The Importance of Edge Analytics in a 5G World: Driving revenue from analytics

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The Importance of Edge Analytics in a 5G World: *Driving revenue from analytics*

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Executive Summary

For the last three decades, mobile operators around the world have focused on making their networks as efficient as possible while providing differentiated service to consumers. It is the consumers that provide the vast majority of revenues for the mobile industry. This model is now changing: simply put, consumers are unable or unwilling to pay more for faster mobile data service or for a larger bucket of GBytes. Mobile operator economics are changing rapidly with the result that the focus today is network monetization and not simply network optimization.

As the industry works towards the first 5G deployments in the next few years (*iG*R expects the first networks using IMT-2020 to be built starting in 2020), mobile operators are also starting to build the infrastructure and platforms necessary for monetizing the new generation of mobile networks. 5G networks differ from today's LTE (Long Term Evolution) networks in several key ways: higher cell density; use of more edge computing; higher data speeds; and lower network latency. The new 5G architectures will also require a new approach to collecting and analyzing data from the networks.

In the past, the majority of analytics information has come from the mobile packet core and has been passive or, at most, used DPI (Deep Packet Inspection) techniques. New mobile analytics capabilities are now needed that provide real-time information from across the network, including the RAN (Radio Access Network) and the user device itself – analytics needs real-time end-to-end visibility. In addition to providing information about the mobile network and its performance, analytics must now encompass how the consumer is using their device, the type of device they have and its current status, the applications being used, and consumer behavior. Active mobile analytics is needed that provides intelligence in real-time.

It is critical of course that the mobile operator can use active mobile analytics to drive revenue and support new business cases. This can be accomplished in several ways:

- Over The Top (OTT) optimization – As more consumers demand access to various OTT services and applications on their mobile devices, MNOs are being forced to support these services in their networks. Active analytics become a critical part of the OTT business model, providing intelligence on which services are being used, when, on which devices and by whom. Mobile network resources can then be allocated in real-time to improve the OTT customer experience and maximize the revenue potential.

- New revenue streams and services – Mobile Network Operators (MNO) are exploring new revenue opportunities such as advertising, location-

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based services and supporting Mobile Virtual Network Operators (MVNO). All of these opportunities require network analytics to be effective.

- Customer intelligence – Customer bases are no longer segmented simply by demographics but by behavior. Pricing and marketing strategies also benefit directly from analytics intelligence, improving the ability to upsell and cross sell products and services.

- Proactive customer care – MNOs, service providers and content/entertainment providers all strive to reduce churn. Identifying causes of current and potential churn are very important not only to the MNO but also to their partners.

Mobile Edge Computing (MEC) is a new option for network owners that provides computing, storage and communication resources at the edge that can provide detailed analytics data on the network, the CPE (customer premises equipment), and the consumer device. MEC's key value proposition is that it allows an operator to provide new services by opening up their RAN edge. It does this by placing smart nodes at the edge of a mobile network, for example, right where small cells would likely be placed. These nodes run virtualized software on general purpose server hardware all housed within a secure form factor. These edge nodes can emulate parts of the core network, serve as reliable caching units and/or run virtualized applications from any number of an operator's developer partners.

It is important to understand that MEC solutions are being deployed today to support active mobile analytics. ADLINK and their partners provide the network infrastructure directly to the mobile operators and their network OEMs to improve revenue streams for operators. ADLINK's solutions are overviewed later in this paper.

In summary, mobile operators are today exploring, and deploying, new platforms and solutions that enable active mobile analytics to monetize the mobile network, not simply optimize it or improve efficiency. Tomorrow's successful mobile operators will be those that have used active mobile analytics to create new revenue streams (including entertainment, advertising and sponsored content) to fund 5G deployments and grow their existing LTE connections base.

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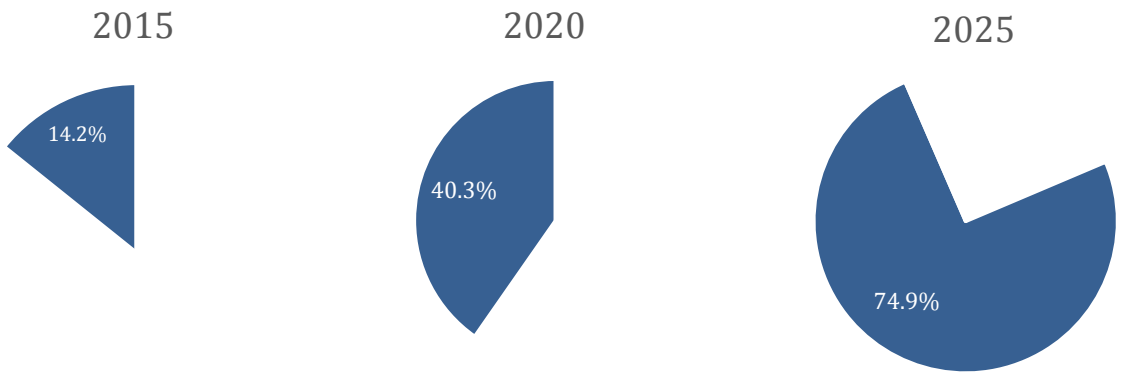
The Need for Analytics for 5G

Mobile network evolution

Mobile networks have evolved over the past few decades from 2G to 3G and now to 4G LTE. While the original digital 2G networks were focused on providing improved voice capacity and 3G networks introduced basic mobile data connectivity, 4G LTE networks offer increased data speeds using IP architectures.

