SOLUTION BRIEF

vIMS for Communications Service Providers

Executive Overview

Intel is accelerating network function virtualization with unique capabilities that enable optimal use of data center resources to deliver communications services. Virtualized IP Multimedia Services (vIMS) provides the Communications Service Provider (CSP) with the ability to introduce new services more rapidly and to scale current and future services more seamlessly. More than ever, traditional Service Providers must keep pace in a world where application developers bring to market new Over the Top services and capabilities that currently take CSPs years to launch. To remain relevant and competitive, CSPs are investing in the development of virtualized networks that will allow creation of new services to retain and grow the customer base. Many IMS functions are available on Intel® Architecture today. This document details the critical technologies and capabilities, and describes Intel's role in the ecosystem that is required to participate fully in CSP production deployments.

Introduction

Increasing market pressures, such as skyrocketing mobile traffic, demand for enhanced services in a more agile environment, and the search for more cost-effective solutions are driving Communications Service Providers (CSPs) to adopt network function virtualization (NFV). Virtualizing services onto standard, commercial off-the-shelf (COTS) hardware and taking advantage of software-defined networking (SDN) will increase network flexibility and reduce costs, as well as enable CSPs to launch new revenue generating services more quickly and with less overhead.

The key benefit of virtualizing Network Functions, such as Virtualized IP Multimedia Services (vIMS), is that a CSP can host multiple workloads on the same rack of Intel® Architecture-based servers and can dynamically scale services up or down depending on real-time requirements, including the busiest traffic hours. Additionally, separation of the workload from the underlying standard hardware enables significant simplification of procurement compared to classic appliance-based approaches. Hardware can be repurposed as service demands evolve, and acquired very quickly compared to the classic "Plan and Provide Infrastructure" processes. CSPs are also encountering competitive pressure from Over the Top (OTT) providers, such as Skype. Deployment of a vIMS solution offers the opportunity to capture new revenue streams and remain competitive with services offered by OTT providers.

The number of subscribers for IMS worldwide exceeds 190 million subscribers.[1] The volume of Mobile traffic is expected to grow at a compound annual growth rate (CAGR) of at least 45 percent,[2] and analysts predict the current USD 2.3 billion NFV market to reach USD 11.6 billion in 2019.[3] CSPs and the ecosystem that supports the industry are evaluating approaches to efficiently scale to meet these traffic requirements.

Many system integrators, software vendors, and platform providers rely on Intel® technologies to deliver the performance and scalability required for vIMS solutions. Using vIMS solutions based on Intel technologies, CSPs can offer a full range of services without having to use multiple purpose-built systems.

This paper describes the technologies required to enable and mature vIMS technologies to support CSP production deployments.

Revision 1.2 April 2016

Table of Contents

Market Opportunity

The key drivers for IMS deployments include Voice over LTE (VoLTE, Long Term Evolution), Voice over Wi-Fi* (VoWiFi), Rich Communication Suite (RCS), and Web Real-time Communication (WebRTC) services.

VoLTE offers high-definition voice through its use of newer wide-band codecs. It also offers network optimization through increased efficiency of its wireless resources. With the popularity of OTT-provided services, such as Skype, CSPs must ensure that they aren't relegated to the status of "pipe providers." To date, many of these OTT and content providers have been the early beneficiaries of LTE's increased bandwidth and access speeds. So operators that have rolled out LTE networks are now turning to VoLTE, RCS, and other value-added services to win back revenue from OTT and content providers. Some of these advanced services require heavier signaling requirements than media requirements, which makes them well suited to virtualization.

There are now over 40 operators across 27 countries that have launched commercial VoLTE services.[4] VoLTE services have been launched in all major geographical regions, including deployments by China Mobile and CSPs in North America and EMEA.[5]

VoWiFi allows a mobile customer to use the same phone number and the same smartphone dialer interface over cellular or Wi-Fi networks. This new VoWiFi capability differs from existing VoIP technology, such as Skype or Facetime, in that these OTT services cannot maintain the call connection when moving from Wi-Fi to cellular coverage. This technology is often deployed by CSPs whose licensed spectrum makes it difficult to provide complete building coverage. If Evolved Packet Core (EPC) is enhanced with evolved Packet Data Gateway (ePDG), VoWiFi can be considered an extension of VoLTE, providing seamless handoffs between LTE and Wi-Fi networks. Successful use of this technology, however, requires VoWiFi support in the handset for seamless handover. An early adopter of this technology was T-Mobile in the United States. Sprint and AT&T also offer this service today. In the United Kingdom, EE and Three UK currently provide a Wi-Fi calling service. Other vendors worldwide include Swisscom and Telkomsel, Indonesia's leading operator.[6]

RCS is a new set of Session Initiation Protocol (SIP) based communication and messaging services. It enhances calls and chat by adding in videos, pictures, music, and files, all of which are available during the call session. RCS should have the significant advantage of working across networks and devices unlike OTT services, which require users to download apps, such as Whatsapp* or Snapchat*. In the United States, AT&T and T-Mobile have offered advanced video and message calling since 2015.[7] However, RCS is not a primary driver for IMS compared to VoLTE.

