WHITE PAPER

Saguna* and Intel – Using Mobile Edge Computing to Improve Mobile Network Performance and Profitability

1 Mobile Network Operators' Business Challenge

With heavy competition in most markets, mobile communications services providers face diminishing average revenue per user (ARPU). Research published by Strategy&[1] shows that global communication service provider revenues are stagnating, even as operating and capital expenditures are increasing due to the exponential growth of mobile data and video consumption.

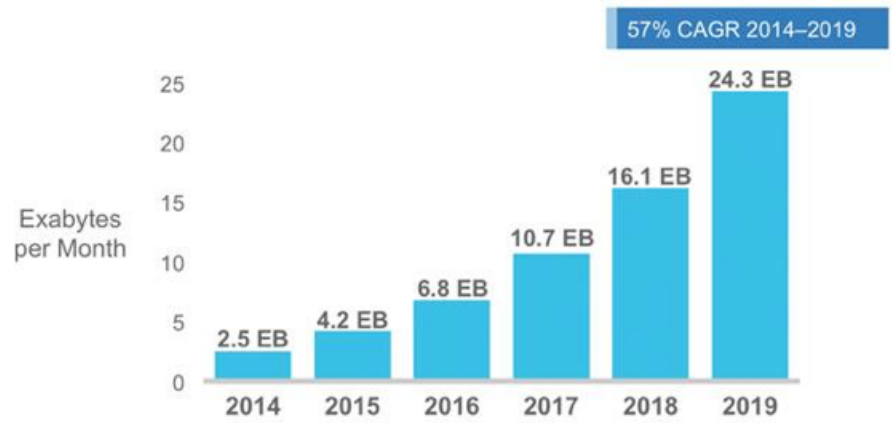

Figure 1. Cisco Forecasts 24.3 Exabytes per Month of Mobile Data Traffic by 2019 [2]

Mobile network operators (MNOs) are also facing competition from over the top (OTT) companies in addition to direct competitors. OTTs offer value-added services that capture customer discretionary spending and reduce mobile networks to commodities, driving the price of MNO services down.

As the price paid by subscribers per gigabyte continues to plummet, MNO profit margins are decreasing sharply. At the current rate, within just a few years the cost and revenue curves will cross and network costs will be higher per megabyte than revenue generated.[1]

[1] *2015 Telecommunications Trends.* http://www.strategyand.pwc.com/perspectives/2015-telecommunications-trends

[2] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2014–2019 White Paper. http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

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MNOs' Business Challenge

These trends combine to create a challenging business environment for mobile operators, one where they are compelled to seek new revenue generation opportunities and reduce the cost of data delivery while scaling their network capacity.

2 Mobile Edge Computing

Mobile edge computing (MEC) helps mobile network operators to improve profit margins by raising the top line, profitability, and reducing the bottom line, network costs. It is a European Telecommunications Standards Institute (ETSI)* standard that is backed by leading communications service providers and other industry participants, including both Intel and Saguna.*

The MEC standard specifies the integration of an NFV-based cloud computing environment within the mobile radio access network (RAN). This brings cloud computing capabilities much closer to mobile users in comparison to traditional architectures, where computational power is centralized at the core network. By operating in close proximity to mobile users, the MEC environment enables services and applications to benefit from ultra-low latency and high bandwidth delivery. The MEC environment also provides real-time radio network information (such as subscriber location, cell load, etc.) that can be used by applications and services to offer context-related services; these services are capable of improving and differentiating the mobile broadband experience.

2.1 The IoT Opportunity

Many MNOs are operating in highly saturated markets, where most of the target population has already adopted mobile technology. This leaves MNOs with limited growth opportunities within their traditional markets. The Internet of Things (IoT) is a new and untapped market that is expected to undergo accelerated growth over the next five years. According to GSMA Intelligence there are 7.1 billion connected devices today and over 50 billion expected in 2020.[3] This presents a huge new market opportunity for MNOs.

There are a number of reasons why mobile networks are a good fit for IoT and a number of reasons they are not yet. Mobile networks offer broadband connectivity almost everywhere. Adding a new device to the network is as simple as installing and activating a SIM card. The ease and speed of deployment makes mobile deployments much cheaper in terms of capital and operational expenditures in comparison to wireline options. WiFi alternatives still require infrastructure deployment, whereas mobile networks are already in place, where you need them, in many cases. In addition, mobile networks offer a high level of security and much lower interference levels than alternatives such as WiFi.

