APPLYING REAL-TIME ANALYTICS IN THE VIRTUALIZED MOBILE CORE NETWORK

Improve Customer Satisfaction	Lower Support Cost and Improve Efficiency	Promote Right Offer at Right Time

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Patrick Kelly, Appledore Research Group

www.appledoreresearch.com

Appledore Research Group

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Tel: +1 603 969 2125 o Email: Patrick.Kelly@appledorerg.como www.appledoreresearch.com

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Applying Real-Time Analytics in the Virtualized Mobile Core Network

PATRICK KELLY, APPLEDORE RESEARCH GROUP

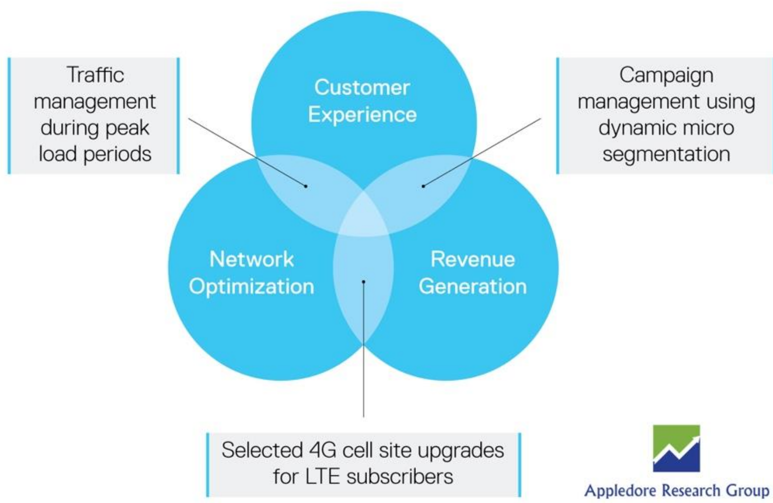
EXECUTIVE SUMMARY

The telecommunication industry is in the midst of a major transformation both in terms of business models and technology. Entirely new markets are being created by significant technology transformation drivers, including:

- Virtualization
- Cloud computing
- Mobility
- Big data analytics

These drivers are making it easier to assure that communication services provide five nines of reliability and availability, thereby driving network optimization, superior customer service, and new revenue generation. Programmable networks that move network intelligence into the software layer in turn require a new management and operational approach to support advanced services.

Figure 1: CSP Business Drivers for Real-time Analytics Solutions



Virtualization of the Evolved Packet Core (vEPC) is a priority for many communication service providers (CSPs) based on our research of ongoing proof-of-concept trials and early deployments of the technology. The economics of virtualizing the EPC enables CSPs to do the following:

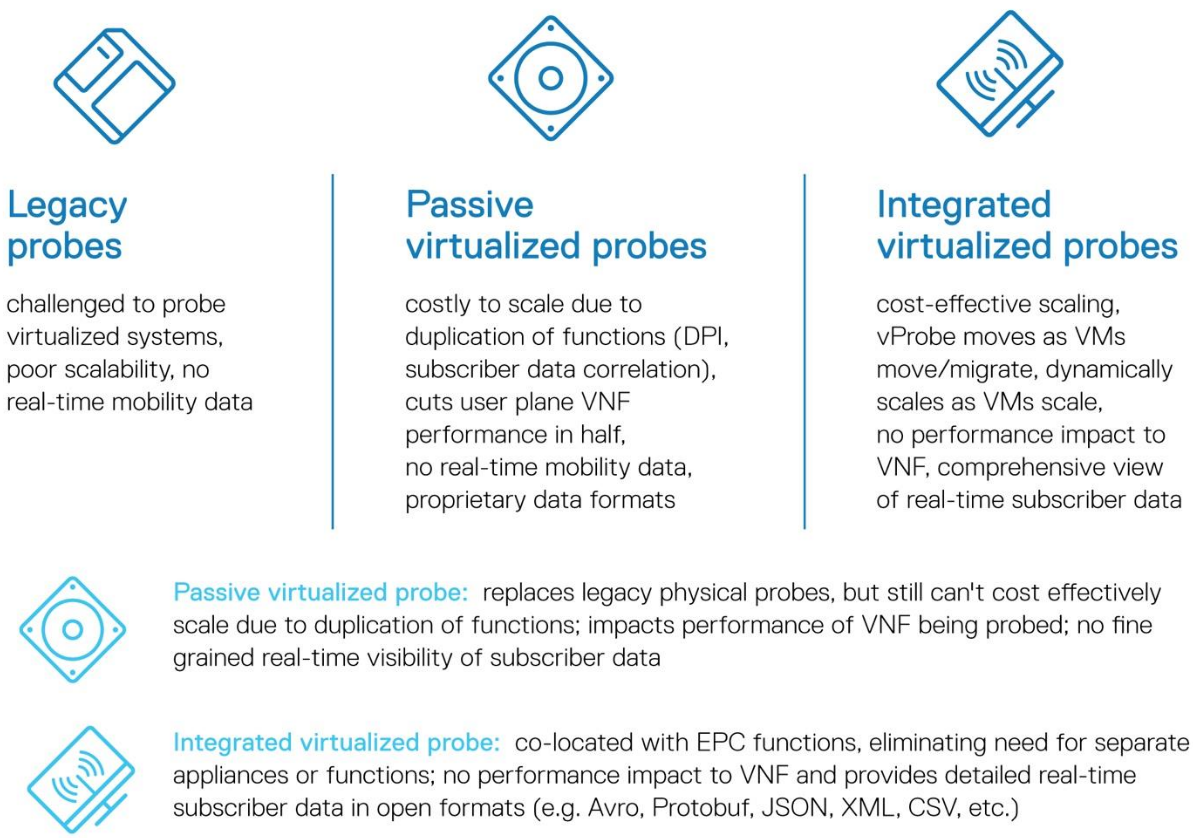
- Cost-effectively scale the mobile network
- Satisfy increased demand for mobile broadband services
- Rapidly introduce new services

