IP-OPTIMIZED MOBILE GATEWAY

THE EVOLUTION OF DELIVERING DIFFERENTIATED MOBILE BROADBAND SERVICES

STRATEGIC WHITE PAPER

Mobile networks have flattened and IP has been adopted as the networking standard. Emerging service demands are being driven by the rapid adoption of smartphones, the deluge of IP-based mobile applications and the shift in mobile user behaviors. In this environment, mobile network operators need to handle the new service demands, simplify their networks, lower OPEX, and plan for future growth. This paper explains why the Alcatel-Lucent 7750 Service Router as a mobile gateway is uniquely optimized for mobile IP networks, now and for future growth and evolution.

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THE NEW ERA OF IP-OPTIMIZED NETWORKS

The world has embraced IP as the de facto standard for networking within telecom operators' infrastructures. Because IP-based networks are interoperable and flexible, they are easy to modify as new functions and features become available through technological advancements without the need for a new infrastructure.

With the adoption of ubiquitous IP networking, operators are in a position to reap operational benefits because their core IP infrastructure can be used to transport packets across many of their revenue-generating businesses (including video, voice, VPNs and the Internet) using many different access methods: 2G/3G, LTE, DSL, GPON and Wi-Fi.

Many Mobile Network Operators (MNOs) have moved or are moving in the direction of a flat, all-IP infrastructure by renovating and upgrading their existing 2G and 3G networks to a Long Term Evolution (LTE) infrastructure. In addition to LTE, other all-IP infrastructures such as LTE-advanced and 5G will naturally follow. LTE and these emerging infrastructures really change the game for MNOs because LTE is more operationally efficient from both a spectral efficiency perspective and a network and packet core perspective. In addition, LTE offers the ability to improve the broadband experience for users.

Users of an all IP infrastructure like LTE will benefit from: a significant increase in download/upload speeds, lower latency, lower connection setup times and deterministic Quality of Service (QoS) capabilities. The results are a dramatic increase in Quality of Experience (QoE) for the users, lower operational expenditure (OPEX) and an opportunity for MNOs to be leaders in service delivery and innovation, and to capitalize on new business opportunities.

A recent global service provider survey by Infonetics [1] shows that the top three drivers for MNOs to upgrade to LTE were better spectral efficiency, higher peak rate and lower latency. When survey participants were asked, in an open-ended question, to provide their key driver for LTE, the desire to offer new services with a better user experience emerged as a key requirement.

MNOs are adopting LTE at an aggressive pace. According to the Global Mobile Suppliers Association (GSA), 213 operators have commercially launched LTE services in 81 countries and 456 operators are investing in LTE in 134 countries. GSA forecasts there will be 260 commercial LTE networks in 93 countries by end 2013. [2]

THE GAME CHANGES WITH LTE

As LTE moves toward mass market deployment, higher expectations by end users for service performance and service innovation will lead to new business models. The higher peak rates, lower latency, improved setup times and more deterministic QoS enforcement capabilities that LTE enables will be leveraged by MNOs to drive a better service experience for their users. However, the status quo must change because legacy packet cores are not designed to handle the emerging demands of this service evolution.

The rise of the control plane

This emerging service reality will change the way MNOs need to think about the architecture of their mobile networks. Packet core signaling volumes, even in the early deployments of large-scale LTE networks, are significantly higher than in existing 2G/3G core networks. The rise in signaling can be attributed to a dramatic shift toward the use of smartphones, dozens of "chatty" applications (for example, social networking, gaming and messaging) that are constantly signaling the mobile network for information and updates, and changing user behaviors.

Other functions can also consume a lot of signaling resources. For example, a smartphone may have as many as 30 to 40 transitions from idle to active and active to idle in a busy hour, putting a severe and sometimes unexpected strain on the control plane. Furthermore, frequent handovers from LTE to 3G because of spectrum shortage or coverage holes adds to the control plane overhead. In some large US metropolitan markets, where LTE is available, network peak usage is as high as 45 service requests per user equipment (UE) per hour in peak busy hours.

