

Increasing Mobile Operators' Value Proposition With Edge Computing

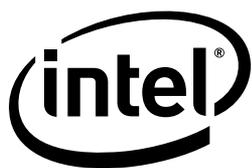
Turn bit pipes into smart pipes with an Intel® architecture-based server embedded into a Nokia Solutions and Networks* base station

Introduction

Base stations haven't changed much since the 1990's. They've always been meant to sit out in the Radio Access Network (RAN) and connect user devices to the network – primarily carrying voice calls and conveying data. But now, base stations are being transformed into intelligent service hubs capable of delivering services directly from the edge of the network, something that has never been done before. This advancement is the result of Nokia Solutions and Networks* fundamentally changing the role of the base station to include IT capabilities, such as localized processing and content storage, and access to real-time radio and network information, thus enabling personalized and contextually-aware services. An IT architecture inside a base station forms Liquid Applications*: specifically the Radio Applications Cloud Server (RACS), which is based on high-performance Intel® processors.

The solution redistributes functions to the edge of the network, directly inside a base station, enabled by the flat architecture of the latest mobile networks (e.g., LTE). Moreover, IT and private cloud technology inside the base station expands the ecosystem and allows applications to be managed independently of the mobile network lifecycle, which typically includes annual or semiannual upgrades. When no longer bound to this schedule, application and software developers, and independent software vendors (ISVs) can deploy new applications and services in days or weeks, rather than in months or years.

The RACS creates an environment suitable for the development and implementation of new services in a way that gives full control to mobile operators. As a result, they can reposition themselves within the value chain since their infrastructure is elevated in importance – changing the definition of personalized services and shedding the perception of the operator network as a bit-pipe. This technical brief describes how mobile edge computing enables improvements to performance and service quality by moving applications and content in close proximity to the mobile subscriber, and how this can be directly translated into value.



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From Bit Pipe to Smart Pipe

Mobile operators are always striving to enhance their customers' experience, primarily to reduce churn but also to attract new ones. Customer perception is often shaped by services offered from Over-The-Top (OTT) providers, for example, Skype* and Netflix*, who typically profit from the rent-free use of mobile operators' infrastructure. This one-sided dynamic is driving mobile operators to develop new strategies intended to change the way their infrastructure is used: from being a bit pipe providing basic connectivity to becoming an intelligent network that provides unique, revenue-generating services. Mobile operators need to find ways to collaborate with other eco-system partners to make money from the evolving Internet-based interactions in Business-to-Business (B2B) and Business-to-Consumer (B2C).¹ The Nokia Solutions and Networks' RACS provides a means to do just that.

The Move to Mobile Edge Computing

The explosive growth of video is expected to represent 70 percent of the traffic volume by 2016²; continuing to be the biggest contributor of network load within a mobile infrastructure. Furthermore, unpredictable traffic spikes will increase as a growing number of subscribers watch viral videos and live television programming at the same time, with the consumption of this content increasing over mobile devices. Each subscriber will download the same content, often in the same location, needlessly wasting network resources.

One solution is to locally cache popular content so it doesn't have to be repeatedly pulled from the Internet and across the mobile network. Today, local caches are typically located outside of a mobile operator's RAN, within the core network or just outside. With the RACS, frequently requested or popular content can be stored inside the base station and sent directly to mobile devices. This edge computing approach provides several benefits:

- **Radical user experience improvement** – Video downloads from base stations are up to five times faster³ than from source servers, typically located deeper in the network.
- **Cost savings** – The RAN's backhaul efficiency is increased through the intelligent processing and caching of data inside the base station.
- **Exclusive control** – Mobile operators control the applications running on their base stations and the delivery to the mobile device, enabling service and experience guarantees to subscribers as well as other content providers.
- **Localization features** – Unlike devices in the core network, base stations are uniquely situated to provide location-specific content, such as special offers from surrounding businesses, or information about nearby tourist and visitor attractions.

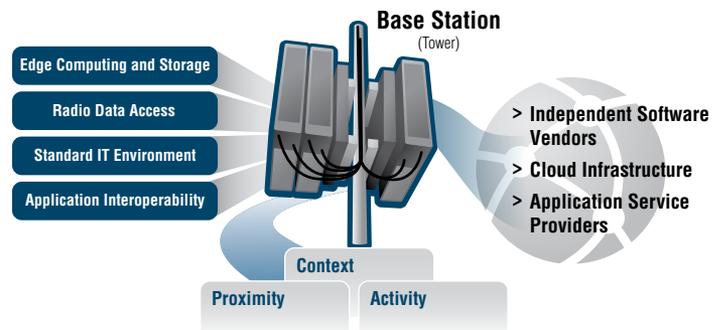


Figure 1. A base station becomes a value creation engine.