As the name LTE suggests (the acronym stands for 'Long Term Evolution'), LTE is the beginning of a new technology family that is expected to be in use for at least another 15 years, if not longer. Figure 1 shows iGR's forecast for the percentage of the world's mobile connected devices that will use LTE for 2015, 2020 and 2025. Obviously, as the chart shows, the vast majority of the world's mobile devices will use LTE by 2025 (the other 25 percent will use mainly 3G and 5G technologies).

Figure 1: Percentage of World's Mobile Connections using LTE, 2015, 2020, 2025



Source: *iG*R, 2016

LTE was originally deployed as 3GPP Release 8. The latest network is Release 10 and Release 11 equipment is coming soon (known as LTE-Advanced). Each subsequent version of the LTE specification includes new features and functions, as well as increased efficiencies on the air interface. In short, each release gives the mobile networks more capacity and more features.

LTE Release 13 is about to be finalized and the first networks will likely be deployed in a few years. Obviously, Release 14 will follow, but this may be the basis for 5G (known as IMT-2020); the industry is still specifying exactly what IMT-2020 will include (finalization is not expected before 2019).

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It is important to understand that 5G IMT-2020 networks will be based on the current LTE architectures. While IMT-2020 is a new specification, it will will rely on some of the prior features of LTE Release 11 through 13. An operator that has deployed LTE will therefore be able to upgrade into IMT-2020 relatively easily, using much of the same core network and architectures. This means that analytics used for LTE will be extended directly into 5G.

The difference with 5G will mainly be in the network topologies and the use of far more cell site densification (giving increased bandwidth to the CPE). More processing will be pushed to the edge of the network, enabling the implementation of low latency applications.

Changing behavior of end users

The evolution of LTE and the subsequent move to 5G is being driven by the changing demands of consumers and enterprises. In short, mobile end users are demanding more network capacity, more data bandwidth and higher mobile data speeds. They want to use their mobile devices in more places and have more devices connected to the networks. For example:

- More smartphones, tablets, connected cars, and Internet of Things (IoT) devices result in more demand for bandwidth on the mobile networks.
- Increased use of Over The Top (OTT) services and content on mobile devices, as well as OTT being packaged by the MNO into their standard service products.
- The increased data speeds available on today's LTE networks encourage more consumer video consumption on mobile devices; this trend will continue and expand in the future with HD video, gaming, virtual reality and other video-based services that require a higher payload be delivered to the mobile device.
- Growth of IoT means that connectivity is needed for more devices in more places. However, since the revenue-per-device will be very low, the MNO must be able to provide network service at an extremely low OpEx to support the IoT business case.

Unfortunately for the mobile operators, while the end users are demanding and consuming more mobile data, they are not willing to pay a lot more for it. Looking at the top mobile operators in the U.S. for the last few years, their average revenue per user per month has consistently fallen every quarter.

Severe competition between operators means that it is very difficult to increase pricing. In fact, prices have fallen significantly in the last 18 months. As a result, the mobile operators find it very difficult to generate new revenues from the consumer.

The answer for the mobile operators is to get a better understanding of how consumers and enterprises are using the mobile networks, how capacity can be

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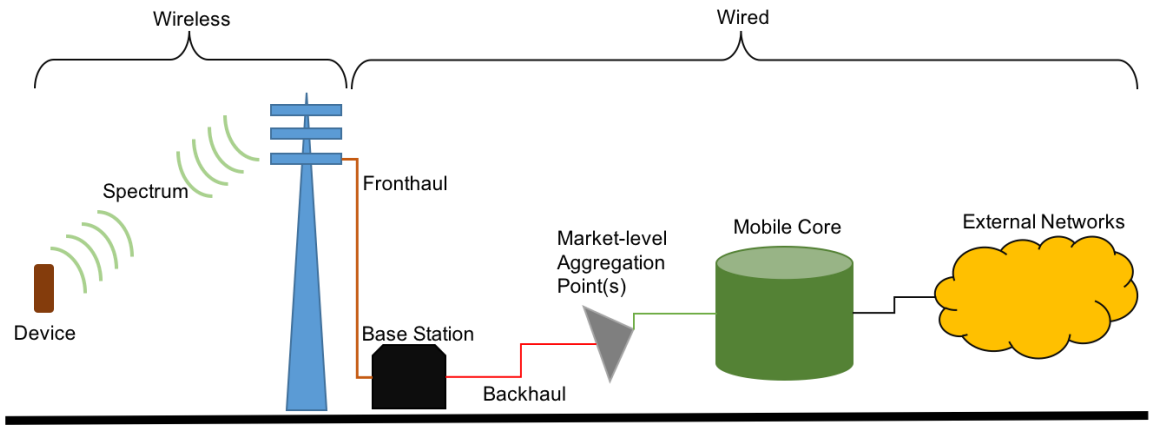
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optimized and how the user base can be segmented based on behavior (not simply demographics). This will help the mobile operators unlock hidden revenues from their networks, as well as understand which services are being used and valued (and those that are not). To do this, analytics will be required at the edge of the mobile network, not just in the core.