As LTE grows in popularity, signaling in LTE's Evolved Packet Core (EPC) will continue to rise, increasing the potential for control plane congestion and signaling storms if not properly managed. As a result, it is clear that the LTE EPC will need to scale significantly in the control plane. For more information on the impact of LTE signaling, please refer to the article Managing LTE Core Network Signaling Traffic [3].

The new data plane requirements

In addition to an increase in control plane traffic, there will be a dramatic shift in the requirements of the data plane. Internal research by Bell Labs show that mobile network data volumes continue to rise and are forecasted to grow to over 15,000 Peta Bytes at a 90 percent annual growth rate (CAGR) to the end of 2016. In addition, there will be a dramatic shift in the requirements of the data plane as legacy best-effort deployments, typical with 2G and 3G mobile networks, move to a higher-performance but more deterministic QoS-driven infrastructure.

For example, voice over LTE (VoLTE) is an operator-owned service offered through the user's data connection but delivered with specific performance characteristics. To deliver VoLTE, the network must dedicate a specific throughput for the lifetime of each call and provide a specific QoS to every VoLTE packet delivered. In addition, the smaller VoLTE packets require the data plane to handle a correspondingly larger packet transmission rate when compared to transmitting much larger packets. This strain on the data plane is further exacerbated by the requirement of concurrently delivering other services with completely different QoS requirements, such as video and all of its various speeds and formats.

In addition to the preceding data plane requirements, MNOs are more frequently deploying advanced packet processing capabilities using L4-L7 Deep Packet Inspection (DPI) techniques to identify and act on specific packet flows for many consumer-orientated Internet services. As an example, this capability allows an MNO to uniquely identify a specific packet flow and achieve differentiated QoS treatment and billing across various Internet services, such as streaming video, social media and gaming.

Some MNOs deploy external DPI appliances for advanced packet processing to physically decouple this functionality from the mobile gateway (MGW). However, doing so increases cost and operational complexity. Others prefer to use DPI capabilities that have been integrated into the MGW itself. Integrated DPI approaches can be very efficient but scaling issues can ensue if processing is performed with shared CPU resources for both control and data.

The problem with legacy packet cores

The new and emerging requirements present a significant challenge for legacy packet cores. Most existing packet core products were developed when control and data rates were low enough that the scalability of both could be concurrently handled by common CPU-based forwarding architectures. These legacy architectures will now have to trade off control plane scalability with data plane scalability. Increase one and the other falls.

This lesson was learned years ago in the design and build-out of fixed-access IPTV networks as operators transitioned from CPU-based routers to those making extensive use of Network Processors (NPs). The heretofore narrowband nature of cellular data rates has allowed CPU-based products to hang on…until now.

ALCATEL-LUCENT IP-OPTIMIZED MOBILE GATEWAY

A cornerstone of the Alcatel-Lucent approach to delivery of the next generation of mobile broadband services is the Alcatel-Lucent 7750 Service Router (SR) functioning as an IP optimized MGW. The concept of IP-optimization is represented by a combination of features that uniquely position the 7750 SR as an MGW apart from its competitors in the industry. Table 1 summarizes the IP-optimized criteria.

