



Increasing Network ROI with Cloud Computing at the Edge

Services running on radio access networks (RANs) enable network operators to optimize backhaul network utilization, thus improving the user experience while generating incremental revenue.

Network operators profit from adding computing power to the RAN.

Overview

End-user devices must ultimately connect to wireless core networks, which is the function of base stations and small cells that sit out in the radio access network (RAN). Traditionally, the RAN has been the 'dumb pipe' for voice calls and data. With the advent of **software-defined infrastructure (SDI)**, network operators can make these pipes 'intelligent' by overlaying distributed cloud computing solutions onto the RAN. At its core, this change requires deploying general-purpose processors and storage onto base stations or base station aggregation points (e.g., radio network controller). This network upgrade will not only decrease operating expense (OpEx), but also accelerate the overall return on investment (ROI) by creating new revenue streams.

This solution brief describes how enterprise-grade cloud computing solutions can be integrated with commercial and enterprise RANs using an Intel® processor-based computing platform. The platform enables one of the largest existing software ecosystems, making products and technologies from the likes of Ineoquest*, Saguna Networks*, SpiderCloud Wireless*, and Tango Networks* available to cellular operators. Distributing specialized software and services across the network edge unleashes new opportunities for network operators: long overdue tiered quality of service for over-the-top (OTT) video or VoIP content as well as reduced backhaul load through improved edge security, for example.



Network Topology

Radio access networks vary in the types of equipment they contain, and as a result, there are numerous ways to deploy cloud computing. In cellular networks, a ruggedized server is typically integrated in an eNodeB or base station (e.g., macrocell) located outdoors and in close proximity of mobile subscribers, as shown in Figure 1.

For indoor networks found in enterprises, shopping malls, and other commercial buildings, a compact server is added to a small cell or an aggregator that manages traffic to multiple small cells. Figure 2 shows how this can be done with an

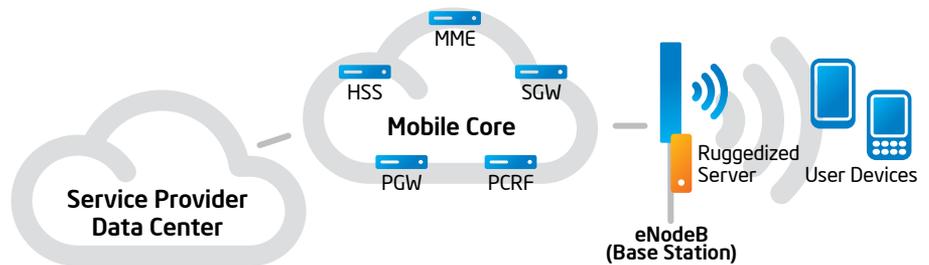


Figure 1. Cloud computing deployed in a wide-area cellular network

The SpiderCloud Services Node includes a high-performance Intel® architecture-based server that provides the cloud computing infrastructure for a large portion of, or an entire building.

Platform for Cloud Computing

Whether designing a ruggedized or compact server to deliver cloud computing at the edge, Intel® architecture processors have the performance to process packets and run multiple applications simultaneously. These processors are exceptionally well-suited for these workloads due to their large on-chip caches, multi-core architecture, fast system memory interfaces, and speedy access to Intel® Solid-State Drives (Intel® SSD). These features enable a base station to quickly transmit large numbers of web pages, videos, and other data content. In fact, these same traits explain why web hosting companies extensively use Intel processors in their data centers.

As the telecom industry adopts principles from network functions virtualization (NFV) and software-defined networking (SDN), orchestration frameworks such as OpenStack* will make it easy to deploy and manage cloud computing at the edge. In fact, the OpenStack cloud management framework has been successfully applied to Intel processor-based small cells and aggregators running a wide range of virtualized software applications, including caching, real-time video analytics, and intrusion protection system (IPS).