Densification of networks

One of the key ways for mobile operators to increase the capacity of their networks is to add more cells – in other words, to densify the network. While this is easy to say, it is hard to do in practice; new cell sites (both large and small) require planning, zoning and building. Figure 2 shows a basic picture of the traditional mobile network, with the base station at the foot of the tower and the mobile core connected back to the external networks. In this depiction, analytics are collected from the mobile core and external networks, while only basic information is usually taken from the base station in order to optimize the RF environment.

Figure 2: Basic Components of Cellular Voice/Data Network



Source: *iG*R, 2016

Modern LTE networks use remote radio heads (RRH). The radios at the top of the tower are connected via fiber to the baseband units (BBUs) in a secure, climate-controlled enclosure at the bottom of the tower. The BBUs are then connected via backhaul (typically fiber) to the mobile core. The RRHs may also be mounted on a roof top or a street pole.

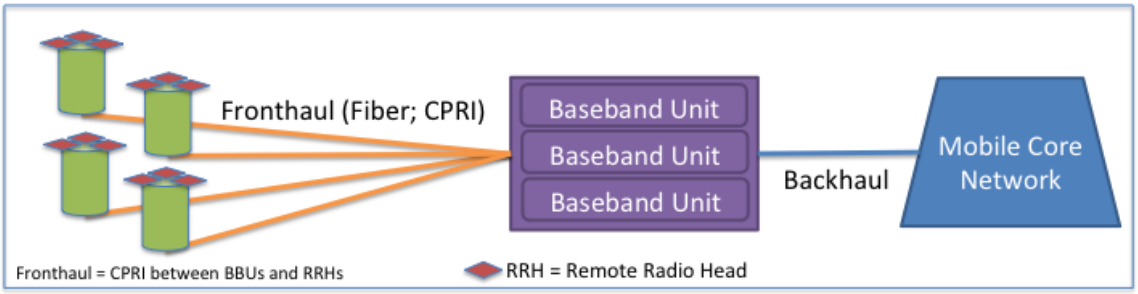
The first step towards a C-RAN (Cloud RAN) is to move the BBUs from the bottom of the tower to a centralized local data center. Note that this must be a local data center (there are distance limitations between the BBUs and the RRH on the tower) but that many BBUs can be centralized in one data center. This type of architecture is typical in today's 4G LTE networks in metropolitan markets. Analytics can now be collected from the BBUs, as well as from the radio heads. Content servers (including for video) may also be deployed at the local data center, putting the content very close to the BBUs.

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To evolve to a Cloud RAN now requires running base station functions as software on commercial servers deployed in data centers – that is, "decoupling" the hardware and software platforms of wireless base stations (Figure 3). So, instead of dedicated hardware, baseband units are "pooled" in a single database and then connected via fronthaul to the RRHs while also being backhauled into the mobile core.

Figure 3: Baseband Unit: Centralized & Pooled



Source: *iG*R, 2015

It is important to understand that the network densification described here will be required for more advanced LTE networks, as well as 5G. And to support this densification, more advanced edge analytics will be needed.

Impact of densification

One of the impacts from having more cells (from densification) is that people are more likely to move between cells as they use the mobile networks. Since cells will be smaller, a consumer will be handed off to and from more cells as they move through the network.

Similarly, new small cells will sit under the umbrella of a larger macro cell (the small cell is added to provide additional capacity at a specific location).

The net result of denser networks is that more advanced analytics are required to optimize the traffic on the network. For example, a consumer may be sitting outside a coffee shop using a tablet to watch video. Rather than use a small cell at that location, the network may decide it is more efficient to have the larger macro cell serve this subscriber, or even hand off the traffic to a managed WiFi network.

Another consumer may be moving through the network (being served by the same macro cell) and is about to enter the coverage of the small cell. Rather than simply hand off to the small cell, the network may decide that the subscriber's data traffic is better handled by the macrocell and therefore will not hand off.

These two (simple) examples require detailed local analytics. The first example requires that the network know the content being served, the device being used,

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the fact that the consumer has been stationary for some time and that there is a managed Wi-Fi network at that location that could be used for video. This type of analytic data cannot be obtained from the mobile core; it must come from the edge of the network.

Changing mobile operator economics

Mobile markets are becoming far more competitive around the world as the number of people who do not have a smartphone decreases and competition among operators pressures margins. All operators are therefore looking for new sources of revenue.

Competition is also driving improvements in mobile networks, both in terms of speed and coverage. Operators are being required to deliver faster services to more people in more places, all of which adds cost to the networks (both in terms of CapEx and OpEx).

New sources of revenue could come from advertising (being explored by several operators around the world), enterprise services and applications (including network slicing), and by carefully targeting new services to specific segments defined by usage profiles, not demographics. All of these new potential revenue sources require input from edge analytics to be successful.