WebRTC is a technology allowing users to directly communicate with one another through video calls on browsers without installing any software or apps. Although WebRTC is also not viewed as a primary driver for the IP Multimedia Subsystem (IMS),[8] major CSPs, such as Telefonica and Orange, have deployed this solution.[9]

VoLTE, VoWiFi, RCS, and WebRTC all use the IP protocol to carry audio/voice/video traffic, and the IMS architecture is the element in the core network to implement this.

IMS is an architectural framework for delivering IP multimedia services. It is a layered architecture that consists of three layers: Service/Application, IMS, and Transport. A number of network elements are required to implement this function in the mobile core. More details on the architecture and network elements are described later in this document.

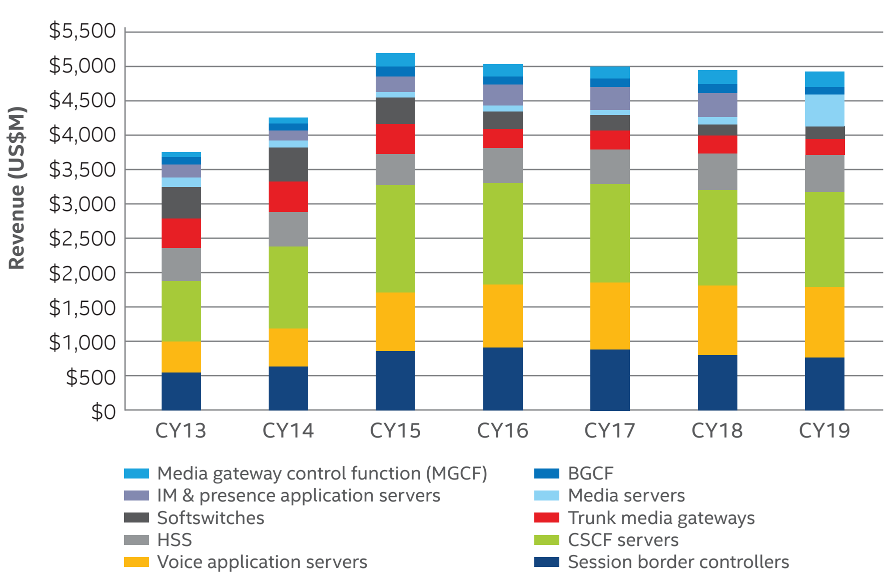
The report "CSP VoIP and IMS Equipment and Subscribers" from Infonetics[10] provides a good snapshot of the market opportunity for IMS network elements. Figure 1 reflects CSP spending on IMS network elements for the third quarter of 2015. The top three network elements are circled and include Session Border Controllers, Voice Application Servers, and Call Session Control Function (CSCF) servers.

Current and projected IMS network element growths are shown in Figure 2.

Exhibit 1 **Worldwide Service Provider VoIP and IMS Revenue in Review**

	Worldwide Service Provider VoIP and IMS Revenue (US$M)			% Change	
	3Q14	2Q15	3q15	3Q15 vs 3Q14	3Q15 vs 2Q15
Trunk media gateways	$106.1	$142.5	$139.7	31.7%	-2.0%
Session border controllers	$155.4	$219.6	$215.9	38.9%	-1.7%
Media servers	$21.6	$21.8	$24.0	11.1%	9.9%
Softswitches	$161.0	$118.1	$95.6	-40.6%	-19.0%
Voice application servers	$122.2	$210.4	$229.6	87.9%	9.1%
HSS	$138.6	$146.3	$100.7	-27.4%	-31.2%
CSCF servers	$265.7	$370.5	$389.3	46.5%	5.1%
BGCF	$19.8	$38.3	$34.5	74.6%	-10.0%
Media gateway control function (MGCF)	$5.2	$13.5	$101.0	1,841.6%	650.6%
IM and presence application servers	$38.1	$59.9	$57.4	50.7%	-4.1%
Total revenue	**$1,033.7**	**$1,340.8**	**$1,387.6**	**34.2%**	**3.5%**

Figure 1. Quarterly worldwide CSP spend on IMS network elements.



An additional report from Infonetics[11] states that "Worldwide CSP VoIP and IMS product revenue increased 34 percent in 3Q15 over 3Q14 to $1.4B, which is 21 percent higher than originally forecast with sales related to VoLTE from Asia Pacific, particularly China and India, starting to take shape. Additionally, mobile operators that have launched VoLTE and fixed-line operators continue a steady pace of expansion."

Figure 2. Projected annual CSP spend on IMS network element.

Industry Challenges

CSPs have been losing revenue to OTT providers across many important services, such as Skype for voice calls and conferencing and Whatsapp for messaging. This has resulted in CSPs looking at VoLTE and VoWiFi to compete or at least remain relevant. These services should provide better call quality and a broader array of competitive capabilities. IMS supports both services and can offer seamless call transfer without dropping the call.

The costs associated with the initial deployment, the uncertainty of customer adoption, and the longer term return on investment (ROI) may make certain SPs hesitant to deploy IMS using classic appliance-based infrastructure. The industry is looking to drive cost reductions with major Telecommunication Equipment Manufacturers (TEMs) offering NFV solutions for IMS.