Mobile edge computing provides mobile operators opportunities to positively impact their customers' experience through fresh and exciting personalized service offerings and increased performance. With this recent development, base stations will be able to tailor the content they send based on subscriber context that fundamentally changes the definition of personalized services.

Value Creation Engine

The new base station platform from Nokia Solutions and Networks extends applications and services that would normally reside within the Internet, or the centralized core and data centers of mobile operators, to the very edge of the network and in close proximity of the mobile subscriber. A mobile operator's dense network of base stations is transformed by the RACS into numerous value creation engines. They enable innovative, low-latency services, such as mobile gaming and augmented reality, and accelerate media-rich applications that deliver an enhanced quality of experience for the mobile subscriber. The RACS can process large amounts of data in real time that would be prohibitively complex and costly to deliver on a traditional centralized cloud. Figure 1 lists some of the key features that enable a base station to become a value creation engine:

Low cost – Facilitate applications, processing and storage from the network edge in order to free up valuable core network resources that alleviate network load and reduce an operator's Total Cost of Ownership (TCO).

Manageability – Take advantage of a standard IT environment to agilely develop and deploy applications.

Interoperability – Export data to/from external applications platforms that reside elsewhere within the operator network or the Internet.

Relevance – Make the most of network data, which is unexploited to date, to provide real-time context to applications.

Use-Case Scenarios

Mobile edge computing capabilities enable mobile operators to offer a wide range of new applications and services, some examples of which are described below:

Hyper-Targeted Mobile Advertising

Businesses and product manufacturers (e.g., brands) are constantly looking for new ways to segment and target consumers, with the widespread use of smartphones creating some novel opportunities. In conjunction with the RACS, mobile operators can place specific and relevant content near stores (Figure 2) or point locations in order to create a virtual physical area that, when accessed by “opted-in” mobile subscribers, triggers targeted messages to their smart devices (aka geofencing). Some examples include:

- **Location and direction** – Information on where consumers are and their direction of travel.
- **Analytics** – Data on how often consumers are in a specific area and how long they have stayed there.
- **Proximity** – Data on when a consumer is about to enter the mall so a targeted advertisement can be displayed on digital signage nearby.
- **Personalized loyalty program** – Deal or discount coupons are sent to the smart device of a consumer in the proximity of a specific store.
- **Promotions** – Maps and tourist promotions are sent to the smart device of a consumer walking inside an airport, near a museum or gallery, etc, or entering a hotel.
- **Engagement** – Sports clips are sent to consumers’ smart devices in real time in a specific location (e.g., a sports bar). Such hyper-targeted mobile advertisements have been shown to double mobile advertising revenue, as well as generate as much as a \$5 (USD) average revenue per user (ARPU)⁴

Service Level Agreements

In mobile networks, RAN awareness can complement real-time policy management used to prioritize subscribers based on applications and/or Service Level Agreements (SLAs). Real-time radio data concerning the mobile cell can be used by other mobile operator equipment (e.g., the packet gateway, which handles optimization of content) to ensure subscribers get a good user experience when the cell is congested. The same real-time data can guarantee a better quality of service and experience for premium users on congested cells. When mobile operators are able to offer dynamic SLAs to enterprise customers or premium service providers, along with new applications and services, new business opportunities will arise in premium new markets (e.g., Machine-to-Machine, smart cities and other vertical applications).



Figure 2. A Radio Applications Cloud Server (RACS) can provide a wide range of services in a shopping mall.

Media Processing

Data compression and transcoding can reduce file download time and graphics computing requirements. The RACS can provide real-time network data to equipment that transcodes video streams in order to adapt to network conditions (e.g., congestion) or make adjustments that accommodate the capabilities of individual endpoints, like smart phones with small screens. These network functions not only help mobile operators make more efficient use of their resources, but also improve performance during peak periods, which could be a source of revenue.

Hosted Services

Mobile operators have the capability to host third party applications and services inside the base station for OTTs and ISVs, who require the benefits of subscriber proximity and localization. By placing their content at the point where people connect, mobile subscribers receive a superior experience, which is a high priority for most OTTs and ISVs, and from which they can create additional value.

Content Caching

Mobile subscribers will experience a faster response time when accessing services directly from the RACS and will not be subjected to other bottlenecks than the radio interface itself. For example, when a user wants to stream something that is already available at the base station (e.g., a video), the download will start faster than usual (approximately 30 percent faster response time) and with a lower probability for the mobile device to freeze due to network latency or buffering, as there are no other bottlenecks other than the radio interface itself. This means that all available radio capacity is at the disposal of the user, compared to the current situation where videos are typically streamed from the Internet, often through multiple countries and subject to different speeds, even during the transfer of the same session.