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Getting Analytics from the Edge

Introduction to Mobile Edge Computing

Mobile Edge Computing (MEC) is a new option for network owners. Its key value proposition is that it allows an operator to provide new services by opening up their RAN edge. It does this by placing smart nodes at the edge of a mobile network, for example, right where small cells would likely be placed. These nodes would run virtualized software on general purpose server hardware all housed within a secure form factor. These edge nodes can emulate parts of the core network, serve as reliable caching units and/or run virtualized applications from any number of an operator's developer partners.

Importantly, MEC can also provide detailed analytics data on both the edge of the network and the CPE.

For the mobile operator, the benefits of MEC boil down to several factors which include the:

- Potential to monetize in a different way that highlights the reach and power of its network as it relates to content providers and their need for a digital distribution channel.
- Ability to provide a better "customer experience" through lower latency, higher throughput, more diverse, localized and personalized services. This is accomplished in part through edge analytics.
- Support for emerging, enhanced services such as Voice over LTE by having virtualization at the edge assist with the strict quality of service requirements imposed by VoLTE, particularly on the X2 links between eNodeBs.

MEC is lead by a new Industry Specification Group (ISG) within ETSI which has been set up by Huawei, IBM, Intel, Nokia Networks, NTT DOCOMO and Vodafone. Since late 2014 when the MEC SIG was announced, more than 28 companies have joined the effort to create an open standard for mobile edge computing. The MEC SIG is already generating considerable interest in the market and participation in the effort continues to grow.

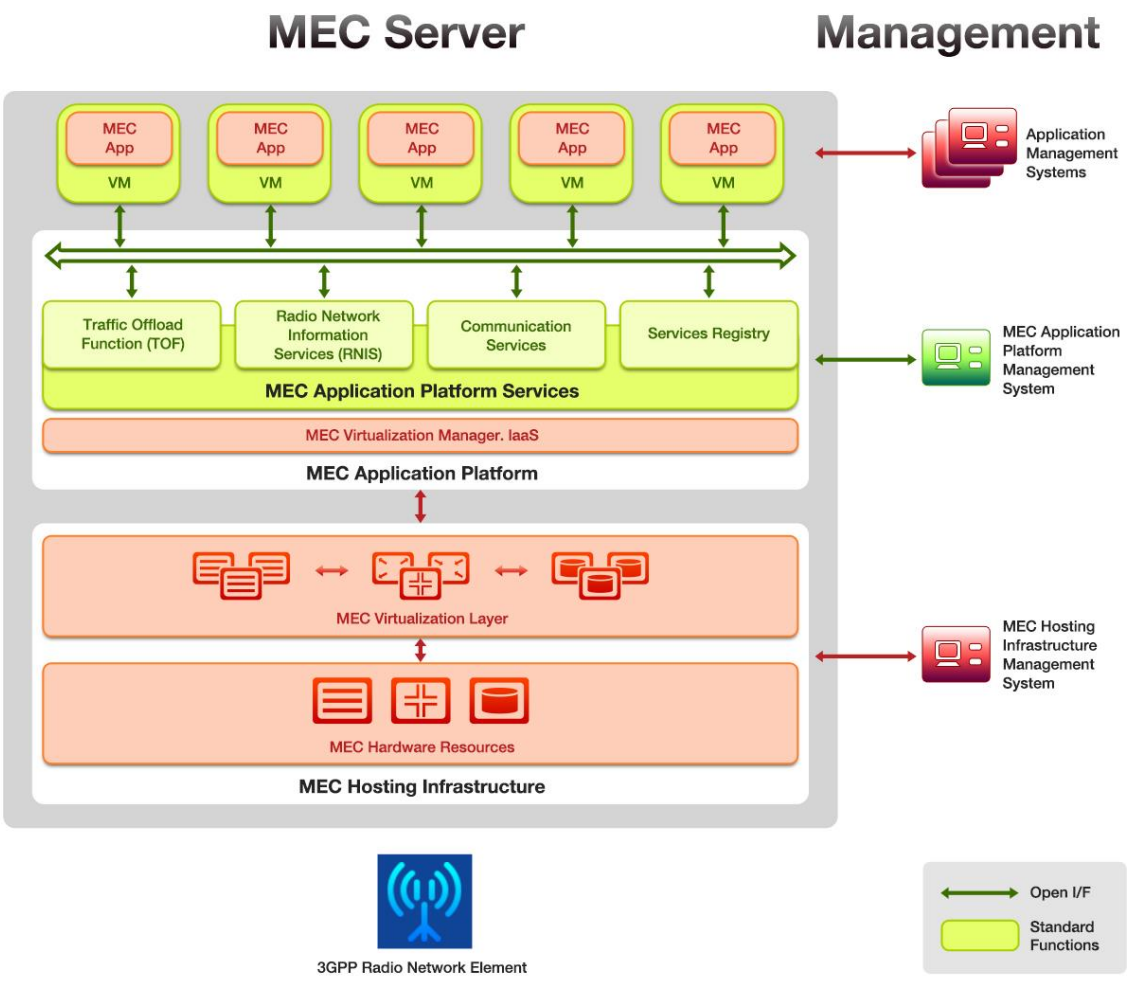
MEC Offers cloud-computing capabilities and an IT service environment at the edge of the mobile network. And it offers an ultra-low latency, high bandwidth and real-time access to radio network information. However, all of these capabilities have to be built into the hardware of the base station itself (or into a "box" that is collocated with, and connected to, the base station).