Interoperability between IMS networks is a challenge. This is being addressed by standards bodies like the GSM Association (GSMA), release 5, and also by cooperation among CSPs.

Support for VoWiFi has in the past not been supported by all handsets; however, this is changing since the release of Apple's iPhone 6 series devices. Many major CSPs will likely take advantage of the opportunity to introduce VoWiFi.

Most of the application services and CSCF functions have been available as software functions for a number of years and are becoming available on cloud platforms today. However, the challenge is that the network elements that process media (voice and audio) traffic have stringent real-time requirements for jitter and latency.

State of the Industry

Current IMS deployments have server-based control and media gateway/transport elements that are serviced by fixed function appliances that take a long time to deploy, are expensive to operate, and do not provide an evolution path to allow an operator to introduce new services quickly. These fixed function call servers generally use optimized software running on Intel Architecture processors in ATCA or proprietary form factors. In the data plane, the gateway boxes often use network processors to handle the routing and security processing and Digital Signal Processors (DSPs) to handle media transcoding.

Vendors have been evolving their call server products to run as virtualized workloads on standard COTS Servers, taking advantage of the commercial benefits. There are also virtualized solutions for media processing, such as Session Border Controllers (SBCs), available today; however, adoption is limited to "Access" rather than "Interworking" use cases. Since media processing such as transcoding requires vector arithmetic, proprietary DSP processors have been designed and architected for this purpose. If a transport element, such as an Interworking SBC or Media Gateway, has a high level of transcoding to implement, a virtualized version may not compare favorably to the fixed function appliance. SBCs that are classified as Access SBCs (first point of contact from User Equipment, UE) generally do not have high levels of transcoding. Since peering or interconnect SBCs may have to connect to other CSPs and facilitate codec conversions, higher levels of transcoding performance are required. Comparisons of media network elements between physical functions and those running virtualized are usually based on session capacity and transcoding capacity and do not focus on flexibility benefits. However, Carrier Grade SBCs that have a decomposed architecture (that is, separated Signaling Controller and Media Gateway) allow independent scaling of these functions to optimize the deployment to handle the expected call set-up rates as well as data plane throughput. The use of virtualized controllers could be beneficial for RCS, VoLTE, and VoWiFi requirements, all of which have heavy signaling requirements compared to media processing requirements.

While IMS today is already in every CSP network that currently provides 4G-LTE VoLTE service, there is evidence that CSPs are considering virtualized network elements in order to add additional capacity. This provides an opportunity to handle peak traffic loads on virtualized platforms that can be reused for other workloads (or switched off to minimize energy consumption) at other times of day. Operating a hybrid-installation is simplified as the legacy Element Management System can generally be used to also run the Virtualized servers with minimal technician upskilling.

By adoption of industry standard servers, CSPs can also simply exploit the "Moore's Law" ongoing improvements in the performance of servers currently enjoyed by IT datacenters, which addresses the growing demand for processing while minimizing the impact on operational accommodation.

Intel is contributing to several open source communities, including Open vSwitch*,[12] OpenDaylight*,[13] OpenStack*,[14] and the 3G Partnership Program (3GPP) Flexible Mobile Service Steering project, to drive open source integration efforts, such as the Intel® Open Network Platform (Intel® ONP) Server and the Open Platform for NFV* (OPNFV*)[15] and to support the growth of technologies required by vIMS. Intel is also working with ecosystem partners and suppliers on proofs of concept to validate end-to-end solutions that demonstrate the capabilities and maturity of the technologies. These end-to-end solutions will provide the industry with visibility into the gaps impeding broader adoption of vIMS using SDN/NFV technologies for mobile CSPs' services.

Intel's Role in Addressing Market Pain Points

The market adoption of technology innovation requires the business drivers for the technology to solve a problem or enable a new capability that will drive cost reductions or new services or both. Intel is driving the ecosystem forward to make NFV a commercial reality. Intel is providing technology and contributing to the ecosystem to enable virtualized network functions and routing applications to scale more efficiently to optimally deliver end-to-end services. A common software-defined programmability of virtualized functions and routing between these functions provides the ability to scale traffic in a more efficient manner.

Service agility and speed of introduction are key benefits for deploying vIMS. Services Providers have faced revenue competition from OTT providers that have deployed a broad array of customer-friendly services. Current IMS deployments do not currently have the flexibility to cope with rapid traffic volume changes.

For network elements, such as Session Border Controllers (SBCs), challenges include media (audio) transcoding on Intel® Architecture, throughput, latency, and jitter performance. With respect to throughput or more specifically, the overhead introduced by the hypervisor in a virtualized environment, this can be solved by data acceleration methods such as:

- Core pinning
- PCIe* passthrough
- Single Root I/O Virtualization (SR-IOV)
- Accelerated Virtual Switches (vSwitches)

Intel has been ensuring that features like Core Pinning, which come under the Enhanced Platform Awareness (EPA) feature set, are exposed in OpenStack. Core Pinning can be specified as a CPU policy. Intel is also ensuring instruction extensions (for example, Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI)) are exposed using the OpenStack Nova libvirt driver. PCIe passthrough and SR-IOV can also be configured using the OpenStack Nova configuration file.

