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HEAVY READING

WHITE PAPER

Customer Experience in the 5G Era

A Heavy Reading white paper produced for RADCOM

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INTRODUCTION

The rollout of 5G standalone (SA) core networks currently underway will provide communications service providers (CSPs) with an opportunity to rearchitect service delivery. This is because 5G core (5GC) networks will introduce a service-based architecture that will enable the exposure of application programming interfaces (APIs) at the edge of the network. And these APIs will be capable of supporting ultra-low latency and ultimately high value, premium-priced slice-based services.

For end-user subscribers, the rollout of these services will only serve to increase their expectations on the breadth and performance of services they will be able to seamlessly access on a ubiquitous basis. Accordingly, CSPs must also consider the customer experience (CE) implications of deploying 5G technology as they push ahead to monetize this investment. To accomplish this, CSPs will need to put in place advanced monitoring techniques that will allow them to correlate network performance on a per application, per subscriber, and per service level to ensure CE is optimized. This approach, referred to as Customer Experience Index (CEI), is rapidly becoming a critical component of CSPs' 5G customer upsell and retention strategies.

This white paper documents the evolution of CE, the role of CEI, the related opportunities and challenges, and the monitoring tools necessary to deliver a superior CE experience in 5G networks.

IMPLEMENTING 5G CEI

Understanding how network performance affects CE is not restricted to 5G, but the unique attributes of the 5GC unquestionably demand new approaches to CEI. In the 4G world, service invocation is relatively static in terms of where in the network services are deployed.

In contrast, as captured in **Figure 1** below, since the 5GC is the first mobile generation designed to support cloud-native reusable services, software disaggregation at the edge, third-party software, and software-based service-specific slices, 5G CEI differs significantly from previous generations of CEI implementations. Another consideration is that the 5GC supports control user plane separation (CUPS), which has end-to-end CEI service monitoring implications. This is especially important for edge services, where it is difficult to correlate user plane and control plane data into subscriber sessions vital for network troubleshooting. As a result, multiple data sources, including network events and event data records (EDRs), need to be monitored to assess CEI impacts.

Figure 1: 3G/4G CEI vs. 5G CEI

Attribute	3G/4G CEI	5G CEI
Service invocation	Predominately in the core network	Equally at the edge and core
Third-party software and APIs	Limited support	Full support
API exposure architecture	Not supported	Full support with SBA 5GC anywhere in the network
Slice-based services support	Limited support	Full support

