White Paper

Personalized Subscriber Services: Architectural Options for Mobile Operators

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Personalizing Mobile Network Services

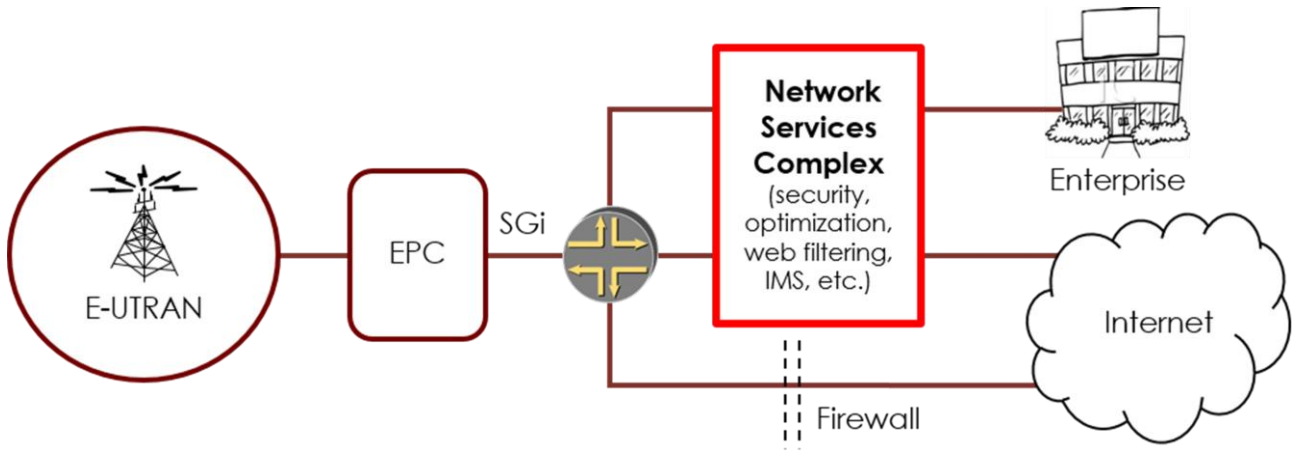
Mobile is the ultimate platform for personalized digital services. In progressive markets, smartphone penetration is now over 80 percent, more than half of customers use 4G networks, and operators generate more than half of their revenue from data. This transition to a data-driven revenue model has been achieved from a generic set of access services driven by coverage, data rates and price. As the smartphone market saturates, operators need to create personalized subscriber services that can be dynamically created, and modified, in response to market opportunities.

This white paper investigates architectural options that enable operators to quickly introduce subscriber-specific services in a virtualized "service complex" using SDN technologies. It will focus on the Layer 3-7 "cloud edge" services typically deployed behind the P-GW. In 3GPP terminology, this is known as the SGi interface.

The Need for a Dynamic Network Environment

The SGi-LAN is the interface from 4G mobile core networks to external networks, such as the Internet, corporate networks, or cloud services. Mobile operators deploy a range of network functions on this interface to secure and manage customer traffic. Combinations of these SGi-LAN functions can be used to create network services, with specific data processing paths for different subscriber types, which map to a corresponding end-user service portfolio. Examples of SGi-LAN functions are: firewalls, NAT, Web optimizers, and parental control. These functions are deployed in the "network service complex," as shown in **Figure 1**.

Figure 1: SGi-LAN Network Services



Source: Heavy Reading

Provisioning services in the SGi-LAN today is a complex, and largely manual, task based on operating specialized hardware appliances deployed back-to-back. There are issues of duplication, over-provisioning, cost and time to market that make it hard to experiment with new services, or to change deployed services. The result is a static network service portfolio that is hard to adapt to changes in the broader digital services market. This unnecessarily restricts mobile operators' addressable markets and limits monetization.

Next-Generation SGi-LAN Service Complex

To overcome these limitations, mobile operators can use software-defined networking (SDN) and virtualization to create a next-generation SGi-LAN network services complex that will support faster deployment of end-user services and faster modification of existing services.

Working in operators' favor is the fact that SGi functions are IP services that are not tied to 3GPP releases and are decoupled from the access technology, which means they can benefit from faster development cycles. They are often well-suited to deployment in a cloud environment and, with an open ecosystem of independent software vendors, operators have a choice of virtual network function (VNF) suppliers.