Table 1. IP-optimized criteria of the 7750 SR as a MGW

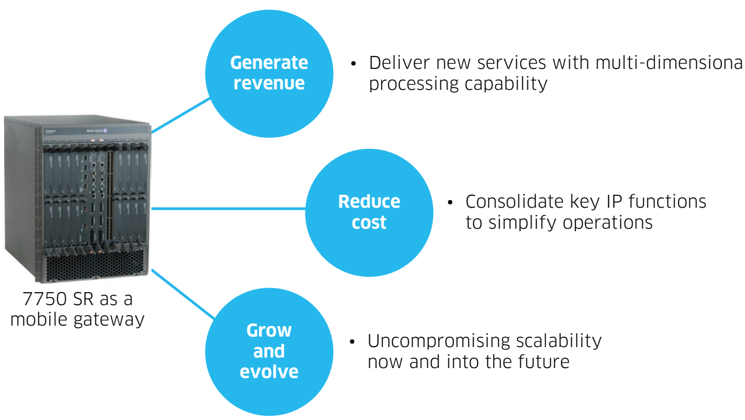
IP-optimized criteria	Benefit
Purpose-Built NP-based silicon designed for next-generation differentiated services	NP-based, award-winning FP silicon designed specifically for the stringent demands of packet processing (such as inspection, forwarding, QoS, accounting, charging and reporting) for each individual IP service flow
Dedicated CPU for control plane processing	The logical and physical separation of the control plane processing, including GPRS Tunneling Protocol – Control Plane (GTP-C), Authentication, Authorization and Accounting (AAA), Policy and Charging Control (PCC) and Online Charging System (OCS), from the data plane packet processing, dramatically increasing scale and performance for the emerging next-generation service demands
Dedicated CPU for advanced packet processing	Performs sophisticated L4-L7 in-line inspection, analysis and processing without additional equipment and without affecting data plane or control plane performance
Inherent IP routing and connectivity capabilities	World leaders in IP routing, Multiprotocol Label Switching (MPLS), Border Gateway Protocol (BGP) functionality, as well as IP connectivity features, including Ethernet Operations, Administration and Maintenance (EthOAM), Bidirectional Forwarding Detection (BFD) and Link Aggregation Group (LAG)
Concurrent multi-functional MGW capabilities	Concurrent support of GPRS Support Node (GGSN), Serving Gateway (SGW) and PDN Gateway (PGW) functions in a single platform and on a single card
Concurrent multi-functional IP network capabilities	Concurrent operating system support for backhaul aggregation routing and provider edge (PE) routing Support for Wireless LAN (WLAN) GW, Broadband Network Gateway (BNG) and IP Security (IPSec) on the same 7750 SR hardware
Enterprise service GW capabilities	Concurrent support for MGW and mobile-access enterprise business VPN services
Advanced hierarchical QoS	Delivers advanced LTE services with uncompromising performance for each user and each application
Non-stop services and non-stop IP routing	Intershelf and instrashelf redundancy with no single point of failure, providing the best-in-class high availability needed to preserve end-user QoE

With an IP-optimized approach leveraging the capabilities outlined in Table 1, the 7750 SR as an MGW is able to:

- Generate revenue by effectively delivering the next generation of differentiated mobile broadband services with scale and performance while overcoming the challenges discussed
- Reduce OPEX by simplifying the IP infrastructure, offering ways to combine and collapse key IP functions needed in the mobile infrastructure
- Flexibly grow and evolve the mobile network with uncompromising scalability as service demands increase

These values are reflected in Figure 1 and represent the areas that set Alcatel-Lucent apart in the industry.

Figure 1. Key values of the 7750 SR as a mobile gateway



Deliver differentiated broadband services

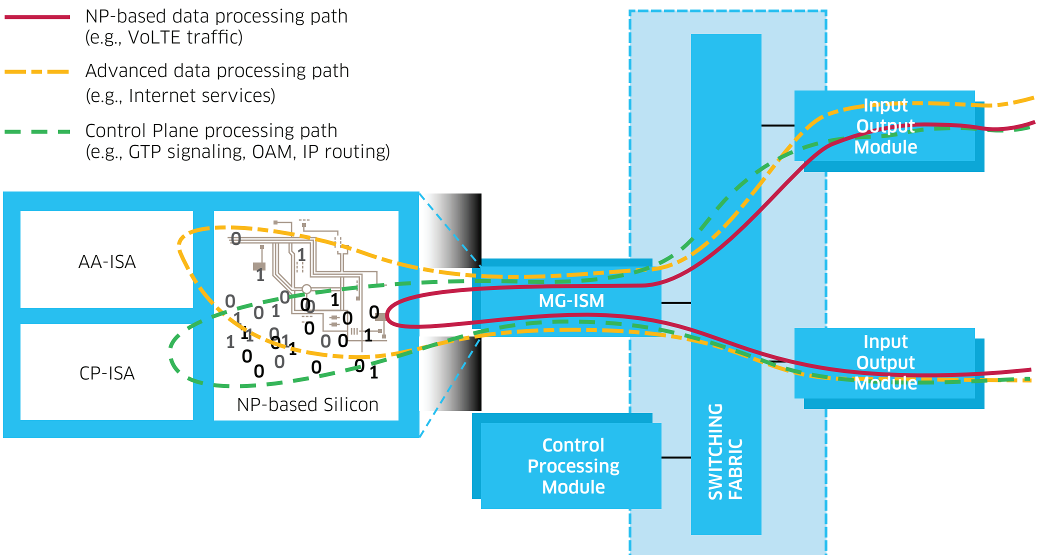
To deliver the next generation of differentiated broadband services while overcoming the delivery challenges that legacy MGWs face, the 7750 SR as an MGW offers a unique delivery architecture. The key to this architecture is its ability to scale independently and concurrently in three dimensions: the control plane for network instructions, the data plane for multiservice processing such as VoLTE and video, and the advanced data plane for deeper levels of packet processing typical for many consumer-orientated Internet services.