However, the current mobile architecture has a number of critical drawbacks that prohibit it from effectively supporting the full range of IoT applications. Due to the long round-trip-time (RTT), mobile networks cannot support low-latency requirements. They are also limited in their ability to handle large numbers of devices, volumes of video streams, or masses of short telemetry type of messages. Large volumes of data, devices, and messages are the hallmark of IoT applications. Mobile networks need an effective solution for these requirements as a prerequisite to large scale IoT deployments.

[3] *GSMA Intelligence The Mobile Economy 2015 (PDF download).* http://www.gsmamobileeconomy.com/GSMA_Global_Mobile_Economy_Report_2015.pdf

2.2 Reduce Network Costs with MEC

With a cloud computing environment located in close proximity to the end device, MEC adapts the mobile network and enables it to support a wide variety of IoT applications. The MEC platform can be used to aggregate large volumes of short messages. Low latency IoT and tactile Internet applications can be operated from the MEC platform to minimize the round-trip time (RTT) and provide near-real time control. The fast response time ensures very short communications times, which extends battery life on the device and conserves network resources.

The MEC environment can be used to reduce the costs of delivering content to mobile users. Caching solutions and content delivery network (CDN) services can be operated as an MEC application. By storing and delivering popular and premium content directly from the RAN, network resources are conserved while subscribers enjoy a superior user experience.

The MEC Radio Network Information Service (RNIS), which provides real-time network congestion data, can be used by content applications to proactively adapt content according to the available network resources. This approach improves radio network utilization and reduces network congestion.

2.3 Looking Forward to 5G

Looking forward to next-generation 5G networks, MEC is poised to play a big role in the network architecture. The next-generation 5G standard is still a work in progress with large-scale deployments expected only around 2020. However, there is an industry consensus around the goals of 5G, which are driven by the need to support the IoT and tactile Internet and the need to deliver much more mobile video and data.

Here is a short summary of 5G goals:

- **Significantly faster data:** 5G is set to increase data speeds up to 10 Gbps.
- **Ultra-low latency:** This will be particularly important for industrial applications, driverless cars, tactile Internet applications, and better user experience.
- **A more "connected world":** The Internet of Things (IoT), including wearables, smart home appliances, and connected cars, is expected to grow exponentially over the next 10 years. This means 5G networks will need to accommodate billions of connected devices.

To achieve these goals, the MEC architecture will become an essential component of the 5G network architecture. MEC pushes computing capabilities into to the radio access network (and, in turn, closer to subscribers), enabling low-latency and high-bandwidth access to content, applications, and services. The distributed MEC architecture makes it ideal for supporting high volumes of connected devices, which will generate even higher volumes of data interactions. MEC provides a standards-based approach to making significant progress toward 5G goals that can be implemented in LTE networks today.

3 Saguna's MEC Solution

Saguna's Open-RAN* is a software-based MEC solution. The fully virtualized platform provides an open environment for running third-party MEC applications. Saguna Open-RAN features an MEC server located at a RAN aggregation point or within the base station and the MEC gateway located in the core network.

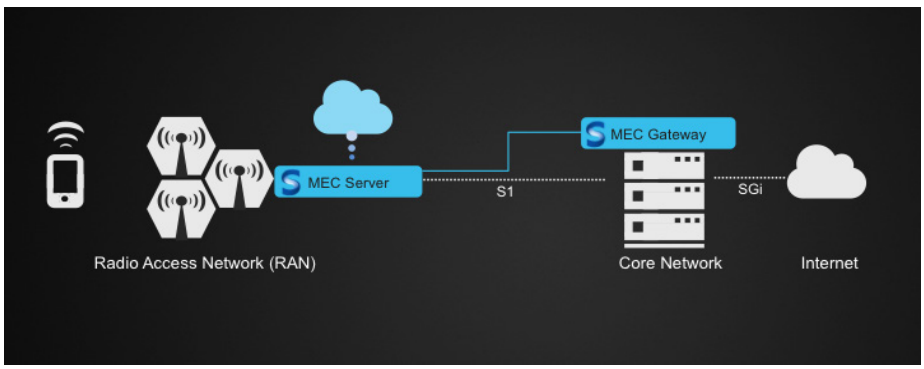


Figure 2. Saguna Open-RAN MEC Solution

3.1 MEC Server

Saguna Open-RAN MEC server node runs at the RAN on a server at an aggregation point, or in the base station. It serves multiple eNodeB base stations or small-cells and can easily be extended to support WiFi and other communications standards in heterogeneous network (HetNet) deployments. The platforms are based on Intel® Xeon® processors and Linux-based* operating systems.