Cloud Computing and Virtualization

A key component of cloud computing is virtualization technology, which creates readily-available, computing capacity for service-oriented software. The technology enables a single hardware platform to run numerous service applications simultaneously in secure

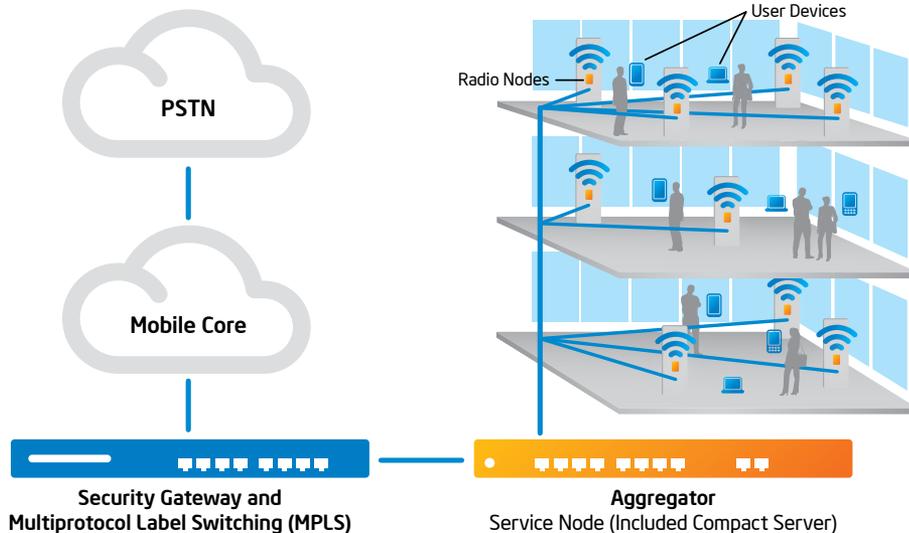


Figure 2. Cloud computing deployed in a building

Enterprise Radio Access Network (E-RAN) system from SpiderCloud Networks consisting of two elements:

- SpiderCloud Radio Node (SCRN): High performance small cell (3G and LTE/4G) system for scalable indoor and venue deployments.
- SpiderCloud Services Node (SCSN): An enterprise premises controller that enables easy installation, self-organizing network (SON) capability, integration with carrier and enterprise networks, and seamless mobility.

The Services Node offers mobile operators and application providers a convenient platform to deliver a variety of services and applications to enterprises and venues. Applications hosted on the server are delivered to end-users over a high-capacity 3G and LTE Radio Access Network. The Services Node aggregates up to 100 Radio Nodes, each of which provides as much capacity as a single HSPA+ and 4G LTE base station, sufficient to provide a high-quality wireless experience to thousands of end-users.

partitions called virtual machines (VMs). Intel Core processors integrate Intel® Virtualization Technology (Intel® VT), which increases the performance and security of virtualization software.

The number and types of applications that network operators and service providers can deploy in the RAN are increasing by the day. The subsequent sections describe

Content Caching and DNS Caching in Mobile Networks

Caching popular content locally eliminates the need to transport it repeatedly across the entire mobile network. Designed for mobile networks, Saguna CODS stores frequently requested or popular content at the base station, small cell, or aggregator and sends it directly to

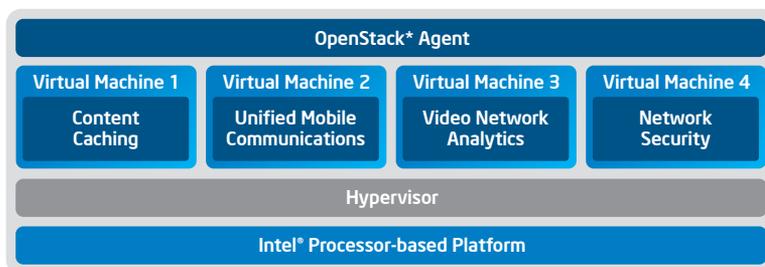


Figure 3. Service applications running on a virtualized hardware platform

how the applications shown running in the VMs in Figure 3 can increase network ROI by helping network operators improve the user experience, and by enabling new ways to make and save money.