This report will explain how virtualization of the EPC creates challenges using traditional measurement and monitoring tools. Physical probes which have been used for more than two decades to monitor critical links in the signaling and data session network are not suitable for assuring voice, video, and data services in the virtualized EPC. Physical probes are also used as the source for analytics applications that support operations, security analysis and corrective actions, customer care, and marketing groups, all of which increasingly want to use real-time data to improve business outcomes.

This report will show how integrated virtual probes – virtual probes that are co-located with Virtualized Network Functions (VNFs) – solve the challenges of traditional tools by making it possible to probe VNFs in a scalable, cost-effective manner, without loss of network visibility or performance impacts, and stream data records in real-time from the probe into the data analytics engine.

Carriers are looking for real-time analytics to help improve customer experience, revenue generation, and network optimization (figure 1). Integrated virtual probes, integrated directly within VNFs, provide a comprehensive view of real-time subscriber data, enabling a multitude of business cases. By deploying an integrated virtual probe (vProbe) within the vEPC and implementing a real-time analytics solution, CSPs will be able to do the following:

- Cost effectively scale networks and probes
- Avoid critical data gaps during the capture and correlate process in a virtualized environment
- Improve overall customer experience
- Identify new opportunities in presenting relevant offers to existing mobile customers



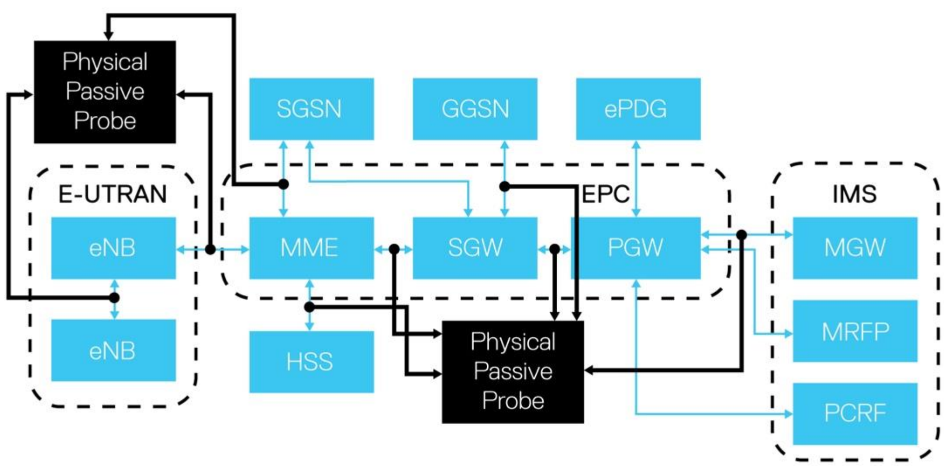
VIRTUALIZATION OF THE EPC WILL MAKE PHYSICAL PASSIVE PROBE SOLUTIONS OBSOLETE

Over-the-top (OTT) competitors are continuing their rapid release of new and relevant services as they analyze the massive and exponentially growing amounts of data generated by mobile users. As just one snapshot – worldwide, telecom is losing $23 billion in SMS and $170 billion in voice revenue to OTTs[1]. To stay competitive in this fast changing environment, telecom operators need to quickly adopt new tools needed to both protect and grow their revenue streams. To that end, many have started to implement Network Functions Virtualization (NFV) in their mobile core networks – the overall NFV market is projected to grow from a base of $2.3 billion in 2015 to $15.6 billion in 2020[2].