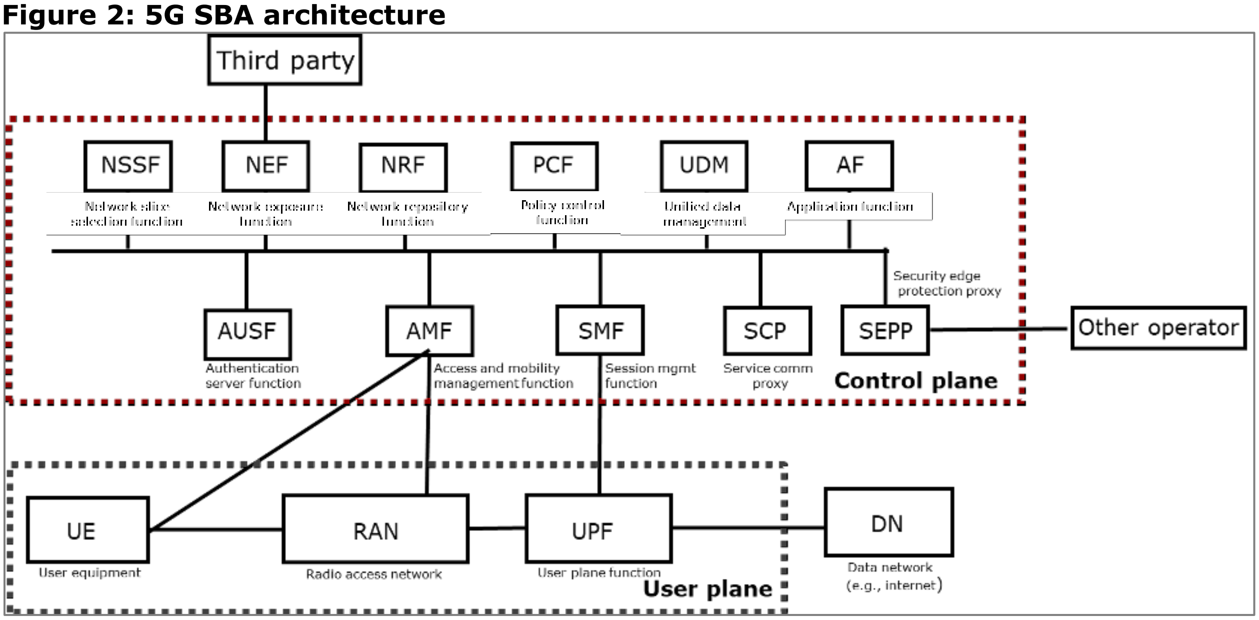
Source: Heavy Reading

Given the differences, 5G is uniquely positioned to drive a new wave of service innovation that will leverage third-party software at the edge to support high value, ultra-reliable low latency communication (uRLCC) services. Examples of such services include autonomous vehicles and consumer applications such as cloud gaming and immersive media.

To support these services, as captured in **Figure 2**, the 5GC implements a services-based architecture (SBA). This is significant since it presents the first true generation of a cloud core network integrating new functions such as API network exposure (including third-party APIs), network slice selection, policy control function, and service communication proxy.

API exposure is crucial since it defines a services architecture that allows software-based services to interact with each other utilizing APIs. This capability, which is not supported in 4G or 3G networks, provides 5G networks with a more flexible and scalable architecture to design, launch, and monitor new services.

Figure 2: 5G SBA architecture

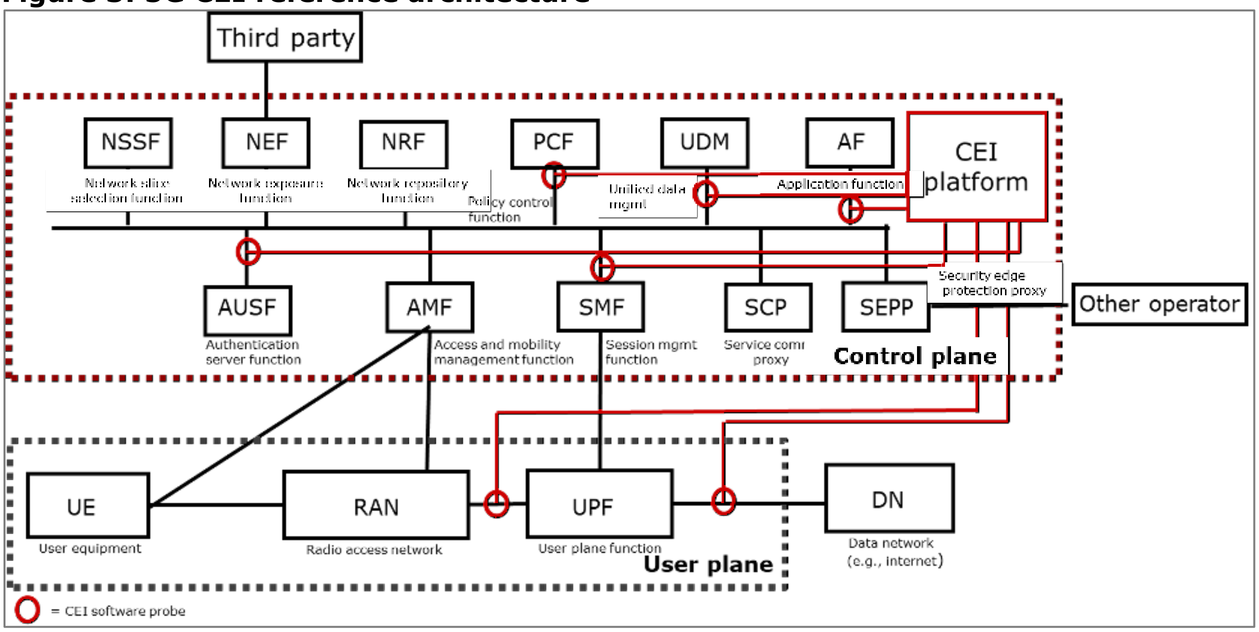


Source: Heavy Reading

The 5G SBA core will support lower latency performance, which will positively affect services delivery and CE. However, it is important to note that the service impacts are more profound. This is because the core network supports network exposure of APIs. Thus, it is possible to monitor individual services on a holistic network-wide basis, something that is extremely difficult with a 4G core.