Augmented reality

Point your smart device at a monument and a pop-up window provides historical information; point your smart device at a restaurant and read about the specials of the day; or point at a cinema and watch movie trailers for films currently being shown. This is an experience using augmented reality, where useful computer-generated renditions are overlaid onto your physical surroundings via your smart device. Location-specific augmented reality is already available today, but tends to be a poor experience as the augmented content has to be fetched across the network and suffers from network degradation (e.g., latency). With the RACS, the augmented content can be stored locally, in close proximity to the mobile subscriber, suffering no network degradation when it is requested. This is visualized in Figure 3, with a tablet displaying a virtual location that is enhanced with augmented content, such as:

- A restaurant within walking distance has a special offer on hamburgers.
- Friends of the subscriber have 'tagged' themselves at an establishment down the street.
- A hotel nearby has rooms available – reserve with this Uniform Resource Locator (URL).

A base station with an edge computing capability processes and conveys this information, for which a mobile operator can generate revenue from the featured businesses and the provider of the augmented content.

Solution Benefits

Mobile edge computing at the base-station level provides an opportunity for mobile operators to offer differentiated services that provide the following benefits:

- **Enhance the mobile subscriber experience** - Content and data is stored right where people connect to the network, thus providing a superior mobile broadband experience. Web-based services and applications can be significantly accelerated when they are deployed closer to the customer, with real time network data effectively being used to contextualize applications.
- **Reduce TCO** - The ability to optimize network traffic by caching content and delivering services directly from the edge of the network alleviates network load and frees resources. In addition, the time and effort needed to develop software in a standard IT environment is decoupled from protracted 3rd Generation Partnership Project (3GPP) development cycles, permitting the development of new services in a fraction of the time that is currently required.
- **Enable new revenue opportunities** - In collaboration with other ecosystem partners, mobile operators can create fresh content, applications and services that take advantage of unique attributes of subscriber context and proximity. In addition, mobile operators can

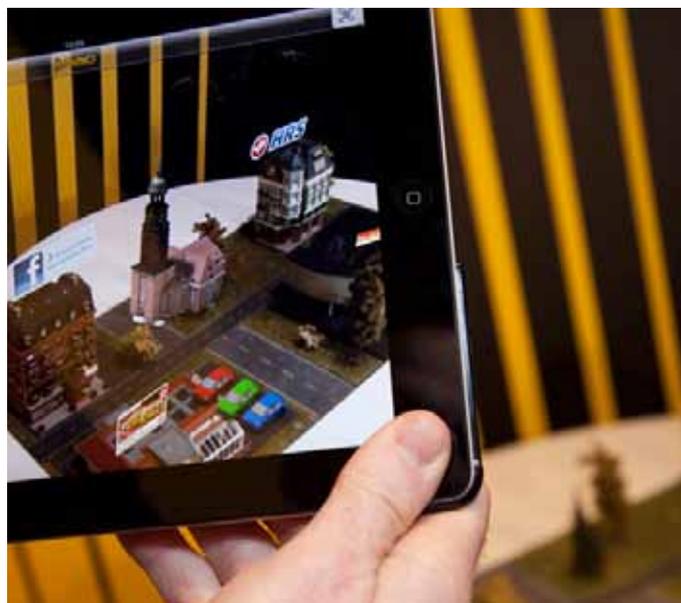


Figure 3. Augment reality overlays are placed over a virtual location shown on a tablet.

host third party content locally on the base station with service level guarantees for priority content, such as video and mobile-based financial transactions.

- **Positively disrupt the value chain and connected ecosystem** - An innovative software system allows mobile operators, service providers and other entities to play complementary and profitable roles within their respective business models as they monetize the mobile broadband experience. This includes developing applications running on a highly distributed cloud made possible by a mobile edge computing platform inside a base station.

Transforming Mobile Broadband

Liquid Applications from Nokia Solutions and Networks is an innovative network technology designed to help mobile operators provide a truly unique and personalized mobile broadband experience. This is achieved by transforming a base station into a local hub for new service creation and delivery. The base station places applications, services and content in close proximity to mobile subscribers using the groundbreaking RACS.

The RACS runs the latest cloud technology and service creation capabilities on standard IT middleware directly inside the base station. It provides processing and storage capabilities together with the ability to collect real-time network data, for example radio conditions, subscriber location, direction of travel and more. This data can be exploited by applications to offer context-relevant services that create value for mobile subscribers. The RACS is fully integrated with the Nokia Solutions and Networks Flexi Multiradio Base Station.

SK Telecom* Focuses on Service-Aware RAN

SK Telecom*, South Korea's leading wireless telecommunications operator, is focusing on realizing Service-Aware RAN as part of its evolution toward an upgraded network. Unlike traditional base stations that essentially only played the role of a communication pipe, Service-Aware RAN is an intelligent base station that provides customers with a unique mobile experience through a wide variety of customized services. Based on the diverse features of intelligent base stations such as localized processing, storage and access to real-time radio and network data, the operator expects to develop services and applications that deliver a contextualized and personalized experience to customers.