Physical Passive Probes

Today's telecom operators are using passive probing within networks to tap critical links between network functions used to support both the packet and circuit switched networks (figure 2). A dedicated purpose built appliance is used for passive probing of these links using T1/E1, 1G, 10G, and 100G uplink interfaces. Almost all suppliers of passive probing, such as Tektronix Communications, Netscout, Viavi (formerly JDSU), Spirent, Empirix, Astellia, and others, support mobile data and data center protocols (GN/Gi), LTE/EPC, and multimedia protocols (VoIP/IMS).

Figure 2: Physical Passive Probe Monitoring points for LTE network



Acronyms

MME – Mobility Management Element
SGW – Serving Gateway
PGW – Packet Data Network Gateway
HSS – Home Subscriber Server
PCRF – Policy and Charging Rules Function
GGSN – Gateway GPRS Support Node
ePDG – Evolved Packet Data Gateway

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[1] http://www.indjst.org/index.php/indjst/article/viewFile/62238/48529
[2] http://www.lightreading.com/nfv/nfv-elements/heavy-reading-mobile-nfv-leads-surge-to-$15b-market-by-2020/d/d-id/726108

Traditional passive probe deployments have been very effective over the past two decades in managing technology cycle upgrades and complex voice, video, and data services. However, virtualization of the network and cloud based services will render physical passive probe technology obsolete.

Need for Virtual Probes

The deployment of a virtualized network function (VNF) presents challenges in the traditional model of assuring services. VNFs will need to be instantiated based on resource demands. The VNFs and the links used to connect services will move dynamically based on utilization, policy, and business logic rules. As VNFs are added, moved, and de-commissioned, the monitoring points must also be created, moved, and retired at the same rate. In a flat IP network architecture, VNFs will be integrated within the mobile cloud. As a result, no clear demarcation points exist to mirror or passively probe IP flows used for troubleshooting and advanced analytics. Virtualization of the network means virtual machines will dynamically move rendering physical fiber splitters and the use of physical layer 2 switch port mirroring functions obsolete.

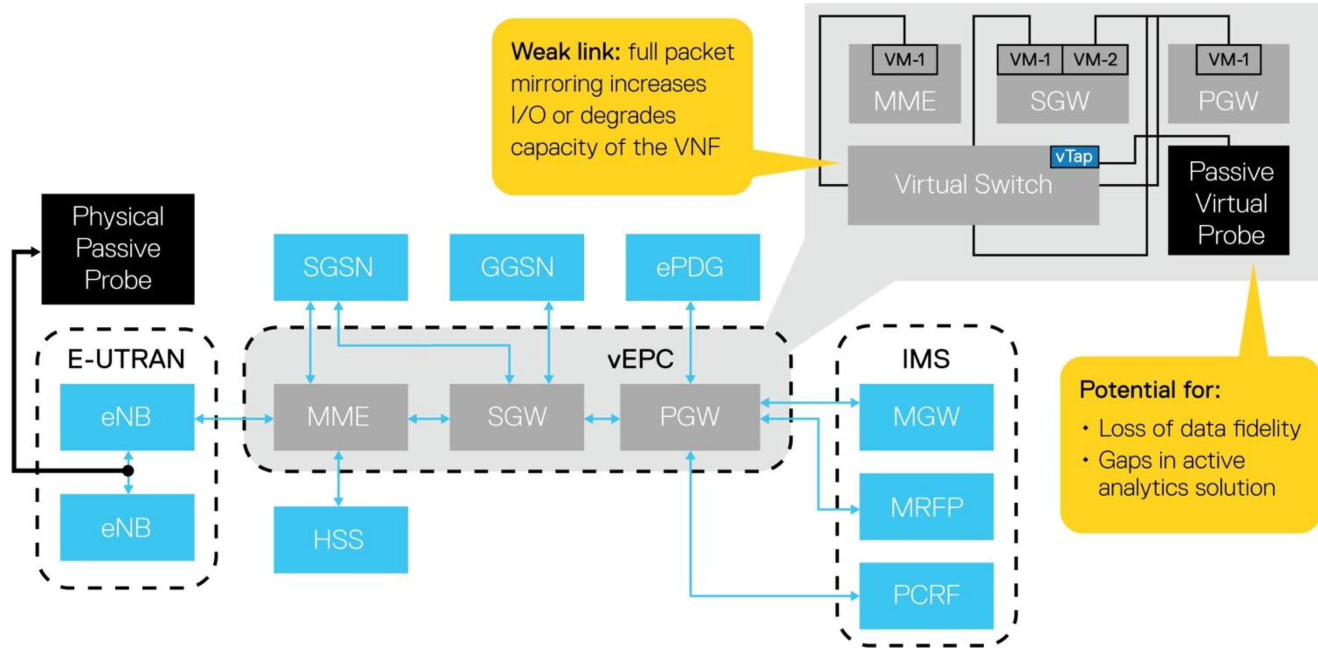
Additional challenges with the hardware approach come as it is difficult for physical probes to access logical interfaces between Internal VM-to-VM communications or between VMs located on different servers. Also, new virtualization techniques, such as containers, rely heavily on distributing traffic between many lightweight, virtualized resources, and legacy physical probes cannot serve these network elements. Figure 3 shows a simplified view of the virtual Evolved Packet Core (vEPC). One or more functions will be instantiated on virtual machines (VMs) in one or more data centers which could span geographic regions.