The key enabling technology that offers this is the Mobile Gateway - Integrated Services Module (MG-ISM). The MG-ISM provides control and data plane handling for the SGW, PGW and GGSN functions. The processing capabilities of the MG-ISM are segregated into three independent hardware and processing paths:

- NP-based packet processing path designed specifically for the stringent demands of multiservice packet processing (including shallow packet inspection, forwarding, QoS, accounting, charging and reporting) for each individual IP service flow
- Advanced data processing path leveraging the Application Assurance Integrated Services Adapter (AA-ISA) that performs sophisticated L4-L7 in-line traffic processing called Application Assurance
- Control plane processing path leveraging the Control Plane - Integrated Services Adapter (CP-ISA), which provides a high-speed CPU to perform the control functions related to subscriber connections

Figure 2 shows this architecture as different traffic flows traverse it: control traffic, VoLTE traffic and consumer-orientated Internet traffic. The control traffic requires specific packet processing from the CP-ISA and follows the control plane processing path. The VoLTE traffic requires high-touch packet processing and follows the NP-based data processing path. The Internet traffic requires advanced L4-L7 packet processing from the AA-ISA and follows the advanced data processing path.

Figure 2. Internal architecture of the 7750 SR as a mobile gateway

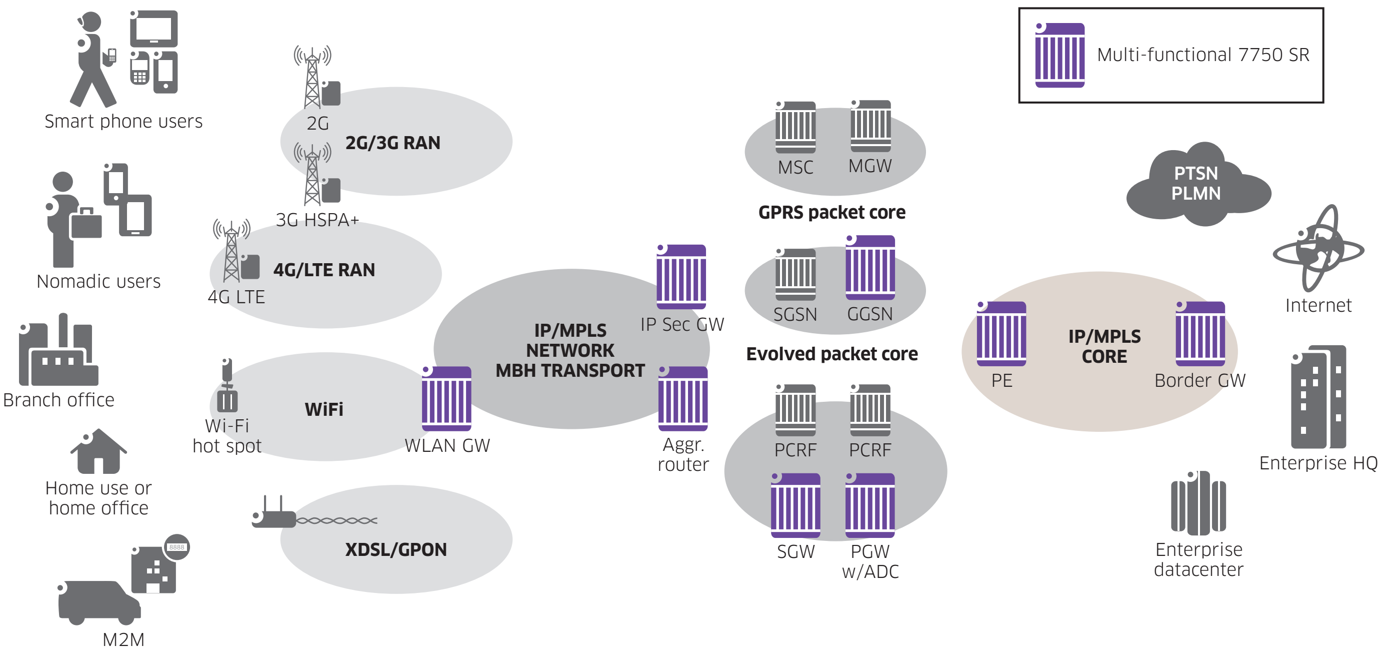


This architecture allows an MNO to handle the delivery of multiple services to each user with uncompromising performance and scalability. Services such as HD video, HD voice, gaming, machine to machine (M2M) communication and Internet partner services (for example, a social media package) need to be delivered concurrently with specific service expectations. Alcatel-Lucent has already demonstrated this multiservice scalability across millions of users and bearer channels and tens of millions of Service Data Flows (SDFs). For the details, see "Delivering Voice in the Emerging Era of LTE" [4].

Simplify operations and lower OPEX

