# Service Chaining the S/Gi-LAN with High Speed Packet Processing

The S/Gi-LAN, a 3GPP reference point that denotes the part of the network between the mobile core and the internet, has always been the domain of some of the most demanding packet processing workloads. All mobile subscribers access their network services through the Gi-LAN, as mobile network operators (MNOs) classify traffic from millions of flows at any one time, directing them when necessary to specific network services in order to meet policy enforcement and specific service level agreement needs. This paper discusses the state of the S/Gi-LAN, the migration to Network Function Virtualization (NFV) and the underlying NFV Infrastucture (NFVI) that will allow improved capital efficiencies compared with dedicated or proprietary hardware implementations.

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## Introduction

The Gi-LAN interface, a 3GPP reference point that denotes the part of the network between the mobile packet core and the packet data network (PDN) or internet, has always been the domain of some of the most demanding packet processing workloads. In LTE Networks the interface is referred to as the SGi-LAN and connects the Packet Gateway (P-GW) in the mobile core network to the PDN.

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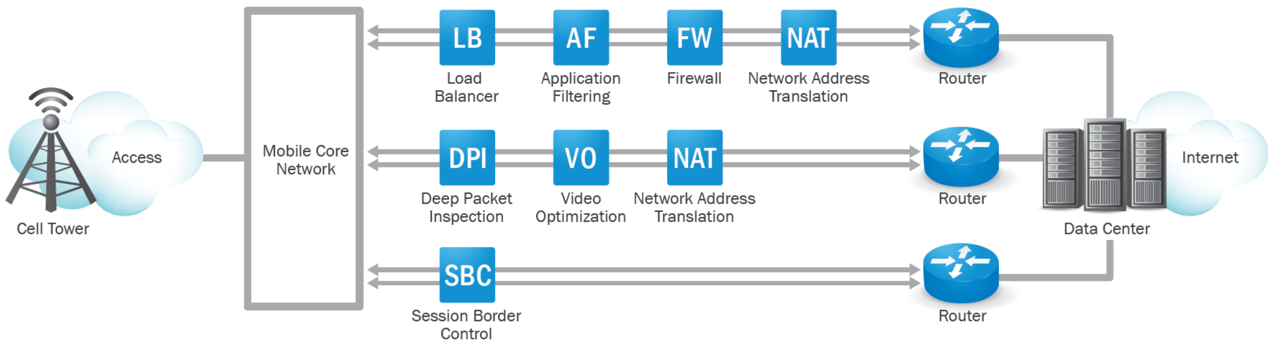


*Figure 1. Examples of S/Gi-LAN Service Functions*

An MNO's value added services in the S/Gi-LAN include network services like firewalls, Deep Packet Inspection (DPI), Network Address Translation (NAT), performance enhancement and content delivery optimization of video and web traffic, TCP optimization & header enrichment, Load Balancers, Session Border Controllers (SBC), caching, etc. This class of services are dedicated to managing network traffic and network policing.

At present, the functions described above are mainly deployed on proprietary platforms using dedicated hardware architectures from a wide range of vendors. These dedicated fixed function platforms, in the form of physical appliances or middle boxes, need to be managed separately, making the Gi-LAN relatively inflexible and pose a challenge from both an evolutionary and operational perspective. The service function models predominantly deployed today, are relatively static and too tightly coupled to network topology and physical resources.

This constrains MNOs from optimal use of service resources, and limits capacity, scalability and redundancy across network resources. When new functions need to be added to a topology, changes often need to be made to upstream and downstream functions resulting in complex network modification and device configuration. This can also have a flow-down effect whereby service changes affect other services further down the flow, the overall result of which greatly limits the ability of an operator to introduce new value-added services and/or service functions.