Many CSPs are looking to deploy vEPC to take advantage of both the benefits achieved from lower capital expenditure and improvements in operational efficiency. The MME, SGW, and PGW are being virtualized. Operators have two options for virtual probes – passive virtual probes and integrated virtual probes.

Passive Virtual Probes

The use of the passive virtual probe supplied by incumbent passive probe suppliers or suppliers of the vEPC will displace the dedicated physical probe appliance as shown in figure 3. Each instance of the passive virtual probe will be instantiated at the same time a VNF function is created or moved to assure a high quality of service. As traffic session flows and transactions increase at exponential rates, virtual probe solutions will be deployed more and more frequently. The virtual passive probe uses the vSwitch of the Hypervisor of the VNF to packet mirror all the traffic going through the VNF. These packets are then sent to the passive probe where they are analyzed, interpreted and then sent on to the analytics application. For passive virtual probes, the virtual switch becomes the weak link in this design because of packet processing design performance and limitations in its ability to record all necessary data records to be used for troubleshooting and other analytics applications on the data plane. The implication of full packet mirroring in the virtual switch either increases I/O requirements or degrades the capacity of the virtual network function being probed. CSPs should be testing performance benchmarks to understand any constraints in acquiring event data records that will be necessary for data acquisition to be used in real-time analytics applications.

Figure 3: Virtual Passive Probe Monitoring points for LTE network



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A passive virtual probe goes through the following steps when monitoring the network:

1. Create mirrored packets at the vSwitch of the VNF– can cause performance impact to VNF, cannot support fine grained filtering as packet mirroring is done in the vSwitch, doubles size of VNF I/O requirements, doesn't support architectures such as SRIOV
2. The probe needs to bring in feeds from other VNF's to have a full view of all packets within the vEPC – difficult to horizontally scale
3. Filter packets, correlate data, and create data records. All being done off-line, adding additional delays from the time the data is generated to the time the data becomes available for analysis.