As a result, CEI also needs to be enhanced to support end-to-end CEI monitoring. As shown in **Figure 3**, this can be accomplished through the integration of a software-based CEI platform utilizing software-based probes on select 5G core interfaces that provide end-to-end visibility of service performance. Through the strategic positioning of these probes, it is possible for application information, policy information, session management, RAN, and control plane performance to be collected to create a service-specific CEI scorecard for any high value 5G service.

Figure 3: 5G CEI reference architecture



Source: Heavy Reading

Additionally, since API exposure aligns with the use of APIs by webscalers such as Google and Amazon, it provides a cloud transition path for CSPs to interwork with third-party cloud services. Consequently, 5G service delivery provides CSPs a much greater opportunity to achieve service differentiation than previous mobile generations.

This type of service delivery supports ultra-low latency services utilizing third-party APIs fortified with the scale capabilities of the cloud. In parallel, it positions CSPs to be successful as the telecom and cloud domains continue to merge, facilitating the adoption of a holistic CEI model that can address any service.

In this new world order, end-user customers search social media to determine anecdotally which CSPs have the best data, voice, and messaging CEI performance. Therefore, higher CEI scores can provide CSPs with a greater opportunity to differentiate and sell premium services to these customers, including slice-based services for latency-sensitive services such as gaming.

THE ROLE OF AI/ML IN 5G CEI

The expansion of CEI to support an end-to-end model represents a strong value proposition. However, it also introduces new challenges associated with making sense of a broad range of inputs and performance metrics.

One of the fundamental challenges that CEI faces is that third-party applications, including those from hyperscalers, are often encrypted to protect sensitive data. As a result, it is difficult to have the necessary level of insight into which application is being used and how it is being used. The use of encryption will also affect CSPs' 5G services as well since many slice-based services designed to support "mission-critical" applications such as autonomous vehicles will integrate encryption such as TLS 1.3 and encrypted DNS to protect data transmission.

Further complicating CEI measurement is the use of *proprietary* protocols such as Google's Quick UDP Internet Connections (QUIC), which is designed to optimize the performance of latency-sensitive applications such as gaming or video streaming.

A final challenge is the number of devices that will have to be measured and monitored. Without question, 5G will drive exponential growth in end-user devices as 5G becomes embedded in many consumer durables. The additional billions of transactions these devices will generate both in the core and at the edge will make analyzing network performance and CEI trends more difficult due to the massive amount of network and application usage data that must be assessed. Therefore, it will ultimately be difficult to correlate how the measurement of network-based jitter and delay affects the quality of experience for specific 5G service key quality indicators (KQIs).

Beyond human touch: The rise of AI/ML-enabled CEI

To address these CEI challenges, new approaches are essential. Heavy Reading believes that any new CEI strategy will have to integrate artificial intelligence (AI) and machine learning (ML) software-based probes into the mix to be successful.

Both are vital because they can manage the increased volume of transactions that humans can no longer manage. They also possess the intelligence to interpret network trends in real time before they negatively affect CEI. Simply stated, AI and ML provide CEI systems with enhanced real-time visibility and deliver the additional intelligence necessary to react "on the fly" at the speed cloud networks demand.

On an application level, AI/ML can be used to gather CE data in real time from actual subscribers to create CE-specific CEI scorecards. This is important since there will be little historical 5G application trend data available for several years to use for future service modeling and for troubleshooting new services as they come online. Additionally, because many of these applications will be encrypted, ML can be utilized to model and calculate quality metrics for high value encrypted data services such as video streaming.

Moreover, AI probes can be used for anomaly detection, including identifying devices or network elements that behave outside the norm. The ability to use AI/ML-based anomaly detection will make it possible to differentiate between false and real alarms, which has always been a challenge with manual processes.

As captured in **Figure 4**, the integration of AI and ML into CEI platforms will address other inherent 5G SBA-related challenges as well.

Figure 4: The impact of AI/ML

Application/ capability	5G CEI-related implementation challenges	AI/ML impact
Third-party software and APIs	Lack of insight into performance and security of third-party APIs.	Provides real-time insight and can be utilized to support ML-based policy enforcement on per service level.
Slice-based services support	5G slices demand end-to-end monitoring to ensure performance meets strict latency budgets for "mission-critical" services. Further complicating the process is the fact that each slice will have its own unique performance and KPI requirements.	AI probes can monitor services in real time while ML can be utilized to learn how service-specific slices must perform to meet or exceed KPIs and take action when performance metrics deviate from the norm.
Edge-based services	5G-based edge services will necessitate software disaggregation on the edge at a massive scale never before undertaken.	AI will provide the scale and performance to monitor and react to changes in service performance. Since AI-based software probes can be placed at the network edge, optimal performance is assured. The AI probe facilitates a proactive approach to sustaining high CE for VIPs and premium services. AI is also used for anomaly detection such as identifying devices or network elements that behave outside the norm.