Mobile operators have also deployed policy and charging control functions extensively. Subscriber policy is used to enforce usage limits, to optimize application performance, and to create services such as speed tiers, sponsored data, mobile VPN services, priority access, shared data plans, and so on. Policy, used in combination with SDN control and forwarding, offers a way to create subscriber-aware and application-aware service chains across the SGi-LAN. These service chains comprise multi-vendor components, in both physical and virtual format, and are managed through a services orchestrator.

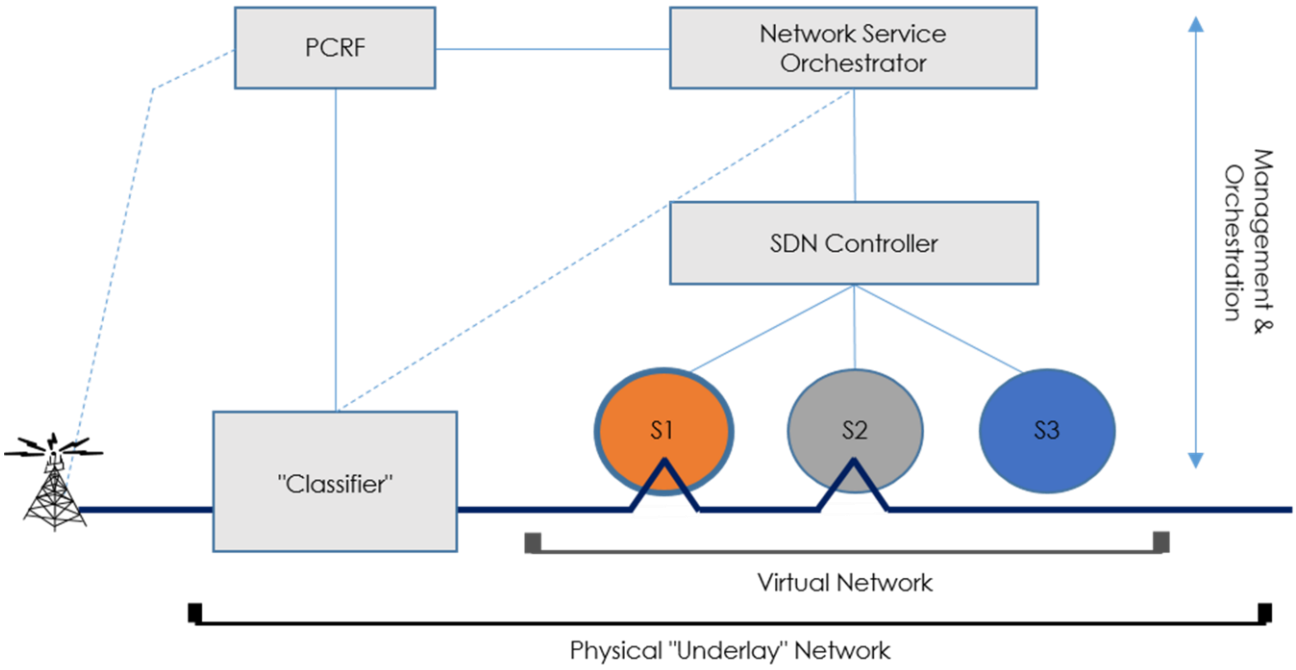
Virtual SGi-LAN Services Architecture

A next-generation "network services complex" on the SGi interface will use service chaining capability to direct traffic to the correct processing function, according to subscriber policy. In more advanced implementations the operator will be able to dynamically insert, and remove, functions in a network processing path. A generic architecture, with multiple implementation options, is emerging for this.

Virtual SGi-LAN Services

Operators typically have a range of functions deployed in the SGi-LAN network for security, optimization, Web proxies, ad insertion, and so forth. These may be physical network functions (PNFs) or, increasingly, VNFs. Both mixed physical and virtual environments, and pure virtual deployments, are expected to be common over time. The idea, shown in **Figure 2**, is to incorporate these functions into SDN-controlled service chains, such that user traffic is routed through only the necessary functions.