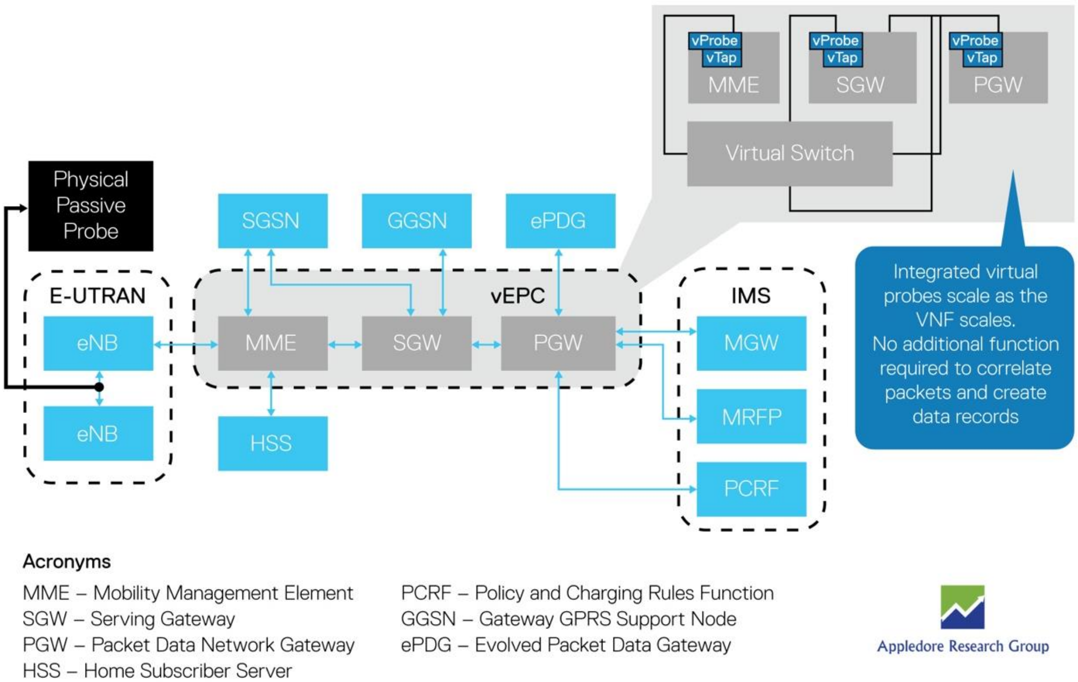
Integrated Virtual Probes

Another approach to data collection without the use of a passive virtual probe or physical probe is an integrated virtual probe implementation (figure 4). Integrated virtual probes embed the tap, probe and packet brokering functions into the VNF such as vEPC, virtual GiLAN Gateway, and virtual WiFi Gateway (ePDG, TWAG). Colocating the evolved packet core and tap/probe/packet brokering functions makes it possible to probe VNFs in a scalable, cost effective manner, reducing current probing costs by as much as 50%. Incorporating probes within each VNF instance ensures that when operators need to scale the VNF, the probes will dynamically scale with it, without loss of network visibility or performance impacts. The integrated virtual probe can pre-filter data sessions and transmit this information to big data analytics systems. This eliminates the need for

Virtual probes cut probing costs by 50%

the virtual switch to packet mirror and avoids any potential I/O constraints and VNF performance impact. The integrated virtual probe can also support creating multiple simultaneous customized data records (e.g. one for operations for troubleshooting, one for marketing for traditional business analysis and one for security). In addition, the CSP does not need to deploy another virtual machine or server, helping to avoid duplication of functions and keep costs down.

Figure 4: Integrated Virtual Probe Monitoring points for LTE network



An integrated virtual probe goes through the following steps when monitoring the network, improving upon the passive virtual probe process at all points:

1. The integrated vTap allows the integrated vProbe to look at the packet during processing of the packets within the VNF – causes no impact to the VNF being probed, can be fine grained, and limits the amounts of I/O consumed; supports all packet forwarding architectures

2. Packets are already correlated, as this is being done in the vEPC functions themselves – no additional function required to do this, full view to all subscriber information, all the time

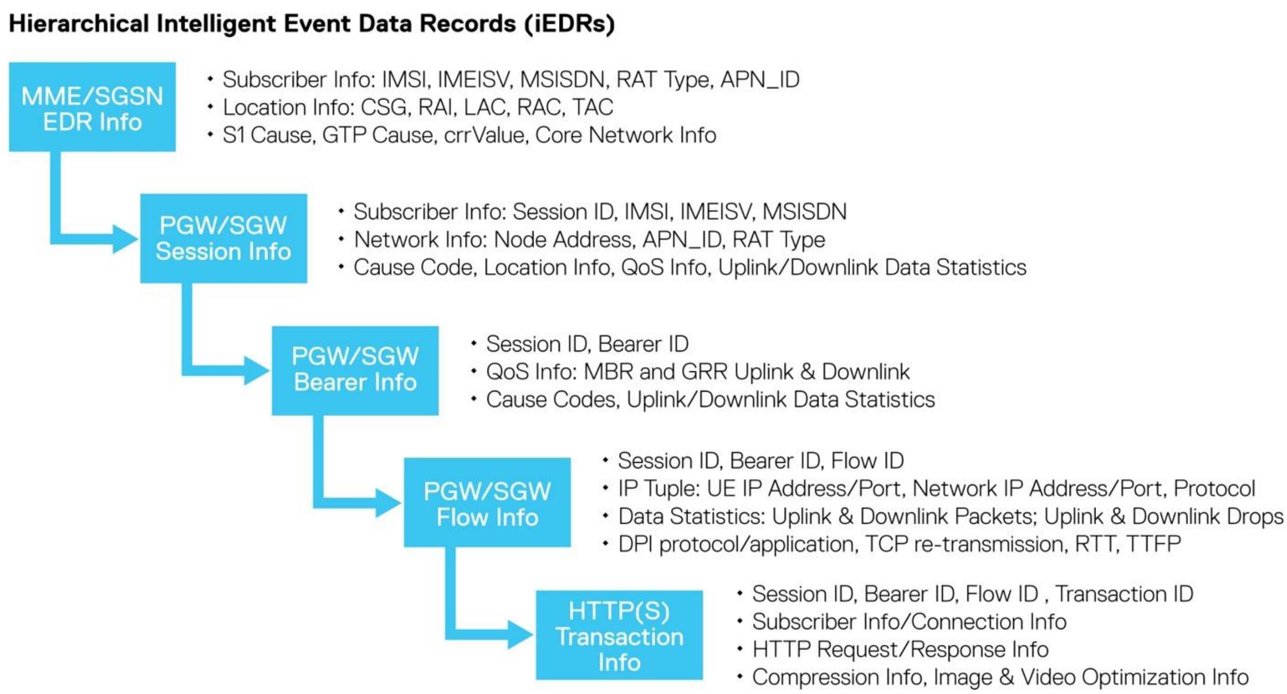
3. Filter packets and create records – no duplication of functions as no additional server is required, and packets from vEPC are converted and sent directly to analytics. Leverages DPI and other functions that are also co-located with the VNF and includes this information as part of the data records. Can also create multiple customizable record streams simultaneously.