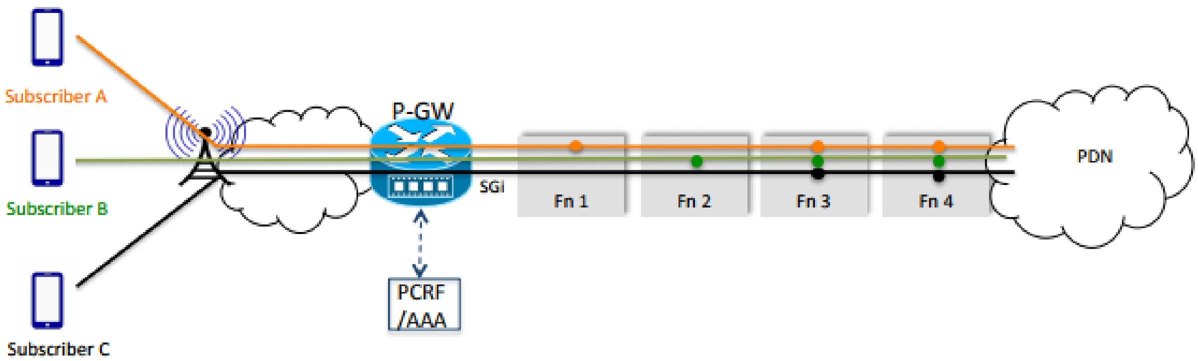


*Diagram source ETSI: https://nfvwiki.etsi.org/images/NFVPER(14)000058r2_Subscriber_Aware_SGi_Gi-LAN_Virtualization.pdf*

*Figure 2. S/Gi-LAN interface and legacy middle boxes*

All bearer traffic flows through the middle boxes in a sequence, whether the service function needs to be applied or not. As an example, the video optimizer appliance or function will also receive non-video traffic and conversely will receive video traffic where certain video streams do not need to be optimized. The better approach would be to implement a context-aware flow steering logic able to make dynamic steering decisions and forward flows only to the required service functions.

In the context of the S/Gi-LAN, the Policy and Charging Rules Function (PCRF) in the Evolved Packet Core (EPC) provides the necessary steering information using subscriber-based policy control for more intelligent and efficient service chaining. In addition, implementing the functions as a flexible virtual Service Function Chain (SFC), either distributed or consolidated on a single appliance will reduce the latency and overhead of processing packets multiple times. Other applications can also be used to apply further context to the flow, for example using network congestion and packet content-based intelligence.

It is clear that the legacy static topology must transition to an open-standards approach based on Software Defined Networking (SDN), Network Function Virtualization (NFV) and Service Function Chaining to enable a more flexible and scalable S/Gi-LAN that will allow MNOs to drastically reduce costs, innovate, and monetize on new services without having to re-engineer the complete network.

## NFV and SDN

When NFV is paired with SDN, real efficiencies can occur as network administrators can now shape traffic from a centralized control point without having to physically touch switches or middle-boxes, delivering services to wherever they are needed without regard to the abstracted hardware.

Together NFV & SDN are essential to attain greater flexibility and elasticity and create a distributed network where workloads can be moved to where they are best suited and service function chaining can be applied dynamically. The way by which virtual network connections can be set up to handle traffic flows for connected services can finally be automated allowing an SDN controller to apply a chain of services to different traffic flows depending on the source, destination, traffic type, or even content.

## Data Plane Developers Kit (DPDK)

Some of the most expensive equipment in the network is deployed in the S/Gi-LAN. As such, the opportunity for MNOs to consolidate fixed function hardware onto a single open architecture x86 platform and apply open-standard packet acceleration technology to meet DPI needs, promises high return on flexibility, CAPEX and OPEX.

The S/GI-LAN data plane is where the bulk of the packetized mobile networking traffic is processed. As such the use of DPDK ensures that networking infrastructure elements deployed there are fast, flexible, and open through a set of libraries and drivers that accelerate data plane performance on general purpose processors by an order of magnitude when compared with other prominent software architectures.

High-performance packet processing is available on the entire range of Intel® Xeon® processors which excel when coupled with high throughput Ethernet NICs and their virtual acceleration features. DPDK enables CPU cores to process packets continuously, unimpeded by the operating system, other applications, or interrupts. This greatly increases system performance and determinism in applications leveraging NFV.