Figure 2: Service Chain Concept



Source: Heavy Reading

There are four major parts to the architecture, each of which can be implemented in different ways. They are:

- Policy control and network service orchestrator
- The classifier function or "service gateway"
- The SDN controller and overlay network
- Network services themselves: VNFs or PNFs

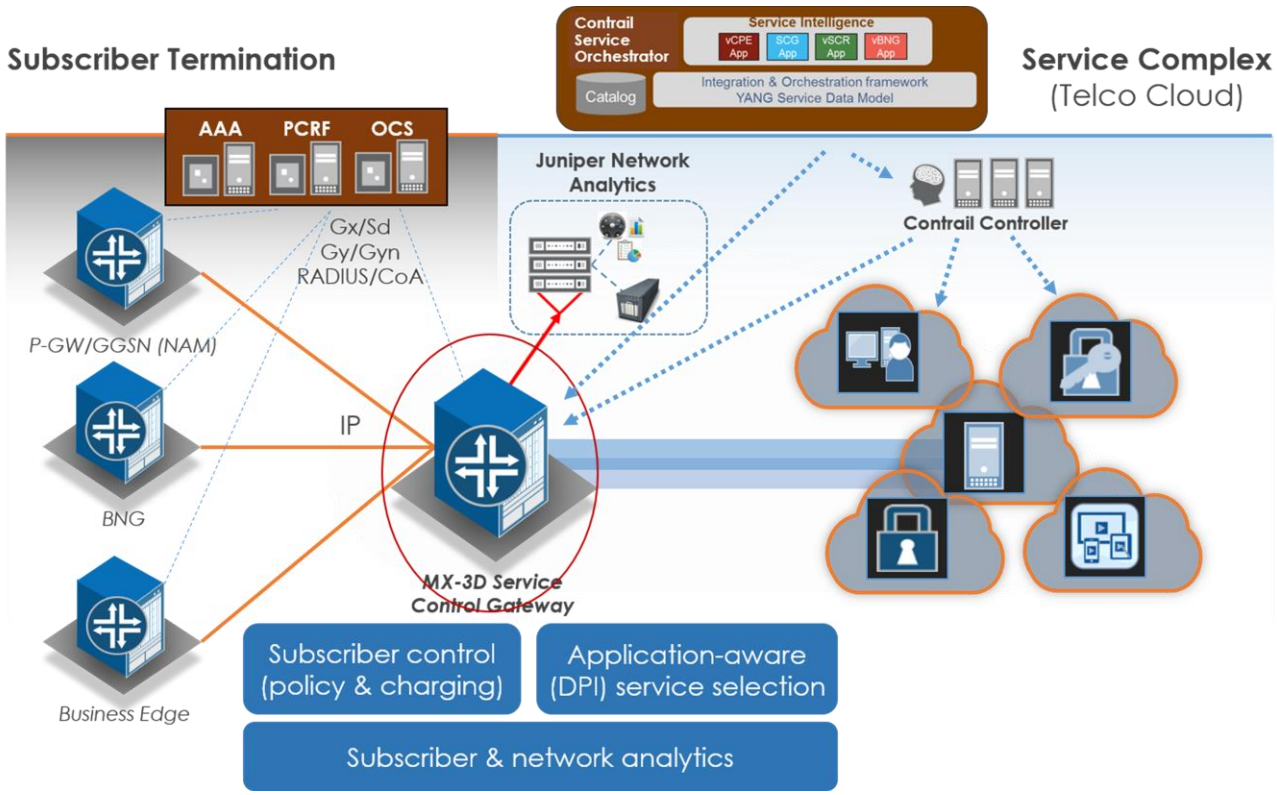
An important principle is that the service control and the "service graph" are de-coupled from the network. This abstraction is fundamental because it generates an architecture that is applicable to multiple network contexts, multiple operator types and many use cases. Example use cases are discussed below.

Implementation of a Subscriber-Centric Services Architecture

How to actually implement subscriber-centric services architecture is another challenge altogether. One approach, as shown in **Figure 3**, is to use a "service gateway" at the border of the access network and the "service complex" to decouple subscriber termination from service delivery.

In this model, the service gateway – shown as the "Service Control Gateway" – is able to route traffic through a processing path according to policy. The IP service functions themselves are deployed behind the gateway and can be deployed as VNFs and PNFs. The overlay network, in this example, uses a Contrail SDN controller to create a service path.

Figure 3: Implementation Using Internet Service Gateway



Source: Juniper Networks

In principle, as well as in practice, the IP service functions (PNFs and VNFs) can be used across different access types, meaning the "service complex" can also be used concurrently for 4G mobile, residential broadband and enterprise users. Rather than having to operate duplicate appliances, the same parental control function,

for example, could be used for mobile and residential access. Or the same DPI and DDoS mitigation functions could be used behind the enterprise, consumer and mobile edge.

Role of Service Gateway in Classification & Routing

The service gateway, also known as a "classifier," is important to the generic architecture (shown as the Service Control Gateway in **Figure 3**) because it identifies and classifies traffic prior to onward forwarding through the services complex. There are several types of classifier, with a lot of commonalties, and some differences, between them. The 3GPP specifies the Traffic Detection Function, while the IETF Service Function Chaining group uses the more generic "classifier" terminology.