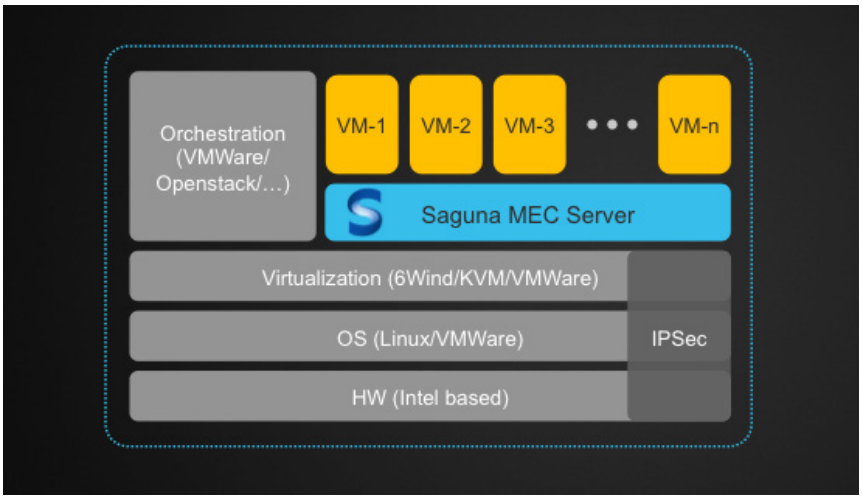


Figure 3. Saguna Open-RAN MEC Server

The MEC server provides the following services:

- Broadband delivery – Features direct connections to mobile users from the RAN, which offers fast content delivery and response times.
- Application registration – Enables the MEC applications to conduct mandatory registration prior to running on the Saguna Open-RAN MEC platform.
- Traffic steering – Inspects packets in order to direct data streams from mobile users to the target MEC application.
- Radio insights – Provides radio network information services (RNIS), including congestion updates. This functionality promotes network-aware content optimization.
- DNS caching – This feature stores frequently accessed DNS addresses locally to accelerate the mobile Internet.
- Replay to core – Allows the MEC server to re-route traffic to ensure continuity during cell hand-overs and support core network functions, including lawful interception, charging, and policy control.

3.2 MEC Gateway

The Saguna Open-RAN MEC gateway node operates as a virtual machine (VM) running on a server at the enhanced packet core (EPC) to ensure user mobility and preserve core network functionality. The Saguna Open-RAN MEC gateway interfaces with charging, policy control, and lawful intercept, providing seamless integration of the MEC solution within the existing mobile network architecture. It also ensures the continuity of services as the subscriber moves between mobile nodes.

3.3 Intel® Technology

Intel Xeon processors and allied technologies are key enablers of the Saguna MEC solution. Saguna Open-RAN inspects data traffic up to layer 7 on a RAN's S1 interface. In order to keep ahead of the traffic, it uses the Intel-developed Data Plane Development Kit (DPDK), a public-domain software library that routes network packets around the Linux OS kernel. Coupled with Intel network drivers, Saguna Open-RAN achieves a significant improvement over non-DPDK traffic flow.

Third-party developers of MEC VMs that are running on the Saguna Open-RAN use Intel® platforms for their development because of the complete range of software available. MNOs deploy with Intel-based systems because of their low cost, high performance, and reliability.

4 MEC Use Cases

As a leader in MEC, Saguna has worked with many key providers of wireless applications to prove the functionality and performance of the Saguna Open-RAN MEC platform. The following case studies show the results of some of these joint projects:

4.1 Radio Network Information Service (RNIS)

The Radio Network Information Service (RNIS) provides real-time radio network data to external applications. RNIS enables Internet and Web applications to proactively optimize content delivery according to the actual network congestion levels. This approach improves the user experience while reducing the overall network congestion.

