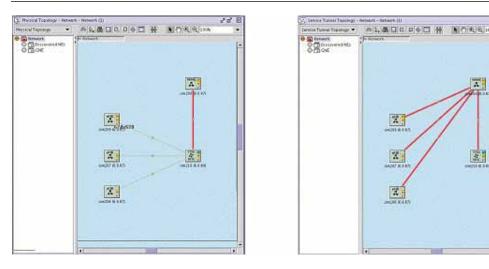- Related LTE equipment alarms

3.2 EPS path visualization

All EPS paths can be viewed from the 5620 SAM topology map (see Figure 4), providing access to a wide variety of information related to each EPS path in the network. The map provides a summary view of the LTE network elements and the Mobile Layer paths (for example, S1-U between the eNodeB and SGW) between them. The path representation between each pair of network elements summarizes all the connections between them and has an associated information table that indicates any active alarms against the underlying paths. From each summary path, the operator can open a pre-filtered list of individual alarmed paths and view detailed state, fault, and performance information related to each path. Information regarding the state of the underlying transport path is also available from the same form.

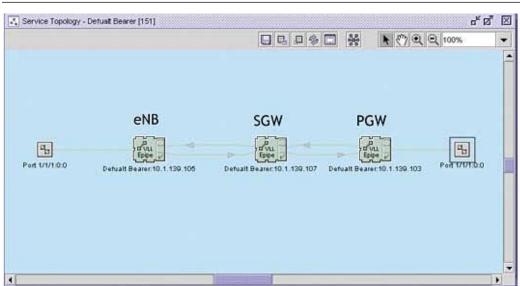**Figure 4. 5620 SAM mobile EPC infrastructure topology**

As part of its bearer visualization capability, the 5620 SAM also provides user plane visualization through its topology maps. As illustrated in Figure 5, the set of nodes (PGW to eNodeB) through which a default/dedicated bearer passes are highlighted on the map. Because user equipment may be engaged in a handover (being handed off from one network element to the next eNodeB to eNodeB or SGW to SGW), maps may be refreshed on demand.

Figure 5. 5620 SAM control plane bearer map – C-Plane and physical views

From the service topology map, operators have access to bearer contexts at the SGW and PGW, which provide state and performance data related to the bearer. From the map window (see Figure 6), the operator can also test the individual segments which make up the bearer (PGW to SGW and SGW to eNodeB), as well as test the end-to-end path (PGW to eNodeB) for IP connectivity, delay, jitter, and packet loss. This latter function is described in more detail in the next section.

Figure 6. 5620 SAM mobile core service topology

3.3 Operations, Administration and Maintenance (OAM) test management

The 5620 SAM provides a test management capability, which — by leveraging the capabilities of the MME, SGW, PGW, eNodeB, and the IP transport layer network elements — allows operators to monitor the SLA behavior of the network.

These OAM measurements can be performed on demand or can be set up to run in the background to monitor connectivity, delay, jitter, and packet loss over the various layers of the network on an ongoing basis. Supported OAM tests include GPRS Tunneling Protocol (GTP) echo, Internet Control Messaging Protocol (ICMP) and Ethernet OAM (802.1ag and Y.1731). This capability allows operators to constantly monitor network behavior and provides a very powerful tool for detecting, isolating, and resolving network faults.

3.4 Advanced route analytics

A significant portion of service failures, provisioning problems, and troubleshooting delays can be directly attributed to IP control plane misconfiguration, undetected routing topology changes, and the lack of simple management tools that reveal the control plane's impact on network services. These operational inefficiencies can lead to a number of business problems for mobile service providers.

Operational inefficiencies make it difficult both to provide consistent quality of service (QoS) delivery and to meet strict SLAs that can differentiate service offerings. Inefficiencies can also make it impossible to scale network operations cost effectively, such as when network operators must rely on scarce in-house IP routing experts to manually resolve Layer 3 infrastructure provisioning problems caused by routing plane misconfiguration.

The Alcatel-Lucent 5650 Control Plane Assurance Manager (CPAM) provides multivendor IP/MPLS route and path analytics, offering scalable, proactive detection and rapid resolution of control plane issues.

The 5650 CPAM is tightly integrated with the Alcatel-Lucent 5620 SAM, giving service providers the industry's first and only fully integrated platform for service-aware element, network, service, and control plane management of IP/MPLS networks. By leveraging its integration with the 5620 SAM, the 5650 CPAM provides simplified diagnosis and intuitive visualization of the relationship between the Mobile Service Layer and the IP/MPLS transport Layer.

With the 5650 CPAM, network operators can overlay Layer 2 and Layer 3 services, MPLS tunnels and service validation traces on the control plane topology map to visualize multiple layers in a single and integrated view.