In practice, the simplest, and most common, method of classification is to use IP headers in combination with user policy to forward traffic into a service chain. Where needed, this can be combined with other packet classification techniques to enable "application-aware" processing – for example, to rate-limit video or bittorrent. Typically only around 10 percent of traffic needs to be inspected by a DPI engine; the rest can be processed on the "fast path" into the service complex.

The classifier can also be implemented in different ways. It could, for example, be integrated with the P-GW in mobile core networks or IP edge in fixed broadband networks. However, it is more common to use some form of hardware appliance based on a router, load balancer, or telco server platform. These products are often known as "Service Gateways" or "Mobile Internet Gateways" and serve as the ingress to the service complex.

The classifier can also be deployed as a virtualized function. This involves a performance compromise on a physical footprint basis, but depending on deployment model and traffic profile, may nevertheless be cost-competitive. Virtualization also offers opportunities for new architectures over which to deliver network services – for example, using micro-segmentation to create "network slices," Enterprises A and B could have their own secure, service environments.

SDN Control of Service Chains & Overlay Networks

In **Figures 2** and **3**, the service chaining architecture uses a virtual overlay network to connect VNFs and PNFs. It is the responsibility of the SDN controller to provide connectivity between the functions in a service chain and to maintain the proper order of IP traffic in both directions.

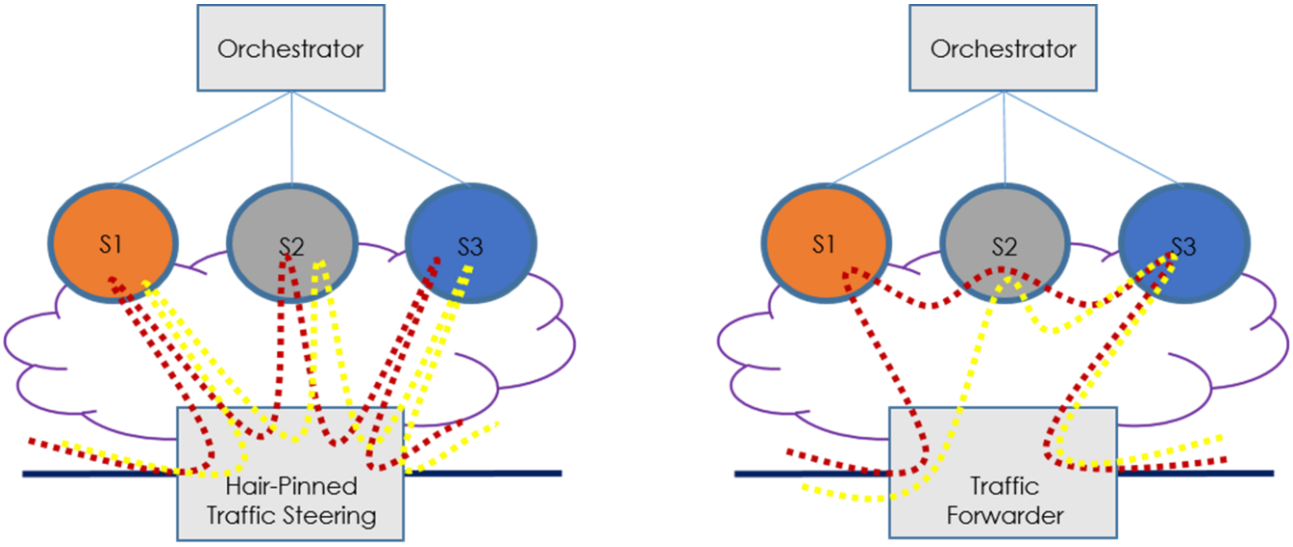
There are several overlay networking options and the optimal type of overlay for different scenarios is widely debated. In the first instance is the decision between Layer 2 and Layer 3 overlays: Some argue that Layer 3 is better for the telco environment because it is more scalable and resilient, and more familiar in an IP core network environment; others believe that Layer 2 is optimal in the data center and is benefiting from rapid innovation in virtual switching. In addition, there are variations on Layer 2, and variations of Layer 3 overlays, and so on.

There are also different SDN controller options for Layers 2 and 3. Many of the Layer 2 controllers are based on OpenDaylight, but also support IP overlays via plugins. Similarly, controllers such as OpenContrail are often used for Layer 3, but also support Layer 2. In each case, the controller must be able to dynamically insert and remove PNFs and VNFs into a service chain. It must also interact using standard interfaces, or APIs, with the network services orchestrator and classifier/gateway function.