Review this whitepaper for more details on these features: https://networkbuilders.intel.com/docs/openStack_Kilo_wp_v2.pdf

Intel has also been involved in developing a number of best-known methods for real-time processing to minimize jitter and latency, which would improve performance of IMS network elements that process voice and media data.

More details on these methods can be found at: http://www.intel.com/content/dam/www/public/us/en/documents/white-papers/real-time-virtualization-on-xeon-server-white-paper.pdf

Intel continues to be an active participant in communications-focused, industry-wide Open Standards and Open Source projects. As part of these efforts related to vIMS, Intel is involved in a real-time KVM project within the OPNFV community.

KVM work can be found at: https://wiki.opnfv.org/nfv_hypervisors-kvm.

KVM best-known methods are summarized here: https://wiki.opnfv.org/nfv-kvm-tuning.

SDN/NFV For vIMS Network Functions

SDN and NFV promise to revolutionize the industry by driving cost reductions, improving operating efficiency, and increasing potential for service revenue growth. However, the transition to NFV will require a number of new, disparate technologies to work collaboratively. The maturity of these technologies is captured in Intel's Network Maturity Model for CSPs.[16]

Technology Overview

The following sections describe IMS and Intel technology contributions in more detail.

Traditional IMS

The IMS system consists of a number of network elements, including Application Servers, CSCF Servers, and Media processing network elements.

Most of the application services and CSCF functions have been available as software functions for a number of years and are available on cloud platforms today. Network elements that process media traffic are typically deployed on dedicated hardware appliances or Advanced Telecommunications Computing Architecture (ATCA)-based platforms. Often these physical appliances use physical cabling and preconfigured static routing mechanisms. Lead times are long for these dedicated appliances, and deployment can be complex, leading to early procurement of infrastructure inventory to accommodate potential future traffic needs. Unlike reusable virtualized solutions, proprietary and ATCA platforms are not interchangeable among applications from different vendors.

CSPs deploying an IMS solution have had to ensure interoperability between IP and legacy time-division multiplexing (TDM) equipment, even though fixed-line TDM equipment deployment is decreasing.

As CSPs move toward an all IP-based network, SBCs are commonly deployed in IMS networks as discrete network elements at the edge of an IP network, where they offer control of signaling and media streams. Originally, SBCs did not have to do much media processing; however, this has changed over time. Since requirements of different peer networks vary, media handling requires capabilities such as transcoding and conversion of a media stream from one codec type to another. As stated previously this is achieved using rigid architectures.

Figure 3 shows a simplified IMS architecture.

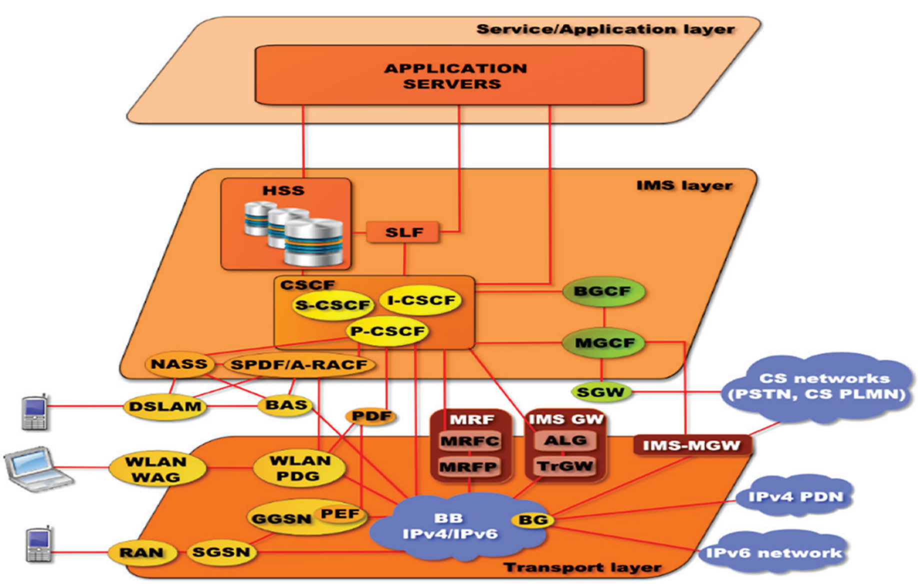


Figure 3. An example of a simplified vIMS architecture.

Media Processing and Nfv

Most of the IMS functions, such as CSCF, Home Subscriber Server (HSS), and voice application servers, are available as software functions today and are widely deployed on servers using Intel® Architecture processors. Vendors are generally porting these to run on a hypervisor with little or no modifications. Intel's high CPU frequency, large caches, advanced pipelines, and hardware accelerators make them ideal for tasks such as large table lookups, hashing, and parsing, which are required for signaling layer processing. The Serving CSCF (S-CSCF), IP Multimedia Subsystem CSCF (I-CSCF), and Breakout Gateway Control Function (BGCF) functions are typically virtualized on dual-socket servers with Intel® Xeon® processors E5-2600 v3 product family and adapters based on Intel® Ethernet Controllers.