Affirmed Virtual Probe

Affirmed Networks is a supplier of virtual EPC solutions. It includes integrated virtual probing in its solution branded as Affirmed Active Intelligent vProbe. Affirmed Network's virtual probe is colocated with Affirmed vEPC. It provides both control and data plane traffic collection and processing in each functional area.

1. vControl Flow – Collection of all control plane traffic. Supports filtering of the control plane traffic if required (i.e. per user, per interface or per protocol)
2. vData Flow – User defined filtering of data plane traffic for port mirroring.
3. Intelligent Event Data Records – Complete granular data capture of session, bearer, flow, and transaction details in the data and control plane. The iEDRs provide a complete view of all traffic, without the need to mirror the data, and a basis for determining filters for vData Flow.

Figure 5: Affirmed Intelligent Event Data Record Hierarchy for deep packet analysis



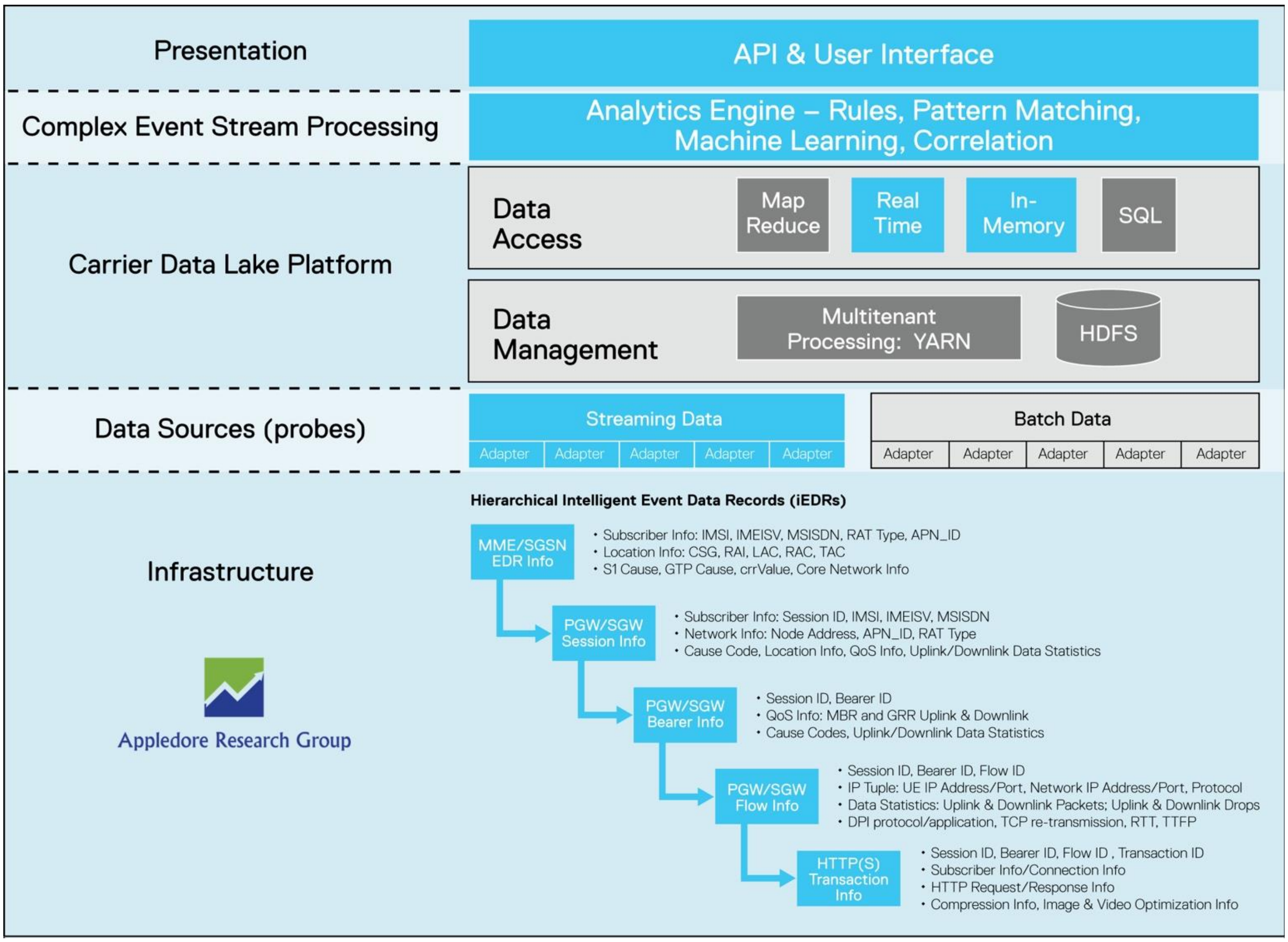
Intelligent Data Records (iEDRs) provide a network-wide granular view of per flow, per subscriber information without needing to mirror the data. Unlike mirroring, creating and streaming these data records does not impact the VNF performance during probing. Streaming these records in real-time from the integrated vProbe into the data analytics engine enables operators to eliminate data silos, rapidly develop valuable reporting tools, and make informed business decisions. The iEDRs provide a comprehensive view of the network - letting operators identify problems easily.