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The following figure illustrates the base components of a MEC server. All of the green-highlighted components are essentially software components running on hardware.

Figure 4: MEC Server Building Blocks



Source: Mobile-Edge Computing – Introductory Technical White Paper, Sept. 2014

Analytics pulls from RAN and device

Using MEC to provide analytics, data can be collected on a variety of network elements to provide a range of information. For example:

- Current status of the end user device (CPE), including the type and model of device, battery status, screen size, memory available, caching, etc. This data is important when deciding how best to deliver specific content (such as video) to a specific device.
- Current and future status of RAN, including the current loading of the cell, the direction of movement through the cell, and the predicted

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movement of the CPE to the cell edge (and the subsequent drop in bandwidth). The latter point is important if a consumer is watching video and is about to move to the cell edge; the network may inform the video delivery server and drop the video quality for a short time until the user moves back into a high bandwidth area of the cell, so as not to pause the video delivery.

- Predict moving to adjacent cells and see the loading on those adjacent cells. If the new cell is heavily loaded, the network may choose to delay handoff in order to maintain the customer experience or may drop the video rate, for example, for a short time until the cell unloads.

- Analytics can also be used to decide whether to offload an LTE subscriber session to a local managed Wi-Fi network. This decision is complex, since it has to consider the customer experience. Is the WiFi network loaded? Is the cell site predicted to have excess capacity? Is the subscriber likely to move in the near future?

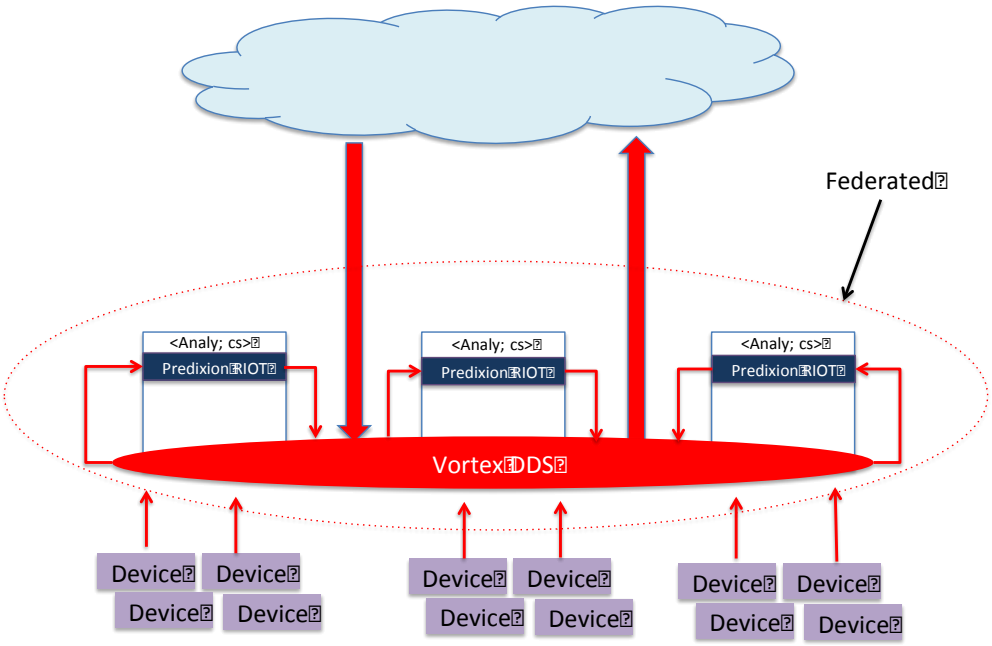
- Behavior analytics can be used to predict what a user is likely to do and this information can then be used to decide the best (highest customer experience) way to deliver network capacity. For example, has the subscriber just started a new video or are they coming to the end of the current one? Are they watching a long movie (and therefore likely to stay stationary) or a short news clip? Has the subscriber cancelled the previous few videos they watched?

As an example, consider Figure 5 below referencing PrismTech's Vortex and Predixion's Riot One software. Here, the mobile devices connect to the RAN as usual. Predixion's RIOT One analytics platform which is based on middleware from ADLINK/Prismtech, is distributed across the edge of network, sitting as close to the radio and baseband as possible. Using MEC architecture, Predixion's insight and analytics platform processes data in real-time using information directly from the device and the network.

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Figure 5: Predixion Software RIOT implementation



Source: Predixion Software, 2016

Active Analytics

In the past, analytics data was collected passively and after the event or session had ended. For example, data relating to a consumer watching a video on their mobile device would be collected and analyzed after the video had finished and the data session had ended. In some cases, analysis took place hours after the event.