Elements such as SBCs and Media Resource Function (MRF) are traditionally built on fixed-function hardware; however, there are solutions for SBCs and MRF running on software today. These network elements operate at the signaling, data, and media layers.

The media layer must perform tasks, such as voice transcoding, and for LTE, codecs such as G711 and AMR are required. Voice transcoding is computationally intensive. Jitter, which is introduced by the hypervisor and is detrimental for voice solutions, is an additional concern. DPDK does not help with jitter.

Intel Technologies and Ecosystem Enablers

For network CSPs that intend to deploy vIMS solutions, Intel's architecture and ecosystem contributions are significant. Intel's product performance, unique platform awareness capabilities, software portability from network edge to core, and significant contributions to Open Source communities and standards bodies support solution realization.

Intel's chipset and platform capabilities enable IMS network functions to facilitate efficient resource utilization through optimal performance and programmability. Intel continues to work with the ecosystem to enable optimal use of these capabilities with seamless integration by the NFV/SDN architecture.

Virtualized network functions benefit from the ongoing efforts to enable and enhance the horizontal platform. Platform capabilities based on Intel's chipsets supporting Open Source ingredients (including DPDK[17] and Open vSwitch[18]) are leveraged by CSPs to achieve the benefits of NFV. The horizontal platform provides the foundation for a virtualized infrastructure and capabilities such as CPU/memory virtualization, I/O virtualization, workload isolation, and acceleration are the foundation of NFV.[19]

Intel has also worked closely with ecosystem participants to develop reference architectures that maximize the value of vIMS. These architectures capitalize on open, industry-standard technologies to help CSPs reduce vendor costs, more easily produce scalable solutions, and accelerate time to market for new solutions. Purpose-built devices require CSPs and their hardware partners to qualify each version of a device, whether it is produced to offer a distinct service or to accommodate a different number of users. With vIMS solutions based on industry-standard technologies, CSPs can produce, and qualify, fewer variations for their solutions. The virtualized environment allows them to support a greater variety of commercial services and to scale more efficiently to meet demand.

Intel Chipset and Architecture Capabilities

Specific Intel capabilities that drive optimal performance and security for virtualized IMS functions are identified in Table 1. Some of these capabilities include: Enhanced Platform Awareness (EPA),[20] Intel® Resource Director Technology (RDT), Intel® QuickAssist Technology (Intel® QAT),[21] Intel® Trusted Execution Technology (Intel® TXT), and Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI), among others.

For vIMS, there are a number of relevant Intel technologies:

Table 1. Key Intel features impacting vIMS functions.

vIMS Function	EPA: CPU Pinning, NUMA, Huge Pages, etc	CAT/ CMT	Memory Bandwidth Monitoring	Media processing and acceleration of Codecs on IA (G.711, AMR...)	QAT	TXT	AES-NI
vIMS Control Plane (vCSCF, vMCGF, vBGCF)	✓				✓	✓	✓
vIMS Data Plane (SBC, BG, MGW, MRF WebRTC GW)	✓	✓	✓	✓	✓	✓	✓
vIMS Applications (Messaging, Presence, TAS)	✓					✓	

Intel® Cloud Integrity Technology

Intel has a portfolio of technologies that are being introduced into the processor microarchitecture to specifically address CSP requirements for secure multi-tenanted infrastructure for virtualized workloads. Specific focus areas include the security of traffic between network elements in service chains, VM-VM confidentiality, secure monitoring, ETSI compliance, and resource visibility and analytics.

These cover four layers of security:

- Platform Integrity, including Intel® TXT + TPM, AES-NI, and Secure Key
- Location & Boundary Control, including geo-tagging
- Workload Integrity
- Run Time Integrity

Intel® Trusted Execution Technology

For CSPs with operations in multiple countries, regulators require that subscriber data be protected to ensure it does not traverse country boundaries. Intel TXT and Geo-Tagging Intel TXT use cases can help operators adhere to this requirement. These technologies use hardware-based geography and asset tags to help control workload placement and migration. They allow for boundary control policies to be set for a workload, allowing or preventing its deployment in certain locations. An enabling guide for TXT is available with details on equipment availability.[22]

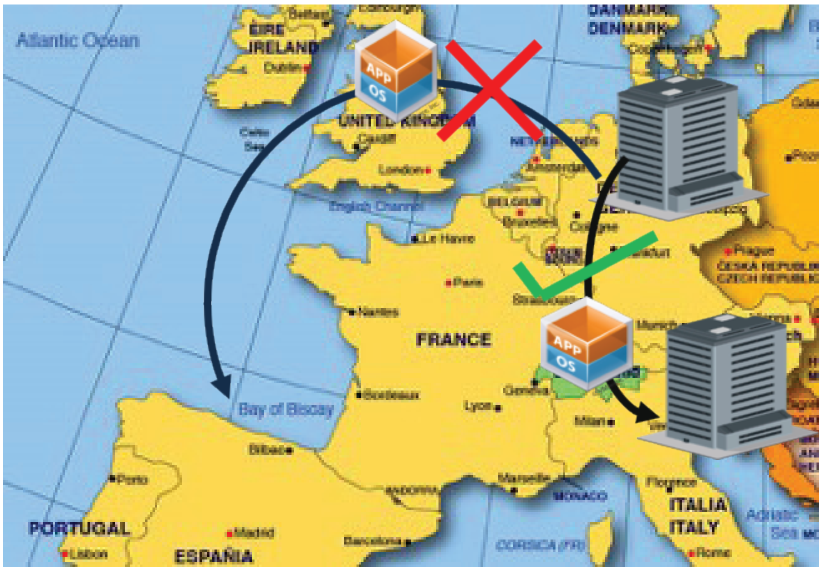


Figure 4. Trusted location and boundary control required for subscriber information.