The move from physical to virtual and integrated virtual probe technology will follow a substitution pattern that we have seen with other technologies. During this transition, where we estimate a substitution crossover to occur in 7 years, CSPs will operate in a hybrid network environment. This means that data will be collected from both physical and virtual / integrated probes to provide an end-to-end view of services and customer experiences across all technology domains.

INTEGRATING VIRTUAL EPC INTO A TELECOM DATA ANALYTICS ARCHITECTURE

The use of probing data is expanding beyond traditional uses in the testing and operations of the network. Increasingly, the data is valuable for customer care, marketing, fraud detection, and network planning and optimization use cases. Figure 6 shows a high level view of how CSPs can benefit from existing sources of data in their networks and incorporate new sources of data from the virtualized EPC. The areas highlighted in blue identify functional areas of the architecture that apply to the use of real-time analytics.

Figure 6: Telecom Data Analytics Reference Architecture



Benefit of Real-Time Analytics

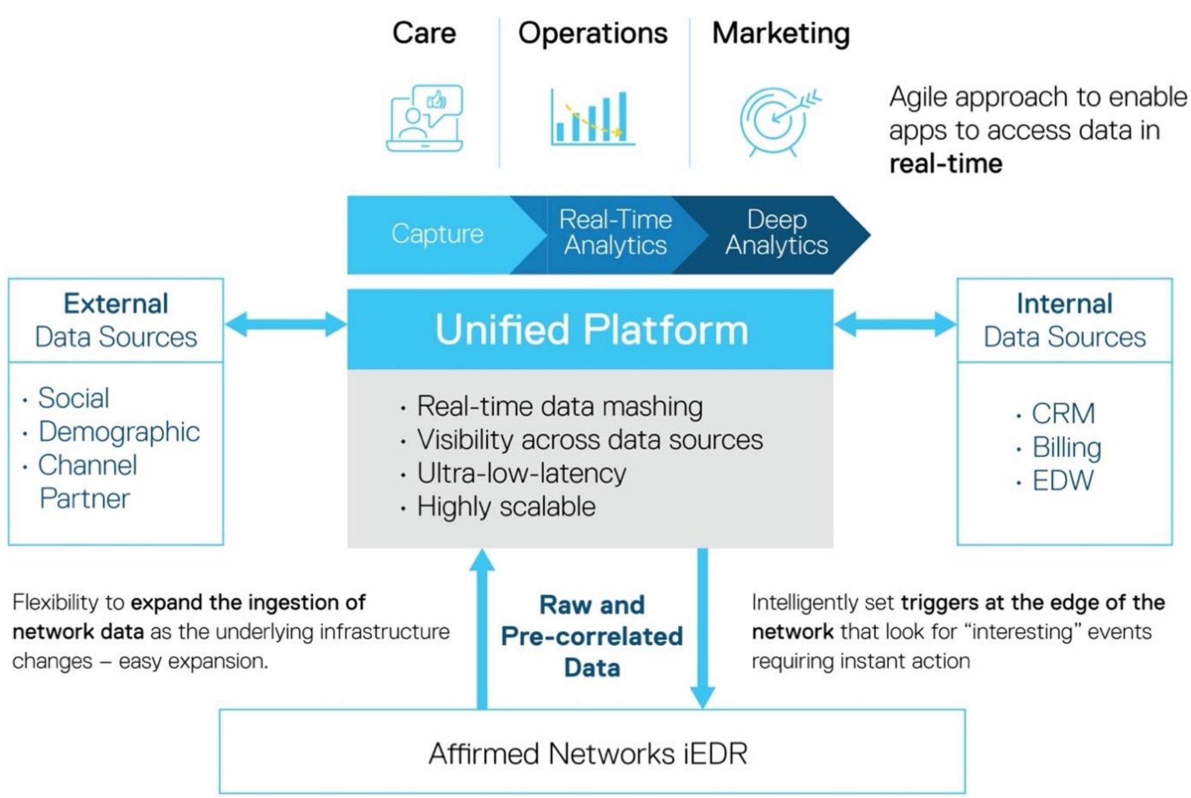
Real-time analytics requires the ability to process and analyze massive amounts of data streams originating from different sources in the network infrastructure. Real-time analytics processing offers CSPs new opportunities to generate revenue from their existing subscriber base, determine where network capacity must be added, and quickly respond to network quality issues. Applying real-time analytics to a telecom data analytics architecture enables CSPs to combine data and improve business outcomes.