Obviously, this passive and time-delayed approach does not allow the MNO, content provider or application provider to optimize their service in real-time. As the loads on mobile networks increase, optimization must take place very quickly in order to maintain the customer experience.

Similarly, with the deployment of SDN and NFV in the mobile network and the ability to adapt the network resources to meet current conditions and demand (new network resources can be brought online and decommissioned as needed), real-time and predictive analytics data is required. Using passive, after-the-fact data to adapt the network defeats the whole purpose!

5G mobile networks also present more of a problem for adaptive analytics since the RAN will be far denser (significantly more cells), the RAN will be smarter and more adaptive (use of massive MIMO antennas and beamforming for example) and more content and processing will necessarily have to take place at the edge of the network (where services and content servers will be located). This means that analytics data must be collected, processed and acted upon in the local data center or at the cell site itself (depending on network architecture).

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Active Mobile Analytics to drive revenue

It is critical, of course, that the MNO can use active mobile analytics to drive revenue and support new business cases. This can be accomplished in several ways:

- OTT optimization – As more consumers demand access to various OTT services and applications on their mobile devices, MNOs are being forced to support these services in their networks. Already today, there are examples of OTT video servers being hosted at the edge of MNO networks in order to improve the customer experience and to reduce the transport costs. Active analytics become a critical part of the OTT business model, providing intelligence on which services are being used, when, on which devices and by whom. Mobile network resources can then be allocated in real-time to improve the OTT customer experience and maximize the revenue potential.

- New revenue streams and services – MNOs are exploring new revenue opportunities such as advertising (from video content and entertainment, for example), location-based services and supporting MVNOs. All of these opportunities require network analytics to be effective – for example, advertisers need to know the screen size of the device, the bandwidth available and what the consumer is currently doing.

- Customer intelligence – Customer bases are no longer segmented simply by demographics but by behavior. For example, two millenials may be similar demographically but have very different network usage, entertainment and content consumption profiles, mobile device usage patterns and social media usage. All of these factors will impact which products, services and applications they are likely to want – note that these products could be provided by the MNO or the MNO partners. Pricing and marketing strategies also benefit directly from analytics intelligence, improving the ability to upsell and cross sell products and services.

- Proactive customer care – MNOs, service providers and content/entertainment providers all strive to reduce churn. The longer a consumer stays with a particular provider, the more profitable they will be. Identifying causes of current and potential churn are very important not only to the MNO but also to their partners.

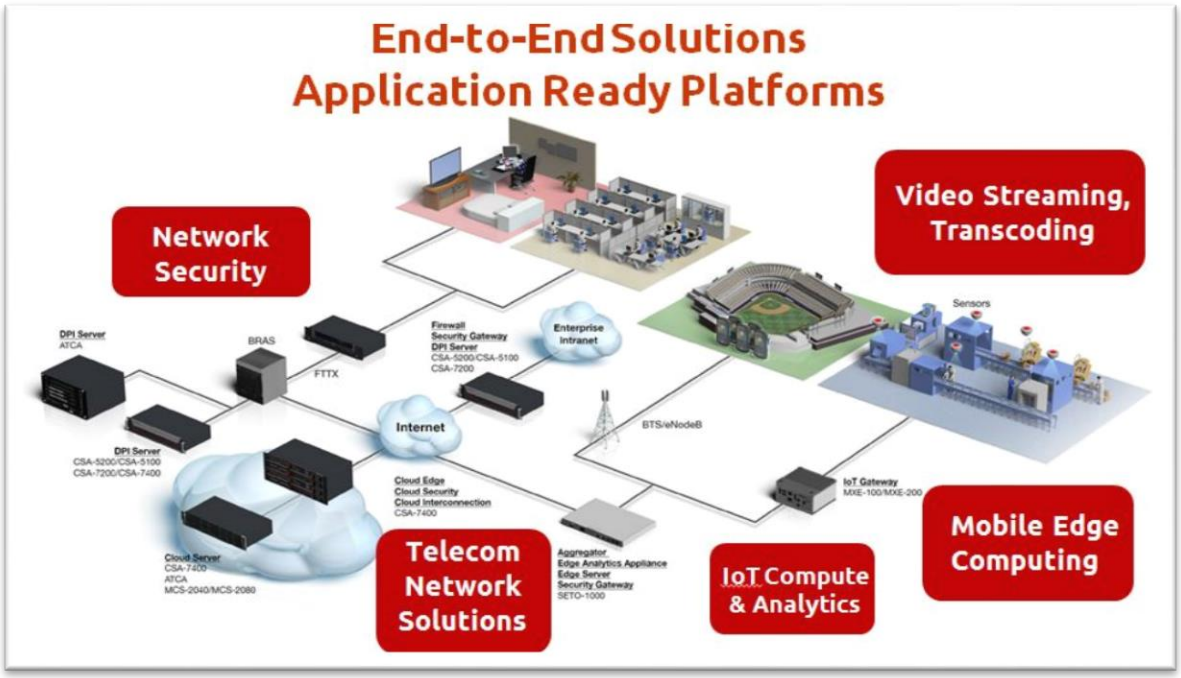
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Solutions for Active Mobile Analytics

Providing analytical data is integral to network architects, planners and the CTO office looking for more monetization of their networks. ADLINK and their partners provide the network infrastructure directly to the mobile operators and their network OEMs (Figure 6). Two key systems, dedicated to applications such as Big Data Analytics, are available to improve revenue streams for operators.