The 5650 CPAM multi-layer, cross-domain capabilities are based on real-time, multivendor control plane information provided by the Alcatel-Lucent 7701 Control Plane Assurance Appliance (CPAA). The 7701 CPAA is a route-listening and route-processing hardware device that non-intrusively participates in routing plane signaling to obtain details about control plane topology and the operational status of all routers in the network, including third-party devices. The operating system in the 7701 CPAA is based on the Alcatel-Lucent proven and continuously evolving Service Router Operating System (SR OS).

3.4.1 Cross-layer (mobile/IP transport) path correlation

Used in combination with the 5650 CPAM, the 5620 SAM details the relationship between an EPS path (user or control plane) and the end-to-end underlying IP transport layer. If the level of service provided by a bearer is below the acceptable standard (as determined by the OAM test management capability described above), the 5650 CPAM and 5620 SAM can quickly isolate the root cause of the service degradation stemming from underlying IP transport layer issues. Such rapid problem resolution and correlation between two layers — mobile and transport — significantly improves the operational agility of a mobile operator (see Figure 7).
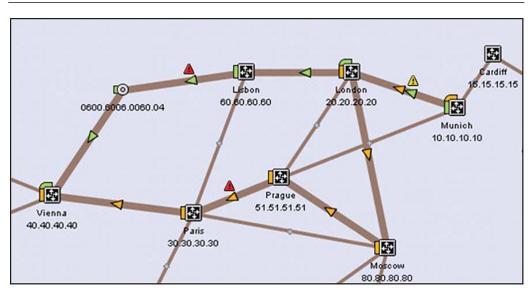
Figure 7. 5650 CPAM IP transport layer path topology

3.4.2 IP reachability monitoring

The 5650 CPAM also maintains a detailed view of the Routing Layer (L3) topology, which it derives from the IP network. Based on this topology view, operators can proactively monitor the reachability of a network IP subnet from any point in the network (that is, assess if there is an IP layer path from SGW and eNodeB).

The 5620 SAM provides the 5650 CPAM with the set of subnets to be monitored using an east-west interface. The 5650 CPAM generates a notification to the 5620 SAM if the reachability of one or more subnets is lost. The 5620 SAM uses this notification to alert operators of problems and affected network elements. With the 5650 CPAM assurance capabilities, operators can then isolate the problem in the routing layer and resolve it.

3.5 Network supervision

Compared to the EPS and IP/transmission domains, the Radio Access Network involves many more network elements and logical resources, typically several thousands for large networks. This is where wireless service providers need purpose-built, highly scalable systems to keep control of the network health without requiring multiple separate management systems and large network assurance teams.

In addition to the usual fault management capabilities that include logging, synchronization, escalation browsing and filtering the alarms, the 5620 SAM implements a workspace organization concept consisting of the following capabilities:
- Supervision groups
- Supervision summary view
- Service views (network elements, interface resources, radio resources)

3.5.1 Supervision groups

This capability allows the operators to group collections of network elements for the purpose of monitoring a given subset of the network thanks to alarm and state information. The rules for defining contents of groups are very flexible in order to match any organizational or operational constraints.

3.5.2 Supervision summary view

A summarized display of the network status helps to quickly identify issues for one or more of the supervision groups, allowing operators to concentrate on fewer, and larger portions of the network, instead of being overwhelmed by large numbers of individual nodes. Multiple detailed views can be quickly displayed by selecting one of the groups, offering various resource type levels, including:
- Network elements
- Radio resources
- Interface resources

Figure 8 represents the supervision window and shows on the left pane four groups with the number of outstanding events for each of these groups:

- Active alarms (unacknowledged and acknowledged)
- Radio resources (cells) operationally down
- Logical interfaces (S1 and X2) operationally down

Figure 8. 5620 SAM supervision group view

3.5.3 Network element view

Figure 9 shows another way of representing large subsets of the RAN, while enabling fast access to the most important service assurance information. This view displays in a tabular format all the network elements of the supervision group selected, indicating a set of critical information such as alarm and state summary, and running software version.

Figure 9. 5620 SAM network element summary view
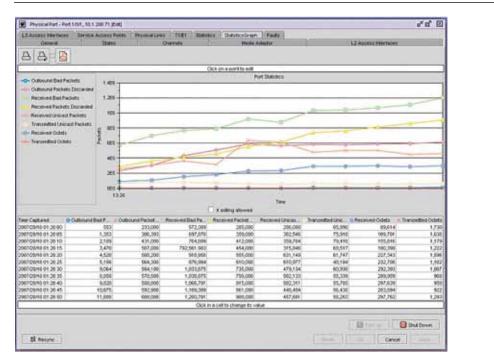
3.6 Performance management

A comprehensive set of statistics counters — collected by the 5620 SAM from the MME, eNodeB, SGW, and PGW nodes — enables operators to monitor network activity, collect planning data, and diagnose faults with the network. A typical performance management data form (shown in Figure 10), displays performance management data collected from a network element.