MNOs strive to lower OPEX while streamlining their operations model. By collapsing certain functions on a single platform, MNOs can achieve both goals. Within a mobile infrastructure there are multiple required IP functions that can be consolidated to provide opportunities to simplify and streamline the network. As shown in Figure 3, the 7750 SR can perform many functions in the mobile infrastructure.

Figure 3. The multiple functions of the 7750 SR in the mobile network infrastructure



3GPP core mobile gateway functions

For 3G networks, the core MGW functions are in the GGSN. For LTE networks, the core MGW functions are in the SGW and the PDN Gateway (PGW). Many mobile networks will need to provide concurrent support for both 3G and LTE networks for a long time to come, so the ability to support all of these functions from the same platform is important. The 7750 SR as an MGW supports all of these functions on the same chassis and even on the same MG-ISM.

Mobile Backhaul Aggregation Router

Another function that MNOs can consolidate onto the MGW is the Mobile Backhaul Aggregation Router, which terminates the cellular traffic from the backhaul network and routes it to the core. The Aggregation Router is located at the edge of the backhaul network and is typically connected directly to the SGW function in the packet core. By collapsing the aggregation routing function and MGW function on the same chassis, MNOs can lower both capital expenditure (CAPEX) and OPEX.

For small to mid-sized MNOs, whose data volumes may be small at first, being able to support SGW and PGW capabilities on the same chassis and card is attractive. Providing aggregation routing capability as well can be a very compelling offering.

The SGW is also a natural candidate for local geographic distribution because it is the mobility anchor point and tracks the UE mobility as the UE moves through the local market. Distribution also opens up opportunities for collapsing the routing function at the distribution point. ABI Research sees this as a natural evolutionary path:

"3GPP also has separated the control plane from the user plane in the network, and this encourages the evolution to a distributed architecture with centralized control elements and locally distributed data paths." [5]