Source: Heavy Reading

It is important to note that the speed, scale, and intelligence of AI/ML CEI systems can also be leveraged beyond 5G. In the 3G and 4G domains, the additional intelligence of AI/ML CEI systems injects additional value into established approaches such as the use of deep packet inspection (DPI). In this hybrid model, DPI enhanced with AI and ML software probes can be used to enhance CEI for 3G and 4G mobile networks as well.

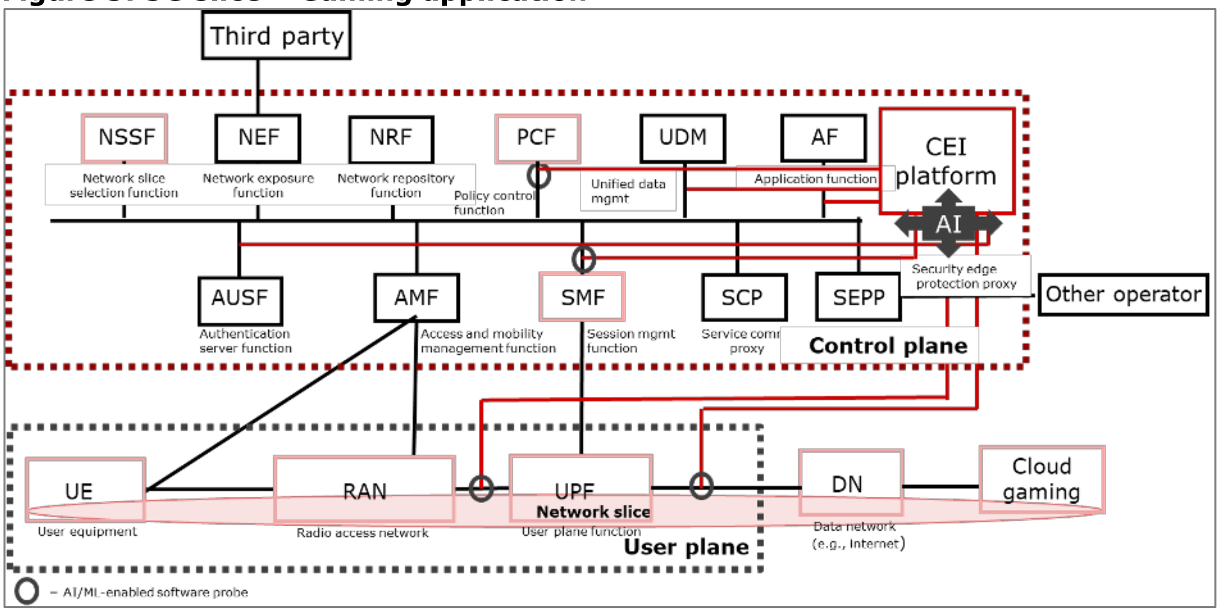
5G CEI use case

There is little—if any—debate among CSPs that 5G service innovation will be video-based. To be clear, video is already an important service enabler for 4G networks, but 5G will take consumption to the next level, maximizing the opportunity to monetize video services on an unprecedented scale.

Heavy Reading believes that one service that will fuel this aggressive video growth will be premium cloud-based gaming services. Given 5G's lower latency performance, the ability to support third-party software, and the expected quantum performance jump in 5G devices processing and storage, all the pieces are now in place to accommodate the stringent performance demands of embedded virtual reality (VR)-based video applications such as mobile gaming.

This use case, depicted in **Figure 5**, utilizes network slicing to ensure the high bandwidth requirements are not compromised. The key 5G core components utilized in this use case include the NSSF, which creates the slice; the PCF, which applies specific service policy control; the SMF, which manages individual gaming sessions; and the gamers' UE device, as well as the 5G RAN and UPF, which support data transfer for the slice-based, public cloud-based gaming application.