Secure Real-time Transport Protocol (SRTP)

Real-time Transport Protocol (RTP) is the protocol that carries the media streams (for example, audio and video in the IMS transport layer). SRTP defines a profile of RTP intended to provide encryption, message authentication and integrity, and replay protection to the RTP data. Preliminary testing on a server with 2 x Intel® Xeon® processor E5-2699 v3 (Ubuntu* Server 14.04.3 LTS, librstp 2.0.0-pre and OpenSSL 1.0.2e, AES-128 counter) using libSRTP library (, ie.,open-source implementation SRTP) shows that the throughput and processing load is improved using Intel AES-NI.

Intel® Resource Director Technology

Designed to optimize resource utilization, the Intel® Resource Director Technology (Intel® RDT) feature set brings new levels of visibility and control over how shared resources such as last-level cache (LLC) and memory bandwidth are used by applications, Virtual Machines (VMs) and containers, enabling new advances in workload consolidation density, performance consistency, and reducing total cost of ownership (TCO).

Intel® Advanced Encryption Standard New Instructions

The Intel® AES-NI instruction set was designed to help improve cryptographic operations used in security protocols, such as IP Security (IPSec). Intel has demonstrated increases of from 15 percent to 100 percent per cycle on a single thread of an Intel® Core™ i7-4770 processor core over an Intel® Core™ i7-2600 processor core.[23]

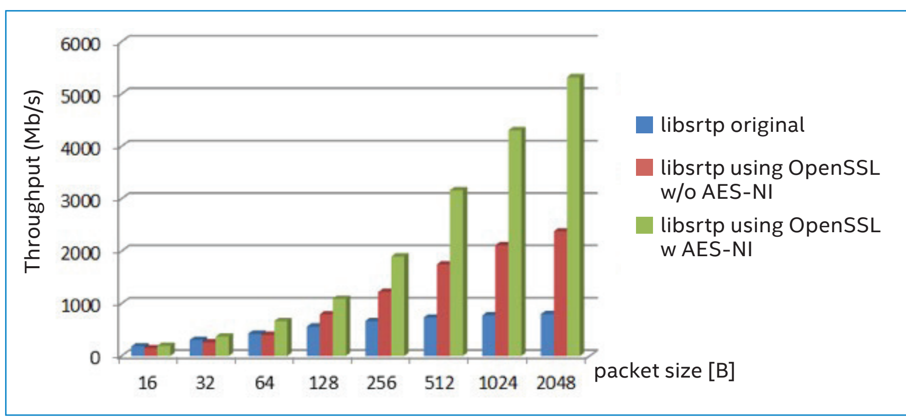


Figure 5. SRTP throughput performance graph.

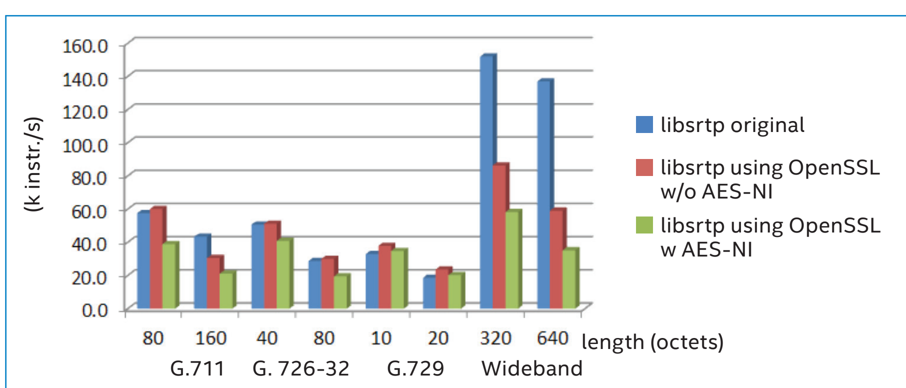


Figure 6. Number of instructions to implement SRTP.

The table below provides links to more information on these specific capabilities.

Table 2. Links to specific capabilities.