Figure 6: ADLINK MEC Network Infrastructure



Source: ADLINK Technologies, 2016

The ADLINK NFV solution features Wind River® Titanium Server™, the industry's first fully integrated and feature-complete NFV infrastructure software platform, available on ADLINK's SETO-1000 extreme outdoor server and Modular Industrial Cloud Architecture (MICA) platform. This complete NFV infrastructure offering is designed to deliver optimized media processing and communications for today's bandwidth-intensive applications.

The ADLINK NFV solution offers optimized software stacks and a mesh topology for maximum throughput and redundancy. All carrier-grade hardware is offered as part of a modular delivery system with an open/closed NFV solution architecture that enables TEMs and CSPs to easily customize functionality based on application requirements, without compromising security or increasing time-to-deployment. In addition, the NFV solution ensures system compatibility and

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future-proofing with APIs based on open source and de facto open standards. Target virtualization applications include:

- Mobile Edge Computing (MEC)
- Customer premises equipment (CPE)
- Radio access networks (RAN)
- Deep packet inspection (DPI)
- Broadband remote access server (BRAS)
- Content delivery networks (CDN)
- Media processing
- Policy management
- Security
- LTE Core.

ADLINK's SETO-1000 is the first high-performance MEC platform specifically designed for extreme environments and outdoor telecom/networking applications. Based on the dual Intel® Xeon® E5-2400 v2 family of processors, the SETO-1000 MEC platform enables delivery of data center performance at the edge of the network. The SETO-1000 provides IT and cloud-computing capabilities within the Radio Access Network (RAN) in close proximity to mobile subscribers, offering a service environment characterized by proximity, ultra-low latency, and high-bandwidth that allows content, services, and applications to be accelerated, maintaining a customer's high-level Quality of Experience (QoE).

ADLINK's MICA platform is an Application Ready Intelligent Platform (ARIP) for industrial cloud computing that adopts an innovative modular design for upgraded scalability and flexibility. Customers can choose from different functional modules (compute, switch, storage, and IO modules) depending on their specific application requirements to build a highly tailored computing platform. The hybrid design allows customers to mix and match between 1/4 and 1/2-width slot compute nodes in order to scale the number of independent systems with different processing capacities in the platform, as needed.

NFV solutions that are pre-validated with Wind River Titanium Server must feature Intel® Xeon® processors and at least 500 GB of storage and 15 GB of RAM, support network interface controllers (NICs) with 1, 10, and 40 GB DPDK-enabled ports, and are recommended to have two cores for OS and virtual switching.

Titanium Server is a carrier grade NFV infrastructure software solution that is designed to meet the stringent "always on" requirements of the telecom

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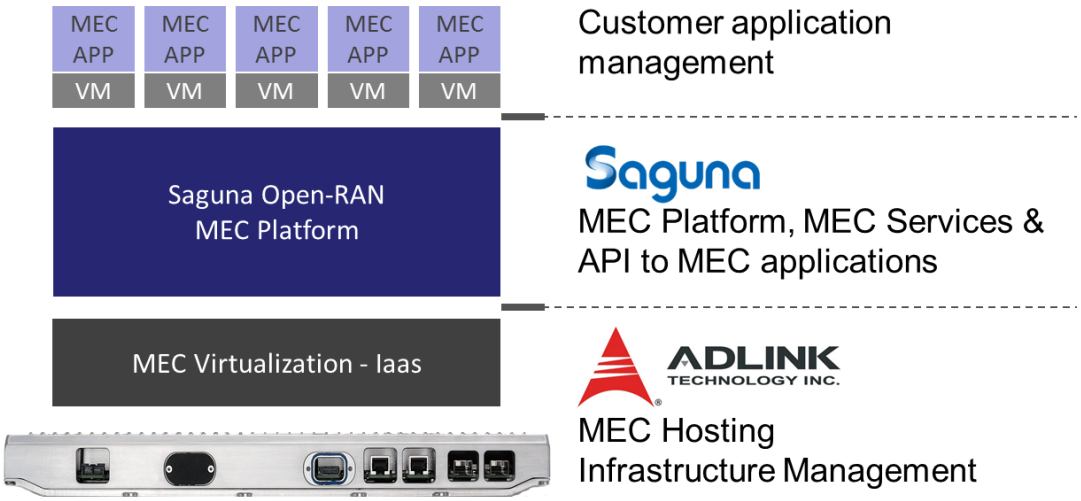
industry. Based on open standards including carrier grade Wind River Linux, real-time Kernel-based Virtual Machine (KVM), OpenStack®, and Data Plane Development Kit (DPDK), while incorporating optimizations for Intel® architecture, Titanium Server delivers high performance and carrier-grade reliability. For more information on Titanium Server, please visit http://www.windriver.com/products/titanium-server/.