Figure 5: 5G slice – Gaming application



Source: Heavy Reading

This use case was selected because it exemplifies a complex high value, premium-priced service with strict performance tolerances that will have a negative impact on CE if not met. The sections below document how a CEI platform utilizing AI/ML-based software probes meets these rigid requirements.

Service-specific latency requirements

The low latency characteristics of 5G networks support the performance requirements necessary to enable the delivery of a VR-based mobile user gaming experience, which cannot be supported by 4G networks. While this will enable CSPs to generate new revenue streams, it also necessitates that they measure the service latency and sustained bandwidth necessary to meet strict gaming tolerances on an individual game basis.

Additionally, it is important to note that given the extremely competitive nature of the gaming landscape, new games are always coming to market while entrenched, proven winners continue to undergo aggressive service feature upgrades to remain one visual ahead of the competition. In this scenario, an AI probe is valuable because it can learn the user behavior of multiplayer internet games and calculate the "update latency" between the client and the gaming server and the impact on CEI.

Therefore, in both these cases, AI/ML probes are extremely well positioned to provide the programmable flexibility necessary to ensure CEI platforms can adjust to changes in gaming performance tolerances.

Software monitoring

An aggressive gaming service delivery program necessitates a flexible testing program that can test these third-party gaming applications and APIs within a continuous integration, continuous development (CI/CD) environment. In this scenario, AI/ML probes can quickly gather end-to-end performance data to monitor and potentially predict how a new specific software release or API will affect CEI.

Protocol interworking

The cloud supports many protocols and APIs. Thus, to calculate CEI for an end-to-end gaming slice, it is necessary to understand not only the specific protocol the cloud is running (e.g., Google QUIC), but also the performance metrics of that protocol since any additional protocol latency must be considered in the overall latency budget. The use of AI/ML software probes has several advantages. First, they can measure the impacts in real time based on a specific game versus simply applying a generic protocol latency budget figure. Second, these probes can be utilized to model how any similar games running over this protocol are likely to perform.

Slice monitoring

Because each slice has unique performance metrics, each will have to be monitored and measured to ensure that slice section and session management functions such as session creation, orchestration, and lifecycle management are optimized. AI-enabled CEI software probes are in the strongest position to capture and provide this information for the CEI platform because they are inline and capture actual performance data.

Managing encryption and optimizing analytics

Since this use case is a public cloud application, there is a very high probability that some portion of the slice will be encrypted by the application. In this scenario, it becomes impossible to measure and inspect every span of the slice to create a CEI scorecard. However, when integrated in CEI platforms, AI/ML can still enhance the visibility of overall performance metrics.

For example, when an AI algorithm notices that some portion of the slice that is encrypted is experiencing poorer response times, it can notify other policy nodes to monitor. If necessary, it can also implement other traffic balancing strategies to ensure the end-to-end performance of this gaming slice does not slip below the KPI threshold.

Furthermore, a 5G slice-based cloud gaming solution will rely heavily on AI-enabled CEI software probes since this data will enhance the performance of analytics platforms, which are also going through an AI-driven transformation. The bottom line is that by aggregating various analytics data feeds, it will become possible to monitor CE on an end-to-end basis.

UE device monitoring

With gaming services, the performance of the individual's UE can have a major impact on overall CE. This is especially true for gaming devices because they typically integrate the VR/AR capabilities necessary to support high value immersive games. By integrating AI/ML-based device monitoring and probes, the CEI platform can capture to what extent overall performance is being negatively affected by this device. It can then feed this data proactively into customer care systems to provide customer agents a definitive view of why the customer is experiencing subpar overall performance.

Looking forward, AI/ML could take this one step further to predict which type of device(s) will attain lower performance scores. This data could be shared with individual customers to inform them that their device is not meeting expected performance standards due to a software bug or other device impairment that could be improved by a software update. It may even be able to quantify that the device needs to be replaced based on the specific troubleshooting performed, such as battery, VR processor, or storage performance testing.

CONCLUSION

The 5G SBA core represents a generational technology shift since it creates a new API-centric template that provides the framework that will underpin all future mobile service innovation.

As the first iteration of a cloud-native core, the 5G SBA architecture defines new scale and performance metrics, which translate into greater end-user service performance expectations. To be successful in this new environment, CSPs must reassess how they measure quality of experience and utilize their CEI platforms.

As this white paper documents, to accommodate new performance targets and complex service use cases, CSPs should commit to integrating AI- and ML-based software probes into their CEI platforms to deliver the end-to-end visibility to meet and exceed CE in the 5G era.