Intel® Resource Director Technology	http://www.intel.com/content/www/us/en/architecture-and-technology/resource-director-technology.html
Intel® QuickAssist Technology	http://www.intel.com/content/dam/www/public/us/en/documents/white-papers/communications-quick-assist-paper.pdf https://01.org/packet-processing/intel®-quickassist-technology-drivers-and-patches
Intel® Trusted Execution Technology	http://www.intel.com/content/www/us/en/architecture-and-technology/trusted-execution-technology/malware-reduction-general-technology.html http://www.intel.com/content/www/us/en/architecture-and-technology/trusted-execution-technology/trusted-execution-technology-security-paper.html http://www.intel.com/content/dam/www/public/us/en/documents/guides/intel-txt-software-development-guide.pdf
Intel® Advanced Encryption Standards New Instructions	https://software.intel.com/en-us/articles/intel-advanced-encryption-standard-instructions-aes-ni http://www.intel.com/content/dam/www/public/us/en/documents/white-papers/aes-ipsec-performance-linux-paper.pdf
Enhanced Platform Awareness	https://software.intel.com/sites/default/files/managed/8e/63/OpenStack_Enhanced_Platform_Awareness.pdf https://networkbuilders.intel.com/docs/openStack_Kilo_wp_v2.pdf
Open vSwitch*	https://networkbuilders.intel.com/docs/open-vswitch-enables-sdn-and-nfv-transformation-paper.pdf
Data Plane Development Kit	http://www.intel.com/content/www/us/en/intelligent-systems/intel-technology/dpdk-packet-processing-ia-overview-presentation.html https://networkbuilders.intel.com/docs/aug_17/Future_Enhancements_to_DPDK_Framework.pdf
Intel® Cloud Integrity Technology	http://www.intelserveredge.com/enhancedsecurityservers/
Hardware Offload	http://www.intel.com/content/www/us/en/ethernet-products/controllers/overview.html

Please note: A separate reference-benchmarking document will detail performance benefits of these capabilities for specific virtualized vIMS network function use cases.

Open Source and Standards:

Intel is driving software contributions and broad market capabilities through important Open Source communities.

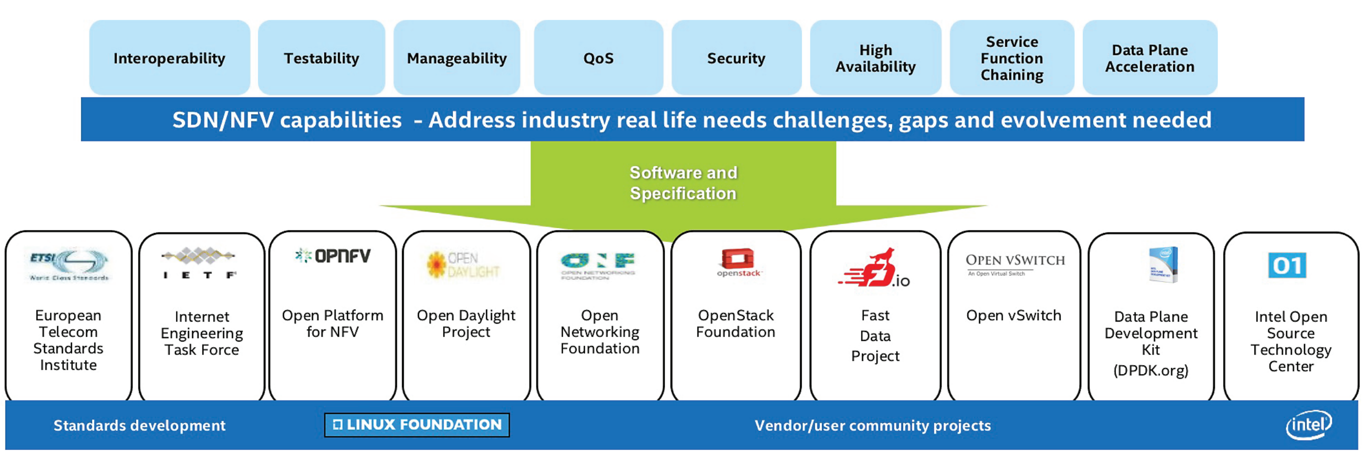


Figure 7. Intel's involvement in open source and standards.

Intel invests in 10 Open Source and Standards initiatives shown on Figure 7, from the ETSI-NFV group to Intel's own packet processing project on 01.org.

Contributions are driven both by the market and by specific customer requirements. These include commercial deployments that meet business needs, support targeted performance metrics, close development gaps, and provide the management tools needed to ensure service levels.

Intel's contribution is across the entire spectrum, including technical specifications, code development, testing and benchmark tools, and reference platforms.

Intel® Open Network Platform Reference Architecture

Intel ONP Server is an enablement program with a reference architecture that integrates Intel's hardware and open source software ingredients for easier ecosystem adoption. One of the key objectives of Intel ONP Server is to align and optimize key Open Community software ingredients for architects and engineers targeting high-performing SDN and NFV solutions. The Intel ONP provides a convenient reference platform to evaluate the latest performance contributions for OpenStack,[24] DPDK,[25] and accelerated OVS.[27]

Intel® Network Builders

Intel recognizes that a key component of enabling network transformation is a strong ecosystem of partners. The Intel® Network Builders community (www.networkbuilders.intel.com) has more than 200+ partners developing SDN/NFV solutions on Intel Architecture. Within this community, there are more than 30 software vendors for critical SDN/NFV use cases, including vIMS. The work of the community extends to proofs of concept, reference architectures and trials. With the help of its ecosystem partners, Intel remains committed to the development of technology solutions and capabilities that will improve the performance of virtualized network functions for CSPs.