A proof of concept using RNIS was demonstrated by Saguna in collaboration with Akamai* showing how encrypted video content could be optimized by providing real-time radio network status information.[4] The network-aware encrypted content optimization solution used SSL injection enrichment to make the CDN

[4] http://www.saguna.net/news-events/press-releases/akamai-and-saguna-network-aware-for-encrypted-content-optimization-solution-nominated-for-the-2015-global-mobile-awards/?utm_source=homepage?utm_medium=button-3?utm_campaign=Q1-2015

aware of cell load and link quality. This, in turn, was used by the CDN server to select the correct video encoding for the conditions rather than encoding at the highest rate and adjusting down when faced with congestion. Because the correct encoding was chosen for the cell conditions, video time to start was very short and the video played from beginning to end without buffering.

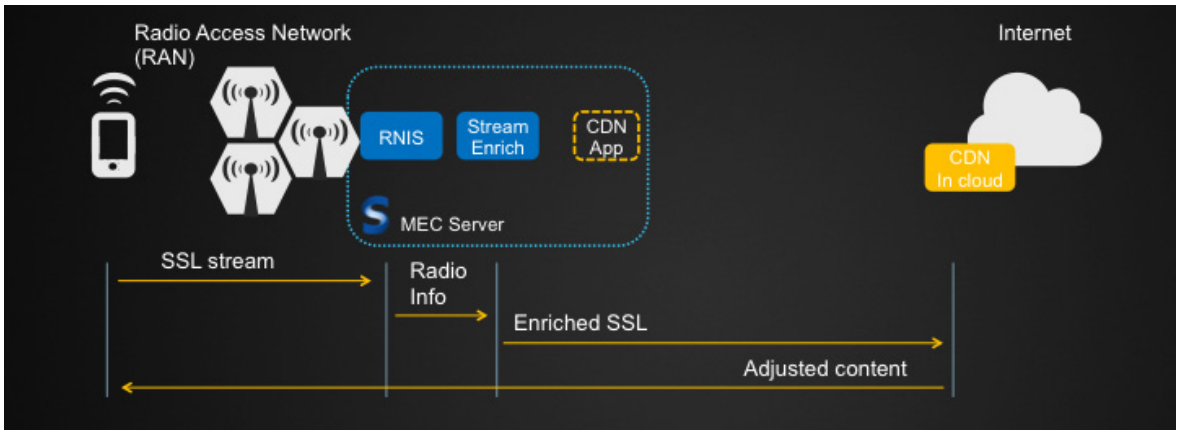


Figure 4. RNIS Proof of Concept

4.2 DNS Caching

DNS lookups take a fraction of a second, but the time can add up as most web pages today may have tens of external links, and each one must be looked up before a page is served. By caching DNS results in the RAN, DNS lookups can be immediately satisfied, thereby reducing the page download time.

4.3 CDN Inside the RAN

At CTIA 2014, Saguna and Akamai won the Best of 4G Award when they showcased the world's first content delivery network operation from a mobile base station.[5] The architecture of this CDN is shown in Figure 5.

An Akamai CDN VM* runs on the Saguna Open-RAN platform, with a transparent breakout connection to the central cloud management system. In this scenario, a subscriber asks for content managed by the CDN. This request is routed to the CDN VM, which provides the content from its local cache, or fetches it from the CDN cloud. It replays all aspects of the content distribution to the EPC core for proper billing, policy, and administrative processes. The MEC-based CDN leverages proximity to accelerate content delivery and optimize air-interface utilization. Operating a CDN inside the radio access network provides significant cost saving for data delivery.

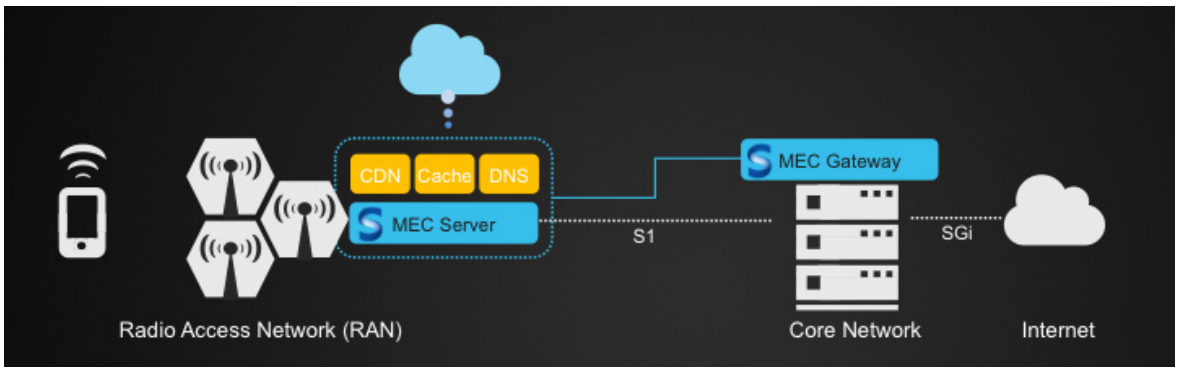


Figure 5. CDN Inside The RAN

[5] http://www.saguna.net/news-events/press-releases/saguna-and-akamai-showcase-the-world-s-first-content-delivery-network-operating-from-the-mobile-base-station/