"Telecom providers are realizing that optimized transmission of data alone can no longer guarantee success in the market," said Dr. Choi Jin-sung, Executive Vice President and Head of ICT R&D Division at SK Telecom. "SK Telecom will work closely with Nokia Solutions and Networks to bring innovative changes to people's lives by developing and applying new network technologies."

For more information about the collaboration, see <http://www.nsn.com/news-events/press-room/press-releases/sk-telecom-nokia-siemens-networks-collaborate-on-liquid-applications-mwc13>.

Intel Under The Hood

The edge computing capabilities of the Nokia Solutions and Networks RACS is delivered by the Intel® Xeon® processor based on highly-integrated, low-power multi-core technology, which allows integration into a non-standard environment. For example, the Liquid Applications hardware plus the Intel-based processing platform both fit inside the required small form factor of a mobile base station. The solution employs several Intel® technologies, including:

- Intel® Virtualization Technology (Intel® VT) to increase performance and security.
- Intel® Trusted Execution Technology (Intel® TXT) to add another layer of platform security.
- Intel® AES New Instructions (Intel® AES-NI) to accelerate data encryption and decryption.
- Intel® Data Plane Development Kit (Intel® DPDK) to speed up packet processing.

In addition, the extensive Intel ecosystem allows many application providers to integrate their solutions into the Liquid Applications platform with minor modifications to their software.

Coordinated Development Effort

Intel® architecture-based solutions are widely used by Application Service Providers (ASP) and Enterprise cloud implementations globally. The Nokia Solutions and Networks solution drew from Intel's rich experience and significant industry investments to implement mobile edge computing at the base-station level with true telecom characteristics. Nokia Solutions and Networks and Intel worked closely to merge key IT advancements and telecommunication applications in a way that yields a state-of-the-art mobile edge computing solution. Both parties are actively collaborating to educate the ecosystem on the benefits of adding computing to the network edge, in closer proximity to the end users. This message is being very well received and is gathering significant support from the market.

The Nokia Solutions and Networks RACS demonstrates high-throughput, low-latency infrastructure for I/O by optimizing performance using the Intel DPDK. Combined with the virtualization hardware support features in Intel processors, the RACS has enough performance headroom to execute new applications simultaneously on the same platform, thus creating new revenue streams for operators.

Furthermore, this solution is based on a virtualized infrastructure running on Linux and built on highly-scalable, Intel-based x86 design, which means engineering development cost can be minimized. This allows Nokia Solutions and Networks to concentrate their resources on enabling an easy-to-use development and innovation environment for application providers. In addition, the existing ecosystem of ISVs, appliance vendors and ASPs is, to a great extent, prepared to deliver an optimized solution on Intel architecture, opening new possibilities for the entire value chain.

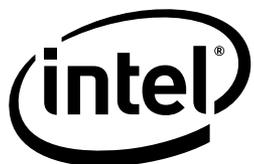
Moving Up the Value Chain

With Liquid Applications, mobile operators can transform the mobile broadband experience by using their dense network of mobile base stations, offering their customers benefits that no other provider can match. Liquid Applications, including the Intel-powered Nokia Solutions and Networks Radio Applications Cloud Server (RACS), will enable mobile operators to create substantial revenue from new business models, services and applications. For example, mobile operators could host content from third parties, such as an ASP, locally on the base station and provide quality of service guarantees, not only for priority traffic but also for mobile-based financial transactions, like online banking and shopping. Furthermore, application developers will be able to use real-time network data to create innovative services, such as connecting mobile subscribers with local points-of-interest, businesses and events.

For more information about Liquid Applications from Nokia Solutions and Networks, visit

<http://www.nsn.com/portfolio/liquid-net/intelligent-broadband-management/liquid-applications>

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



¹ Source: "Telecom Operators Positioning in the APP Economy: The 'Pipe' Way or the Highway," Delta Partners, April 2012, <http://www.deltapartnersgroup.com/telecom-operators-positioning-in-the-app-economy-the-pipe-way-or-the-highway>.

² Source: <http://www.nsn.com/news-events/insight-newsletter/articles/do-you-know-when-youtube-had-the-highest-number-of-concurrent-live-streams>.

³ Source: Nokia Solutions and Networks internal testing.

⁴ Source: "Harnessing the Small Cell Opportunity" presentation by Teresa McEneny of Cisco* on December 4, 2012 at Small Cell Americas, Dallas USA, http://www.smallcellamericas.com/files/0925teresa_2.pdf, slide 11.

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