## Service Function Chaining

Dynamic Service Function Chaining (SFC) is an SDN-based service chaining framework comprised of a service overlay with forwarders, services and gateways which mediate between the physical and virtual network domains. It aims to address the aforementioned problems associated with service deployment in the S/Gi-LAN. When a data stream passes through an input or ouput port on a physical or virtual network device, it is possible to program the precise sequence of functions that the data stream will pass through. This ordered set of service functions is called a service function chain where:

- **A Service Function Forwarder (SFF)** classifies traffic into x-tuple flows and steers flows into tunnels and services along the service chain path. Typically forwarding traffic to one or more connected SFs, transporting traffic to another SFF or classifying and terminating the SFC.
- **A control & management plane** configures the flow forwarding rules on a per forwarder basis.
- **Classifier gateways** mediate between physical and virtual network domains. Provide policy-based functions to identify, select and latch traffic flow with a specific SFC.

Service chain components are not constrained to a single virtualized physical appliance or server and can cross tunneled network connections to other servers using VxLANs or VLANs. A service chain may consist of an edge router for example running as a virtual function on customer premise equipment (CPE), a DPI function in the service chain inspects the traffic, determines the type and requests the SDN controller to create a service chain for a particular packet stream and customer.

In policy models, policy is essentially a set of rules, which can be defined based on subscriber type, for example Premium user, Standard user and Basic user. Rule 1 for a Premium user might be for example "HTTP", where an SFC consisting of DPI, QoS and Firewall functions would be applied to that user's http flows. Rule 2 for that same user might be Video where an SFC consisting of video optimization is applied for a guaranteed HD quality video stream. Inversely, for a basic user with a low-cost subscription for example, no value added services would be applied at all.

The classifier in each case needs to detect the flow, from where and who the traffic is from and apply a set of rules. As network traffic is dynamically changing, some of the services may need to adapt to the change, for example if our Premium user is receiving http traffic but the DPI later detects a DDOS attack then the Policy Enforcement Function can divert the traffic to a scrubbing centre and only allow clean traffic through. Another example would be if the premium user's video optimization function detects an unavailable resource, at which point a load balancer could be dynamically invoked to initiate a scale-out service to bring on more resources.

The use cases are multiple and SDN/NFV service chaining is the enabling technology that simplifies the whole process of running a network. In addition SDN and NFV, allows MNOs to create new chains that increase the efficiency and the capacity of their networks without drastically replacing hardware.

Finally dynamic service chaining on the S/GiLAN gives MNOs an advantage over OTT players and other 3rd parties as it enables them to provide better provisioning and more efficient services in the network itself, leading to increasing subscriber satisfaction and the opportunity to monetize on premium services.

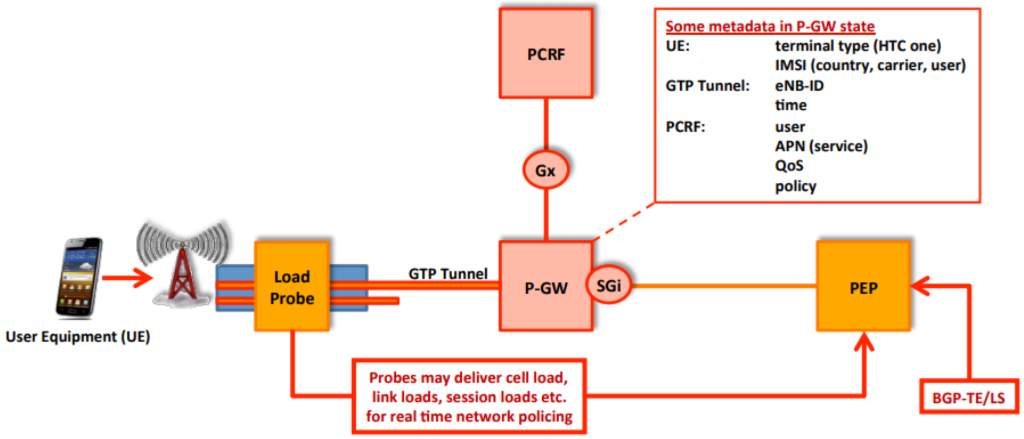


Diagram IETF: https://www.ietf.org/proceedings/87/slides/slides-87-nsc-1.pdf

*Figure 3. Network metadata provides high degree of freedom in SFC creation*

## High-End Packet Processing Platform for the S/Gi-LAN

Advantech has been supplying high performance networking platforms to Network Equipment Providers (NEPs) for high-end packet processing on Intel Architecture leveraging Intel DPDK and Intel Hyperscan technologies for many DPI and content inspection use cases. With the advent of NFV, MNOs can leverage these platforms to transform their network architecture and to consolidate multiple functions onto a single platform.