4.4 mLAN

Saguna is working with Applied Computer Solutions (ACS)* to help enterprises leverage emerging in-building cellular networks for corporate data needs based on MEC. By deploying an MEC platform at the enterprise small cell aggregation point, corporations can offer their users amazing performance without sacrificing security.

Saguna Open-RAN running on ACS Smart Perimeter Enterprise* solution provides a mobile LAN (mLAN) application as shown in Figure 6. This application directly connects corporate users to the local LAN. By eliminating the need for an external connection via a VPN, the mLAN provides a high-bandwidth, low-latency connection while helping to ensure data security. The MEC enterprise platform provides locally provisioned voice, data, and video services to a small-cell connected client. These services will lower enterprise operating cost and can augment or even replace traditional tethered and unlicensed spectrum solutions such as WiFi.

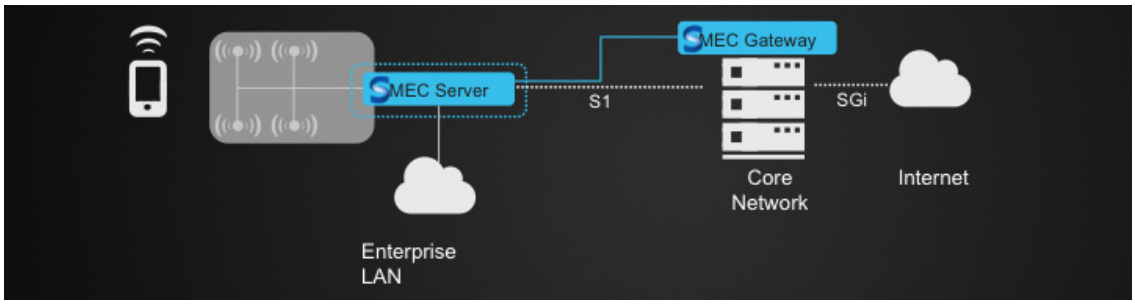


Figure 6. MEC Usage in an Enterprise

4.5 Retail Targeted Video Advertising

The line between the digital and brick and mortar retail shopping is becoming increasingly blurred. According to a Google 2014 (4) report, 75% of the in-store shoppers use their phone for shopping-related activities.[6] Furthermore, according to the same Google report, these informed shoppers are spending more due to cell phone usage.

This opportunity to improve customers' in-store experience is a unique opportunity for brick and mortar retailers. By using location-aware advertising targeted at shoppers' mobile devices, they can increase sales and differentiate their brand.

Placing the content on the RAN edge using MEC is a critical need for both proximity targeting and for delivering great video experience. In this application (shown in Figure 7), small cells can pinpoint user location in or near a particular store and then push targeted content to that user's smart device. With the Saguna Open-RAN operating at a small cell aggregation point, the user detection and video fulfillment is very fast, which is an important consideration for consumers on the move. In addition to hosting virtualized network functions (VNFs) for detecting the consumer and pushing the video, Saguna Open-RAN also ensures seamless integration of crucial administrative features in the packet core, including charging, policy control, and lawful interception.