Performance management data can be collected by the 5620 SAM either on demand or at regular intervals (as defined by a statistics polling policy). The operator has complete control over the set of SNMP MIB tables that are polled by the 5620 SAM, as well as the polling frequency. Polled performance management data are stored in the database and are accessible using the northbound interface.

Figure 10. 5620 SAM statistics log record

The 5620 SAM also provides real-time plotting (shown in Figure 11) for both real-time and historical counters, providing operators with a visual representation of performance data. The minimum collection frequency for the statistics plotter is 10 seconds for real-time data. Multiple counters can be plotted simultaneously on the same plot window for comparison purposes, and multiple plot windows can be open at the same time.

Figure 11. 5620 SAM statistics display

The RAN measurements are collected and stored by the 5620 SAM in a 3GPP-compliant format. As described in the previous section, wireless networks have special requirements in terms of provisioning, and also in terms of performance monitoring and optimization. Dedicated monitoring and optimization systems are available to analyze the very large number of measurements and traces collected by the various network elements to characterize the RAN behavior and ensure the subscribers are experiencing the best quality of experience (QoE). Interactions and roles of these different products with the 5620 SAM are summarized on Figure 12.

Figure 12. The performance monitoring process

4. OPERATIONAL FLEXIBILITY AND SECURITY

Flexible external interfaces and security mechanisms implemented in the 5620 SAM are key to accelerating its integration within the service provider's environment, processes and organization.

For example, the 5620 SAM features a multi-layer security architecture. The system authenticates operators by username and password before they are allowed to access the 5620 SAM GUI. This authentication can be carried out in conjunction with a RADIUS or TACACS + server. User profiles, assigned at login, provide the administrator with fine-grained control over an operator's access rights and privileges. The 5620 SAM has additional span-of-control capabilities, allowing the system administrator to limit an operator's privileges to a subset of managed network elements.

Custom-built, lightweight web-based service portals can add additional flexibility in adapting the product to the specific needs of a service provider. For more information, please visit www.alcatel-lucent.com/serviceportal.

The 5620 SAM offers an XML-based northbound interface, which provides access to all information stored within the 5620 SAM database. Through this interface, an OSS system has access to all configuration capabilities (read/write), performance management data, and alarm information related to the managed network elements and stored in the 5620 SAM database.

This northbound interface allows mobile operators to integrate all managed elements into an OSS infrastructure using a single interface. The interface abstracts, for OSS systems, the different types of network elements and different software versions deployed in the network, dramatically reducing integration costs and complexity. It also reduces network bandwidth consumption, enabling multiple OSS platforms to request the same data from the 5620 SAM instead of going directly to the network elements.

The 5620 SAM also supports 3GPP interfaces for a large set of Information Reference Points (IRPs), including alarm, configuration management, performance monitoring and inventory.

The OSS Connected Partner Program provides ongoing (release over release) certification between the 5620 SAM northbound interface and pre-integrated products from leading independent software vendors. This certification reduces the time and cost of integrating the 5620 SAM into a mobile service provider's network environment.

5. CONCLUSION

The Alcatel-Lucent LTE Network Management Solution provides advanced assurance and provisioning capabilities designed to help wireless service providers to efficiently manage the complexities of today's LTE deployments, from wireless access, across backhaul, to the packet core. Offering rapid provisioning and proactive troubleshooting that spans physical, routing, and service topologies, the 5620 SAM also provides fast and simple integration into existing operational environments and processes, resulting in unmatched operational flexibility.

Proven in more than 400 customer deployments worldwide, including some of the largest and most advanced networks, the 5620 SAM equips mobile service providers with the tools required to manage their networks efficiently.

As service providers continue to transform their networks and services and evolve their operational models, the modular, extensible, and scalable architecture of the 5620 SAM not only addresses today's mobile network challenges but provides a foundation to support tomorrow's market-leading, mobile and converged service offerings.

To learn more, please visit our web site:
- Alcatel-Lucent 5620 SAM – www.alcatel-lucent.com/5620sam
- Alcatel-Lucent 5650 CPAM – www.alcatel-lucent.com/5650cpam
- Alcatel-Lucent OSS Connected Partner Program – www.alcatel-lucent.com/osscp

6. ACRONYMS

3GPP	3rd Generation Partnership Project
BSS	Business Support Systems
EPC	Evolved Packet Core
EPS	Evolved Packet System
GPRS	General Packet Radio Service
GTP	GPRS Tunneling Protocol
GUI	Graphical User Interface
ICMP	Internet Control Messaging Protocol
IRP	Information Reference Point
LTE	Long Term Evolution
MME	Mobility Management Entity
MPLS	Multi-Protocol Label Switching
OAM	operations, administration & maintenance
OSS	Operation Support Systems
PGW	Packet Data Network Gateway
PDN	Packet Data Network
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
SGW	Serving Gateway
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SON	Self-Optimizing Network
UTRAN	Universal Terrestrial Radio Access Network
XML	eXtensive Markup Language