One such platform which recently introduced by Advantech is the FWA-6170, a high-end network appliance ideally suited for service function chaining in software defined networks in both data centers and telecommunications networks. The FWA-6170, is a powerful and flexible 2U platform that delivers up to wire speed IP packet classification using two Intel® Xeon® Platinum Processors with up to 28 cores each. Its new security features and augmented platform modularity, enables equipment and service providers to build faster, more secure networks, bringing greater cost-efficiency to applications in the S/Gi-LAN while leaving sufficient overhead to anticipate future infrastructure changes.

## FWA-6170 Platform based on the new Intel® Xeon® Processor Scalable Family

The Advantech FWA-6170 high-end network appliance has been designed for maximum performance, scalability and functionality in a 2U rack mount footprint. Equipped with a choice of processors from the Intel® Xeon® Platinum, Gold, Silver and Bronze series, this high-end network communications appliance is optimized for computing power, accelerated workloads and high speed, high density I/O with best-in-class energy efficiency.


*Figure 4. Advantech FWA-6170 high-end network appliance*

Two Intel® Xeon® Processor Scalable Family CPUs provide the latest architectural enhancements, including rebalanced cache hierarchy, and new Intel® UltraPath Interconnect for increased bandwidth and transfer rates between sockets at up to 10.4GT/s. In addition the new processor family introduces 512-bit vector capability at up to 2x improvement in peak performance over previous AVX2 for the acceleration of enterprise-class workloads. Each socket now supports 6 memory channels and up to 12 DDR4 RDIMMs, an increase of 1.5x over the previous generation FWA-6520, with a speed increase to 2666 MHz for up to 768GB of ECC memory using the latest technology. Advanced RAS modes such as mirroring and sparing increase platform reliability. The FWA-6170's thermal system design enables support for processors with up to 165W TDP. This allows the appliance to scale from 8 core CPUs to the highest performance 28 core processors available today.

With an abundance of PCI Express lanes, the FWA-6170 can support up to 8 Network Mezzanine Cards (NMCs) for modular, configurable networking I/O and acceleration. PCIe Gen3 technology on all NMC slots provides sufficient bandwidth to support multiple 40GbE and quad 10GbE modules as well as double sized NMCs for 100GbE connectivity. Support for two internal low-profile PCIe add-on cards enables further encryption offload in addition to on-chip PCH-based Intel® Quickassist depending on the appliance model.

Advanced Lights Out Management based on Aspeed's latest iBMC AST2500 and AMI's MegaRAC IPMI suite improves system manageability and reliability, providing platform thermal management, H/W monitoring and supervision. Remote firmware upgrade capability and hardware-based BIOS redundancy make the FWA-6170 an ideal platform for mission-critical and highly available networks. For enhanced platform security the FWA-6170 provides Trusted Platform Module TPM 1.2/2.0 support. Front and rear hot swappable FRUs such as power and fan modules along with service friendly design features such as fan failure LEDs further help to reduce system down time and enhance serviceability.

Management, IO and storage elements include two management Ethernet ports, two 10GbE SFP+ ports, a console port, two USB ports, a graphic-mode LCD module, LEDs for power/location/alert indication and two front-loadable 2.5" SATA HDDs/SSDs as well as two internal M.2 2260/2280 slots.

An optional Storage Expansion Kit replacing the top row of NMCs provides eight 2.5" drive bays.

A new removable front panel cover placed in front of the 2.5" SATA bays allows fast and simple logo customization.

The FWA-6170 is CE, FCC, UL, CB, CCC, VCCI, RCM and RoHS compliant.

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