ADLINK provides a combination of processing power, application-ready intelligent platforms (ARIP) and data ingestion and connectivity software that can provide the distributed yet interoperable infrastructure needed to support the Networks of the future. These platforms address the interests of both end users and their critical suppliers (OEMs, ISVs, CSPs, NEPs, SIs, etc.) and how families of IoT-ready computing nodes (edge, gateway, fog node, cloud server) will facilitate the enablement and exploitation of the business benefits (revenue-line, cost-line and environmental/societal) that the IoT promises.

MEC Solution for Extreme Outdoor Environments

Saguna and ADLINK integrated MEC solution addresses the market need for rugged, outdoor deployments. The joint solution is comprised of Saguna Open-RAN, an advanced and fully virtualized MEC platform, operating on ADLINK's rugged SETO-1000 extreme outdoor server platform designed for extreme conditions (Figure 7). The joint solution is compact, cost-effective and easy-to-install. By co-locating the MEC infrastructure with existing network real estate, mobile operators can reduce costs while delivering new services and improving network performance.

Figure 7: Saguna Open-RAN and ADLINK SETO-1000 Extreme Outdoor Server Platform



Source: ADLINK Technologies and Saguna Networks, 2016

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Key benefits

- Accelerate adoption of value-added MEC services for mobile operators
- Bring an open cloud computing environment into the radio access network with a robust outdoor platform
- Improve performance, increase scalability and reduce response times by operating in proximity to users and the end-devices
- Reduce deployment costs and accelerate time-to-market by co-locating the MEC infrastructure with existing network real estate outdoors.

Solution Components

Open-RAN creates an open ecosystem and long-term growth engine inside the mobile Radio Access Network (RAN) in close proximity to mobile users. The ETSI MEC standard-based solution enables mobile operators to quickly and effectively deploy new revenue generating services for content delivery, Internet-of-things connectivity, retail and enterprise applications and more.

- **Traffic steering** – High-granularity Traffic Offload Function (TOF) service steers individual packets to the relevant MEC applications
- **Content acceleration and optimization** – DNS caching and Radio Network Information Service (RNIS) improve web content delivery by reducing latency and providing real-time congestion status
- **MEC application management** – Registration and Mobility services onboard MEC applications ensure service continuity 'on-the-go'
- **Geo targeting** – Indoor and outdoor location service promotes personalization.

Platform Features

ADLINK SETO-1000 is a robust server for Extreme Outdoors with Intel® Xeon® Processor E5-2400 v2 Series:

- Robust design
    - -40° C to 55° C operation
    - NEBS shock & vibration, Fault Tolerant
    - IP65 intrusion protection
- Server Grade Performance
    - Dual 10-core Xeon® E5-2400V2 with up to 96Gb RAM

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- Ports: Dual 10G SFP+, Dual GbE RJ-45, Optional Optical and Copper Bypass
- Onboard Intel® 8920 crypto engine
- Dual swappable SATA storage bays
- IPMI 2.0 management interfaces.

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Methodology

*iG*R relied on the following sources when writing this white paper:

- The Mobile-Edge Computing white paper published by the founders of the Mobile-edge Computing (MEC) industry initiative in September 2014
- Discussions with vendors in the industry
- *iG*R's primary research, reports and forecasts
- Secondary research.

Disclaimer

The opinions expressed in this white paper are those of *IGR* and do not reflect the opinions of the companies or organizations referenced in this paper. All research was conducted exclusively and independently by *i*GR.

About ADLINK

ADLINK Technology is enabling the Internet of Things (IoT) with innovative embedded computing solutions for edge devices, intelligent gateways and cloud services. ADLINK's products are application-ready for industrial automation, communications, medical, defense, transportation, and infotainment industries. Our product range includes motherboards, blades, chassis, modules, and systems based on industry standard form factors, as well as an extensive line of test & measurement products and smart touch computers, displays and handhelds that support the global transition to always connected systems. Many products are Extreme Rugged™, supporting extended temperature ranges, shock and vibration.

ADLINK is a Premier Member of the Intel® Internet of Things Solutions Alliance and is active in several standards organizations, including PCI Industrial Computer Manufacturers Group (PICMG), PXI Systems Alliance (PXISA), and Standardization Group for Embedded Technologies (SGeT).

ADLINK is a global company with headquarters in Taiwan and manufacturing in Taiwan and China; R&D and integration in Taiwan, China, the US, and Germany; and an extensive network of worldwide sales and support offices. ADLINK is ISO-9001, ISO-14001, ISO-13485 and TL9000 certified and is publicly traded on the TAIEX Taiwan Stock Exchange (stock code: 6166).

About *iG*R

*iG*R is a market strategy consultancy focused on the wireless and mobile communications industry. Founded by Iain Gillott, one of the wireless industry's

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leading analysts, we research and analyze the impact new wireless and mobile technologies will have on the industry, on vendors' competitive positioning, and on our clients' strategic business plans.

A more complete profile of the company can be found at http://www.iGR-inc.com/.

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