Improving Content Delivery

Mobile network operators must contend with the explosive growth of mobile and especially video traffic, which exceeded 50 percent for the first time in 2012.¹ Exacerbating the situation are unpredictable traffic spikes caused by subscribers watching viral videos and live television programming.

In today's mobile network infrastructure, content and the Internet cloud are outside the network, far from the subscriber. As a result, the same content will be downloaded every time a subscriber requests it, needlessly wasting resources, and congesting the backhaul and transport network.

Saguna Networks Content Optimization Delivery System* (CODS) addresses the exponential mobile data growth with an innovative RAN-based, open computing software platform. With Saguna CODS, popular content and applications can be served directly from the 4G Radio Access.

mobile devices. Taking advantage of cloud computing at the edge, Saguna CODS accelerates content delivery while preserving user mobility.

Domain Name Server (DNS) caching also reduces the network congestion. More importantly, it dramatically improves the user experience with fast web-page loading times. Every time a user loads a web page, it initiates a request to a remote DNS server, located outside the mobile network, for the IP address of the web page. By caching popular IP addresses locally at the edge, the round trip time (RTT) is minimized, and web pages load much faster.

Monetizing the RAN

Now that mobile network operators have an open platform that can serve Internet content and applications directly from the RAN to on-the-go users, they can explore new revenue opportunities. For example, network operators can deploy location-based services using the Zonal Awareness* API from Aepona*, which sends notifications (e.g., enter zone, exit zone) about subscriber activities in the vicinity.

By utilizing the RAN as a computing and storage cloud, the solution provides several key benefits:

Optimizes network utilization²

- Traffic load is reduced during peak hours by approximately 70 percent.
- Radio utilization increases by around 20 to 30 percent.
- The cost of data delivery per megabyte goes down.

Improves the user experience

- The download experience is fast.
- Movie viewing is smooth and stall-free.

Generates incremental revenue from over-the-top (OTT) services

- Content providers can establish preferred service levels, justifying some revenue-sharing.
- Location-based information is valuable to advertisers and content owners.

Live Trial Results²

In live trials, the Saguna Networks solution provided substantial benefits in a number of areas, as shown in Table 1. The DNS cache in CODS improves the user experience by reducing RTT, resulting in a two second reduction in average web page download time. This performance improvement would be particularly noticeable to users interacting with social applications, like Facebook*, or business people looking for real-time information such as flight status and traffic conditions.

The content cache had a 30 percent hit rate, enabling the backhaul link to handle 50 percent more traffic. Video playback on user devices started in half the time and with zero rebuffering, delivering a much improved viewing experience. The transmission control protocol (TCP) optimization application increased RF utilization by up to 20 percent, thus reducing congestion over the air interface.

SAGUNA* CODS LIVE TRIAL RESULTS

RAN APPLICATION	FIELD MEASUREMENTS	VALUE
DNS cache	Up to 40% hit ratio	2 seconds reduction in web page download time
Content cache	Up to 30% hit ratio	50% more traffic over the same backhaul link
Video optimization	Up to 50% reduction in video start time, 0 rebuffering	Much better user experience
TCP optimization	Up to 20% improvements in RF utilization	Relieve congestion over the air interface

Table 1. Saguna* CODS live trial results

**Mobile Unified Communications
Increases User Satisfaction**

A growing number of enterprise employees expect “Bring Your Own Device” (BYOD) support in the workplace, requiring IT administrators to provide adequate broadband coverage and capacity, as well as integration with existing infrastructure.

But the reality is most enterprises have not extended their PBX functionality to BYOD, leading to a great deal of inefficiency. This forces employees to have two business phone numbers (mobile and desk), two voice mail boxes, and two contact lists. In addition, enterprises are unable to establish BYOD policies that save cost and reduce security risks. For example, many companies find it difficult to implement policies that automatically route international calls from smart phones through its PBX in order to take advantage of low-cost, direct dialing and avoid expensive cellular roaming charges.