Figure 8. Intel® Network Builders

The following table lists vIMS ecosystem partners with products and technologies supporting deployment:

Table 3. vIMS ecosystem partners..

Partner	Product (*) or Technology
Alcatel-Lucent	5900* MRF
Alcatel-Lucent	5420* Converged Telephony Server (CTS)
Alcatel-Lucent	1430* Unified HSS
Alcatel-Lucent	5450* IP Session Controller
Dialogic	BorderNet* Virtualized SBCs
Ericsson	Session Border Gateway (SBG)
Ericsson	Media Resource Function (MRF)
Ericsson	Multimedia Telephony Application Server
Ericsson	Home Subscriber Server (HSS)
Ericsson	Call Session Control Function (CSCF)
Genband	QUANTiX* Session Border Controllers
Genband	EXPERiUS* Application Server
Genband	SMART CORE* IMS
HP	OpenCall* Media Platform
HP	I-HSS
Huawei	SE2600* SBC
Huawei	MRP6600*
Huawei	ATS9900*
Huawei	HSS9820*
Huawei	CSC3300*
Italtel	NetMatch-S*
Italtel	i-MCS*
Italtel	i-TDS*

Next Steps

- To learn more about Intel's technology for NFV, attend the courses available in the Intel Network Builders University at https://networkbuilders.intel.com/university
- To learn more about Intel Network Builder partner's vIMS and other NFV products, visit https://networkbuilders.intel.com/solutionscatalog
- To build a testbed using the Intel ONP Reference Architecture, download the documentation at https://01.org/packet-processing/intel%C2%AE-onp
- To get the best security in your NFV systems, specify Intel Cloud Integrity Technology in your infrastructure and VNF procurements.
- To get the highest performance from your NFV systems, specify compatibility with the Data Plane Development Kit in your Infrastructure and VNF procurements.
- To get the highest return on investment from your NFV systems, specify use of Enhanced Platform Awareness in your Orchestration, Infrastructure and VNF procurements.

Additional Information

Related efforts in Intel:

- OpenDaylight Contribution and IETF efforts on NSH
  https://tools.ietf.org/pdf/draft-ietf-sfc-nsh-04.pdf
  https://wiki.opendaylight.org/view/Project_Proposals:Service_function_chaining
- OpenStack EPA contributions:
  https://01.org/sites/default/files/page/openstack-epa_wp_fin.pdf
  https://networkbuilders.intel.com/docs/openStack_Kilo_wp_v2.pdf
- Intel Open Network Platform
  https://01.org/packet-processing/intel-onp-servers

Intel Network Builders Related Information:

- https://networkbuilders.intel.com/docs/Intel-Virtual-VOIP-Orch-RA.pdf
- https://networkbuilders.intel.com/solutionscatalog/session-border-controller-74
- https://www.brighttalk.com/webcast/12229/181563

ETSI-Defined vIMS Proofs of Concept (POCs):

POC 27: VoLTE Service based on vEPC and vIMS Architecture

POC 11: Multi-Vendor on-boarding of vIMS on a cloud management framework

[1] http://www.gsma.com/network2020/all-ip-statistics/
[2] Ericsson Mobility Report, June 2015 - http://www.ericsson.com/res/docs/2015/ericsson-mobility-report-june-2015.pdf
[3] http://www.fiercewireless.com/tech/story/study-nfv-market-will-hit-116b-2019/2015-07-20
[4] http://www.gsma.com/network2020/all-ip-statistics/
[5] Communications Service Provider VoIP and IMS Equipment and Subscribers, Infonetics, November 25, 2015.
[6] Virtualization drives more VoLTE and VoWiFi adoption, ABI Research, July 7, 2015.
[7] http://www.fiercewireless.com/story/att-launches-rcs-based-messaging-and-video-calling-following-t-mobile/2015-11-20
[8] SBC Strategies and Vendor Leadership, Infonetics, Oct 285h, 2015
[9] http://www.fiercewireless.com/europe/story/telef-nica-uses-webrtc-tu-go-orange-ramps-libon/2015-02-27
[10] www.infonetics.com
[11] www.infonetics.com
[12] http://www.openvswitch.org
[13] http://www.opendaylight.org
[14] http://www.openstack.org
[15] http://www.opnfv.org
[16] http://www.intel.com/content/www/us/en/communications/service-provider-network-maturity-paper.html
[17] http://www.dpdk.org
[18] http://openvsitch.org
[19] http://www.intel.com/content/www/us/en/virtualization/virtualization-technology/intel-virtualization-technology.html
[20] https://software.intel.com/en-us/articles/openstack-enhanced-platform-awareness
[21] https://01.org/packet-processing/intel%C2%AE-quickassist-technology-drivers-and-patches
[22] https://software.intel.com/en-us/articles/intel-trusted-execution-technology-intel-txt-enabling-guide#_Toc383534414
[23] http://www.intel.com/content/dam/www/public/us/en/documents/white-papers/haswell-cryptographic-performance-paper.pdf
[24] http://www.openstack.org
[25] http://www.dpdk.org
[26] http://openvswitch.org