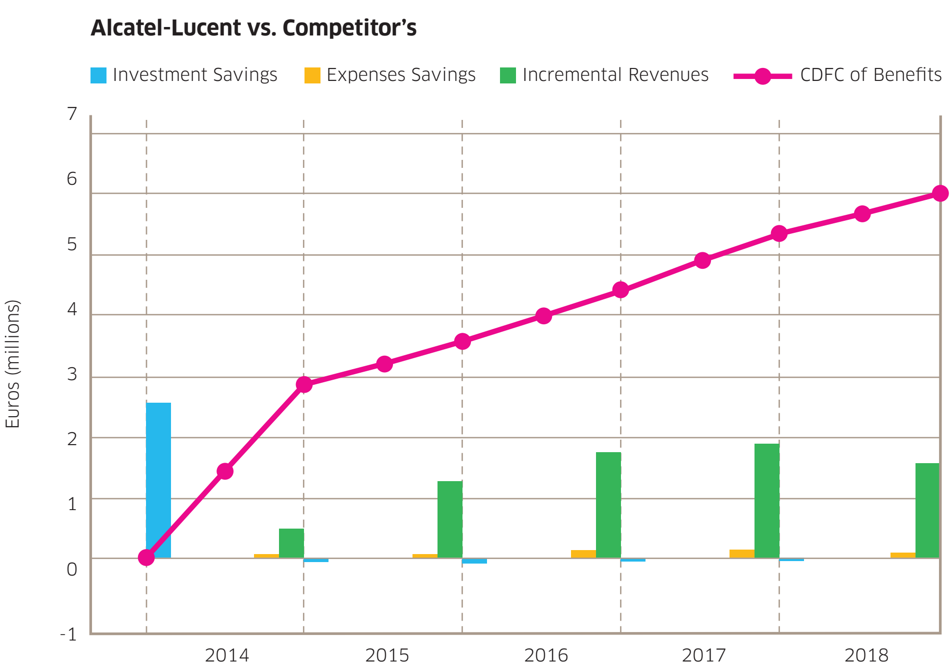
Alcatel-Lucent Enterprise Services Gateway

The Alcatel-Lucent Enterprise Services Gateway is a dedicated node that allows operators who offer fixed-line VPN services to augment their existing offering with 3G or LTE access, adding incremental revenues while offering an enriched service. By leveraging the 7750 SR in this role, the GGSN (or PGW) and PE routing functions can be collapsed into a single node. The results are significant CAPEX and OPEX savings and a substantial incremental return on investment (ROI) when compared to a competitor's approach.

Alcatel-Lucent studied the business case for this opportunity and developed a model for a medium-sized European operator providing services to nomadic business users. The model compared CAPEX, OPEX, revenue and Network Present Value (NPV) for the Alcatel-Lucent approach and a competitor's solution that required a separate PE router. The study shows that deploying the Enterprise Services Gateway could result in significant benefits over competitors' alternatives.

Figure 4 shows the benefits of the Alcatel-Lucent approach relative to a major competitor's solution over a period of 5 years. The graph displays the Cumulative Discounted Cash Flow (CDCF) of benefits based on the yearly investment savings, expense savings and incremental revenues of the Alcatel-Lucent approach compared to the competitor approach.

Figure 4. CDCF of benefits for with Alcatel-Lucent approach



The Enterprise Services Gateway resulted in a total of 6 million euros NPV of incremental benefits by Year 5.

Application detection and control

The 3GPP Application Detection and Control (ADC) function leverages DPI technology to offer L4-L7 application inspection and detection capabilities that enable dynamic policy control on specific IP packet flows.

For the 7750 SR as an MGW, the ADC capability is inherent on each MG-ISM through the AA-ISA and requires no external additional platform or appliance. The inherent processing capabilities include L4-L7 in-line inspection and analysis, and advanced packet processing of specific application-level IP traffic flows. These capabilities, collectively known as Application Assurance (AA), leverage embedded subscriber, service and application intelligence to provide enhanced integrated service capabilities, effectively extending the 3GPP ADC functionality.

In addition, AA allows the MGW to implement both the Policy Charging Enforcement Function (PCEF) and ADC under a common Gx PCC rule set for policy control and charging rules.

WLAN Gateway

Wireline and wireless providers are making significant investments in Wi-Fi as an access technology to expand their service footprint. Wi-Fi enjoys widespread device support and end-user acceptance, as evidenced by the proliferation of both paid and free Wi-Fi services. The WLAN GW is the network element defined within the 3GPP standards for trusted Wi-Fi access to the mobile packet core.