Why Mobile Unified Communications?

In general, mobile unified communications solutions integrate the service providers’ mobile network with enterprise IP telephony and PBX infrastructures. As a result, an employee’s smart phone is transformed into a fully-featured business phone that is managed by the enterprise IT department.

IT Solution for BYOD

Tango Networks’ mobility solution gives enterprises the ability to extend PBX capabilities to mobile devices with a high

level of control and management that IT departments demand. Fully supporting a BYOD strategy, the solution enables companies to satisfy their employees’ desire to utilize their personal mobile devices for both personal and business identities. It also provides a simple way for IT staff to manage corporate mobility without the expense and headache of managing mobile device applications.

By satisfying the enterprises’ need for mobilizing business applications and mobile device management, telecom service providers can monetize their investment in enterprise small cells through recurring revenue value-added services that Tango Networks’ mobility solution provides.

Small Business and Enterprise Benefits:

Improves the user experience

- Employees have one business phone number, voice mail box, and contact list.
- Every mobile device is supported.
- Calls are seamlessly moved between mobile and desk phones.
- Mobile phone behavior can be modified for personal or business use based on location, time-of-day, incoming caller, etc.

Reduces operations costs

- International long distance calling costs are minimized.
- Mobile call recording is supported cost-effectively (Regulatory requirement in some industries, like Finance).
- Mobile policy is enforceable by the IT department.

Telecom Service Provider Benefits

Generates incremental revenue

- The 93 percent of businesses that use premise-based UC and IP-PBX platforms are potential customers for a mobile unified communications solution.
- Like content caching, this solution increases customer loyalty, reduces churn, and enables new revenue streams.
- Minutes of use (MOU) increases due to the added convenience.

**Improving Video Network
Performance**

Network operators know that managing video quality and performance is not easy. Video networks are complex and generate vast amounts of data that make it difficult to understand. The challenge is turning this data into understandable and actionable insights that enable proactive management of video networks.

Why Video Network Analytics?

Critical to the success of monetization, content providers need to gather a lot of information and have it readily available. They need to evaluate operational data (e.g., service quality data), and also go beyond network performance metrics and analyze information about the consumer’s behavior. Only when all of this information, both operational and behavioral, is brought together can providers get a clear picture of exactly what is happening within their networks and how to take advantage of that knowledge.



Figure 4. IneoQuest* video analytics solutions convert vast quantities of operational and behavior data into understandable and actionable information and reports

Video providers have an abundance of so-called “big data” that can give them insight into a number of areas, including who is watching what programs, on what devices, and for how long. This type of subscriber data is critical, but to be truly effective it also needs to be tied into operational data to get the full picture.

Providers need to gather quality data (real-time and historical), performance statistics, and behavioral data (Figure 4) to truly understand the overall network and grow their returns.

Optimizing Video Networks

IneoQuest’s Analytics solutions, cPAR and AMP, provide real-time and historical reporting and analysis, giving insights into the video deployments and the customer experience. These solutions enable better decisions for managing and monetizing video services.

IneoQuest’s cPAR system collects operational performance data from a single or multiple IneoQuest video management systems (iVMS), providing a simple interface for operational analytics and historic reporting across the entire video service, improving performance management, and solving systemic issues. By storing data over long periods of time, cPAR benchmarks performance to

analyze trends and architectural issues in the service, and provides a valuable resource to analyze program availability and performance against service level agreements (SLAs).

IneoQuest’s Audience Measurement Platform (AMP) leverages award-winning IneoQuest probing technology to harvest behavioral analytics across adaptive streaming networks. AMP collates behavioral data aggregated from the video services both in real-time and historically, allowing comprehensive analysis of the video assets, devices, protocols, and end user behavior. AMP provides views and reports that enable monetization of video services by providing the behavioral data needed to better target advertising and new services, tuning of service efficiency, and demographic profiling of consumers. By using the latest web service technology, AMP can be integrated seamlessly into big data systems, as well as existing business support, marketing, and advertising management systems.