The services complex is not a static environment, and operators can expect technology in this part of the network to evolve rapidly as development moves to software. One important area of progress is likely to be how operators control service chains through the service complex. In particular, there is an opportunity to move from a model where user traffic is hair-pinned to a gateway, as shown on the left of **Figure 4**, to one where traffic is forwarded through the complex on a node-to-node basis, without having to return to the gateway, or classifier, each time, as shown on the right. This model may offer efficiency benefits and more "elegant" service control.

There are several ways this type of service chain forwarding can be achieved. One reasonably mature option today is to use BGP and MPLS-based traffic forwarding, which are well-known and widely deployed protocols. Another emerging option is to use Service Function Chaining (SFC), in combination with a new Network Services Header (NSH), as specified by the IETF. This option may be more attractive over the longer term as more PNFs and VNFs are updated to support NSH.

Figure 4: Evolution of Service Chaining



Source: Heavy Reading

Use Cases for Subscriber-Centric Architecture

A next-generation SGi-LAN has some requirements that are specific to mobile, but the subscriber-centric architecture, shown in **Figure 3,** can be applied to many different scenarios. This is important to converged operators that want to combine service capabilities. Some of the more attractive use cases are shown in **Figure 5**.

Figure 5: Service Chaining Use Cases

Mobile Traffic Steering	• Lead use case for traffic steering; already deployed commercially worldwide • Route subscriber flows to correct optimization or security function • Enforce policy in data plane (e.g., rate-limit according to policy)
Converged Fixed/Mobile	• "Follow-the-user" services across residential WiFi and 4G mobile • Enables sharing of functions across access types, driving efficiency • Policy is consistently applied (e.g., parental control works inside and outside home)
MVNO Traffic Separation	• Gives MVNOs independent "slice" of multitenant SGi-LAN services environment • Services configurable by MVNO through administrative portal • Speeds up on-boarding of new MVNO customers
Mobile Enterprise	• Offer discrete network services to different enterprise customers • Customer has control of service configurations (e.g., firewall setting) through user portal • Can make mobile access an extension of a wireline cloud VPN service

Source: Heavy Reading

Mobile traffic steering is the lead use case for service gateways. The idea is to apply subscriber-policy based on factors such as access type, class of service, quality of experience, and so on. This has already proven relatively successful from a monetization perspective – for example, by offering group data plans to increase revenue per user, or using zero-rating of video content to attract and retain customers. The demand now is for a more "programmable" infrastructure that will enable operators to move much more quickly to address market opportunities.

Large integrated operators are now also looking at "**follow-the-user services**" that work across residential WiFi, carrier WiFi and 4G. This is set to be an important market for the next-generation service complex over the next few years, as operators develop converged retail offers. It offers more potential service combinations and spreads the cost of infrastructure across a larger group of subscribers.

Mobile enterprise is a very interesting market. A "network service cloud" for functions such as security, policy, application optimization and monitoring will make it simpler to combine mobile VPNs with a broader cloud VPN offer. Using admin portals, enterprises gain control of their own networking environment.

The **mobile virtual network operator (MVNO) market** is expanding in many countries, particularly as residential broadband operators look to add a mobility offering. The use of virtual mobile core technologies, including SGi-LAN functions, can help resolve the issues that most MVNOs want to control their services, but to deploy an owned core network is onerous from an integration perspective, and costly.

Conclusion & Future Evolution

The deployment of a next-generation "network services complex" will support faster deployment of end-user services and faster modification of existing services. In the first instance, SGi-LAN functions in the mobile core are good candidates for virtualization. Virtual Layer 3-7 "cloud edge" services, in combination with policy and SDN, enable operators to deploy an effective, flexible, subscriber-centric architecture.

A router-based service gateway that serves as the entry point to the virtualized service complex and supports Layer 3 overlay routing, with SDN control, is a good option for initial deployment. From an operations perspective, operators are familiar with router platforms in the core network, and this model has relatively little impact on the 3GPP mobile core. This allows operators to take advantage of rapid innovation occurring in the software-centric networking technologies used in the service complex itself.

Because access is decoupled, the same service complex can be used by other access methods. This will become more important over time as personalized services are widely applicable and as operators look toward converged service offers. This model reduces duplicate investment and allows operators to spread cost over a greater subscriber base. The subscriber services architecture outlined in this white paper is deployable today.

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