The WLAN GW provides three essential functions:

- Secure tunneling and aggregation of traffic from Wireless access points
- Access to the EPC through secure tunneling mechanisms
- An interface to the Home Subscriber Server (HSS)/AAA for authentication of the UE

In 3GPP terminology, the WLAN GW is referred to as the Trusted Wireless Access Gateway (TWAG).

The 7750 SR-based WLAN Gateway supports a variety of wholesale and retail service models suitable for service providers, multiple service operators (MSOs), MNOs and mobile virtual network operators (MVNOs). The WLAN GW function is supported on the same 7750 SR chassis used for the 7750 SR as an MGW.

Flexibly grow and evolve your network

Growing the mobile network to support more and more user sessions, across more and more services, will create an unpredictable increase in both user data volumes and signaling demands. Mobile gateways must adapt to this growth while ensuring that packet processing performance, which is directly tied the user experience, does not suffer.

The 7750 SR is built for scalability and growth of packet processing demands, as exemplified by its multi-dimensional scalability. With the 7750 SR as an MGW, the MNO is assured that performance will not suffer as the platform is pushed to its stated limits on number of bearer channels, throughput, SDFs and other parameters.

As competitive forces mandate cost reduction and service differentiation, MNOs are exploring Network Functions Virtualization (NFV) and cloud architectures as a network evolution path. The 7750 SR as an MGW supports this path to virtualization while continuing to increase scalability and evolve to meet 3GPP gateway requirements. This capability enables MNOs to evolve their network into virtualized, cloud-based architecture at their own pace while being assured that their existing MGW can meet performance and scalability requirements for years to come.

CONCLUSION

IP networking and existing and emerging radio standards such as LTE, LTE-Advanced and 5G are driving a service inflection point that necessitates an architectural change by MNOs. This is especially true with MGWs because legacy elements are not designed for the new and emerging scalability requirements.

MNOs need an MGW that supports the multi-dimensional scaling required to meet these demands without service or performance degradation. The Alcatel-Lucent 7750 SR as an MGW is uniquely suited to meet these requirements because it scales, independently, the control plane for network instructions, the data plane for multi-service processing, and the advanced data plane for consumer-orientated Internet services.

Coupled with these advanced service capabilities, the 7750 SR as an MGW offers multiple essential IP networking functions that can be collapsed onto a single node, greatly simplifying the network while lowering OPEX.

As networks inevitably grow and evolve, the 7750 SR as an MGW is positioned to support massive growth with no service deterioration while offering a path to virtualization.

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ACRONYMS

2G	second generation
3G	third generation
3GPP	3rd Generation Partnership Project
4G	fourth generation
5G	fifth generation
7750 SR	7750 Service Router
AAA	Authentication, Authorization and Accounting
AA	Application Assurance
AA-ISA	Application Assurance - Integrated Services Adapter
ADC	Application Detection and Control
BFD	Bidirectional Forwarding Detection
BGP	Border Gateway Protocol
BNG	Broadband Network Gateway
CAGR	compound annual growth rate
CAPEX	capital expenditures
CP-ISA	Control Plane - Integrated Services Adapter
CPM	Control Processing Module
CPU	central processing unit
DPI	Deep Packet Inspection
DSL	Digital Subscriber Line
EPC	Evolved Packet Core
GGSN	Gateway GPRS Support Node
GPON	Gigabit-capable Passive Optical Network
GPRS	General Packet Radio Service
GSA	Global Mobile Suppliers Association
GTP-C	GPRS Tunneling Protocol – Control
GW	gateway
OM	Input Output Module
IPSec	IP Security
IPTV	Internet Protocol television
LTE	Long Term Evolution
MG-ISM	Mobile Gateway – Integrated Services Module
MGW	Mobile Gateway
MNO	Mobile Network Operator
MPLS	Multi-protocol Label Switching
NP	Network Processor
NPV	net present value
OCS	Online Charging System
OPEX	operational expenditure
PCC	Policy and Charging Control
PDN	Packet Data Network
PE	provider edge
PGW	PDN Gateway
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
SDF	Service Data Flow
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
UE	user equipment
VoLTE	Voice over LTE
VPN	Virtual Private Network
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
XDSL	any DSL