Improving Network Security

Most carriers and telecom service providers are focused on the migration from circuit-switched, wireless networks to packet-based 4G/LTE networks. Some

are not fully aware of the malicious actors, and why should they be? Until now, mobile threats mostly involved smart devices and user data, and not operator infrastructure.

What are the Risks?

The transition to packet-based broadband wireless service ushers in new vulnerabilities and threats to telecommunications and service provider organizations. As carriers deploy wireless Internet technologies to enable 4G/LTE networks, attackers can use old Internet techniques to attack broadband data services, mobile devices, and infrastructure. An all-IP network, in addition to being efficient, also increases the security risk for both subscribers and infrastructure.

There are broadly two types of security risks:

- **Attack on the infrastructure:** This is in the form of scans, probes, and floods with the intent to overwhelm the signaling infrastructure. This results in subscribers dropping their data connections altogether or experiencing a very low quality of service. The attack on the infrastructure can be on the services hosted by the smart edge or even on the services in the core.
- **Attack on subscriber devices:** It is in the form of a malicious application, which is downloaded to smart phones, tablets, etc., and infects devices. It results in unwanted paid SMS, high phone bills, unresponsive phones – leading to high helpdesk support expenses.

Securing the Edge Cloud

Intel’s Virtualized Network Security Platform (NSP) developed by McAfee* is a uniquely intelligent security solution that discovers and blocks sophisticated threats in the network. Using advanced threat detection techniques, it moves beyond mere pattern matching to defend against

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stealthy attacks with extreme accuracy. Intel's Virtualized NSP provides a wide range of benefits:

Optimizes network utilization

- 200+ types of scans/worms are detected/blocked up to Layer 7.
- 1000+ botnet families (with millions of zombies) are identified and blocked are identified and blocked via industry-leading McAfee GTI (global threat intelligence).
- 99 percent of known Android* malware are blocked from being downloaded. Option to inform the subscriber. Network availability increases because attacks are prevented.

Satisfies Customers

- Protect smartphones, tablets, and other endpoints from malware, botnet, hack attacks.
- Lower support cost and happy customers.

Provides comprehensive application-level visibility and enforcement

- Over 1500 Apps are identified, including point-to-point, voice and video-over-IP, chat, etc.
- Enforcement rules to limit concurrent connection, bandwidth, or block group of applications based on policy.

Generates incremental revenue

- Subscriber-aware dashboard (phone #, IMSI/IMEI, APN on the dashboard).
- Value-added security can generate additional revenue from enterprise customers.
- Industry-leading security could attract new enterprises and individual subscribers.

Next Steps and Future Benefits

Decreasing latency and improving real-time performance has been a concern when vitalizing network equipment. Making further progress in this area, the cloud usage models presented in the paper will be enhanced with adaptive real-time virtualization using Wind River* Linux* and Wind River Open Virtualization Profile (OVP). This added step will enable adaptive timing to meet the various needs of different services running in the network cloud. The exceptional low latency and jitter delivered by Wind River Linux and OVP can dramatically improve the performance of any KVM distribution today, providing real-time applications with more CPU cycles and increased determinism.

Increasing Network ROI

Cloud computing at the edge has the potential to significantly increase profitability for network operators. The software applications presented here demonstrate ways network operators can create substantial revenue from new business models, services, and applications. Adding cloud computing to the RAN, in the form of Intel processor-based platforms, enables network operators to get more out of their networks through higher utilization and improved customer satisfaction. With the help of OpenStack or other orchestrators, these computing resources can be easily deployed, operated, and managed on bases stations, small cells, and aggregators.

For more information about Intel solutions for communications infrastructure, visit www.intel.com/go/communications.



¹ Source: Cisco*, "Cisco Visual Networking Index (VNI) Global Mobile Data Traffic Forecast Update, 2012-2017," February 6, 2013, http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

² Source: Saguna Networks*.

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