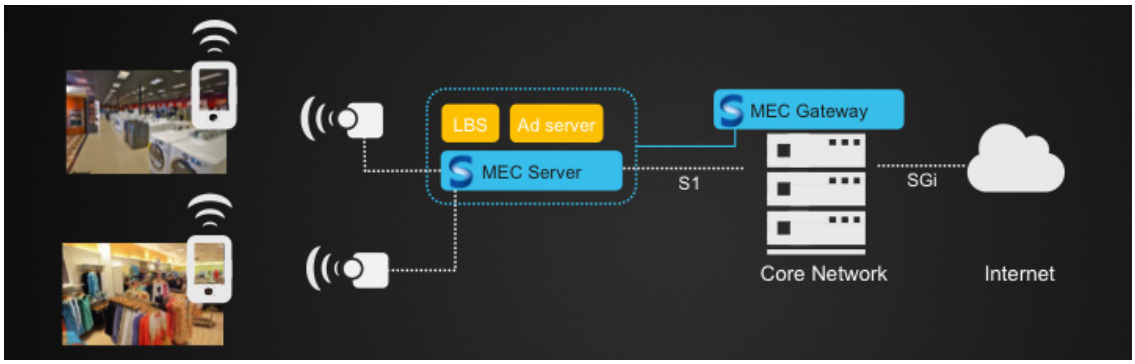


Figure 7. Retail Targeted Video Advertising

[6] *2014 Holiday Shopper Research: Shopping Never Sleeps.* https://www.thinkwithgoogle.com/articles/2014-holiday-shopper-research-shopping-never-sleeps.html

4.6 Safe Cities and Smart Security

Through the placement of millions of Internet-connected sensors, the Internet of Things (IoT) is emerging to create a smarter, more connected world. For mobile operators, IoT presents a new addressable market and new revenue generation opportunities. The development of smart city applications, where the "things" include security cameras, parking sensors, and other devices, is an example of a lucrative IoT application.

4G/LTE networks are being used in smart city applications because they are ubiquitous and deliver very high bandwidth. As mobile operators plan how to manage the bandwidth needed for all of these high-bandwidth video streams, they are turning to MEC solutions such as Saguna Open-RAN to provide processing power at the network's edge to keep some of the data traffic off of their networks.

In such a smart city application, the MEC platform creates a computing "cloudlet" located in close proximity to the cameras, where it operates video analysis VNFs and provides storage. Thus, the application transmits low resolution/low bitrate video in real time for constant monitoring. The bitrate is quickly switched to high resolution upon event detection or a request from security personnel.

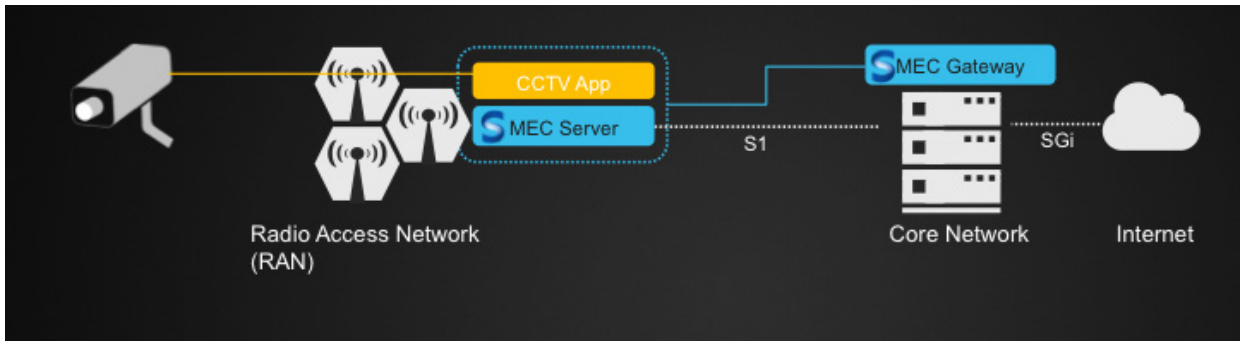
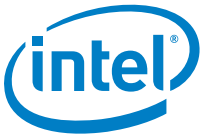


Figure 8. Safe Cities, Internet of Things Application

5 Conclusion

Mobile ARPU is declining and data consumption continues to soar. As a result of these trends, MNOs are facing tough, seemingly conflicting, business challenges. To improve their bottom line, MNOs need to reduce the cost of delivering data while scaling the capacity of their networks. To improve the top line, MNOs must seek new revenue generating opportunities and expand into new markets like the fast-growing IoT segment.

Saguna's Open-RAN is a software-based MEC solution. The fully virtualized platform provides an open, vendor-agnostic environment for running third-party MEC applications. It brings IT cloud computing into the mobile RAN operating in close proximity to mobile users enabling services and applications to benefit from ultra-low latency and high bandwidth delivery. Saguna Open-RAN, running on Intel technology, is the ideal platform for MNOs looking to implement MEC in their mobile network. With this MEC platform, MNOs can improve user experience, reduce the cost of data delivery, offer new revenue generating services, and expand to new markets like IoT.



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