As subscribers make calls, download data, and purchase applications, CSPs can combine this real-time data with billing, account status and other information and present targeted offers based on subscriber-specific information. Real-time processing can also help CSPs quickly detect network performance problems and immediately analyze additional data and pinpoint where the problems are occurring to determine how to optimize the network and plan for network upgrades.

Real-time analytics is required to achieve these business outcomes. These cannot be achieved with batch analytics systems, which report critical issues days or months after subscriber impact, long after the opportunities to prevent customer churn and cross-sell and up-sell new services has passed.

Figure 7 provides a reference architecture that supports real-time actionable intelligence. The Affirmed and Dell EMC solution combines real-time network data with batch processing systems to understand customer experience, promote effective marketing campaigns, and optimize the performance of advanced services.

Figure 7: Combining rich network data plane traffic with unified real-time analytics



HIGH LEVEL USE CASES APPLIED TO REAL-TIME ANALYTICS

Implementing real-time analytics in the mobile packet core network allows CSPs to recognize business outcomes that are tied to high impact business goals (figure 8). The examples below reflect Appledore Research Group findings from our research of CSP implementations in different regions across the globe. These use cases reflect broad categories that impact the business. In reality, CSPs will apply very specific use cases to target a business outcome that satisfies the requirement of the business unit. This may include developing a smart charging platform which uses real-time data analytics to understand subscriber usage patterns and correlate those patterns to service offers that closely match the profile of the subscriber resulting in a new order. The matrix shown below can be expanded and may in-fact result in hundreds of use cases for a specific CSP. The business owners should engage in assessing their own environment and apply a data driven workflow process. Using rich network data that already exist in the operator's network, and combining it with real-time analytics, puts valuable information in the hands of business managers to make timely, actionable decisions.

Figure 8: Real-time Analytics Business Outcomes

	Business Goal	Stakeholder	Real Time Analytics Business Outcome
	Improve Customer Satisfaction	CEO, CTO	Improve subscriber quality of service. Increase NPS and correlate to internal management systems
	Lower Support Cost and Improve Efficiency	COO, CIO	Reduce first call resolution and avoid unnecessary call load to contact center
	Promote Right Offer at Right Time	CMO	Next best offer based on usage and subscriber profile

Improve subscriber quality of service

In many mobile markets, subscriber saturation and falling ARPUs have led to a focus on customer experience. The use of Net Promoter Score as a survey method to understand customer satisfaction is used to drive a focus on touch points at each phase of the customer lifecycle. Network quality of service accounts for 40% of subscriber churn. According to our research, an enormous gap still exists between the internal service assurance and network monitoring systems and the overall satisfaction of the subscriber. As a result, CSPs are turning to real-time analytics as a way to correlate the customer experience with network reliability and performance. It's no longer sufficient to measure network KPIs such as call failures and slow data connections. Instead CSPs want to understand subscriber impact based on value of the subscriber.

Real-time analytics systems combine network KPIs with subscriber management systems, billing data, and handset data to construct a more accurate view of the customer experience. Virtual monitoring of the vEPC provides the underlying data for real-time analysis of session initiation by monitoring both the control plane at set-up and continuity for the data session via user plane monitoring. The analytics engine must have self-learning attributes allowing the model to discern important KPIs that impact customer satisfaction and lead to customer churn.

Reduce first call resolution and, in many cases, avoid inbound calls in the call center reducing operational support cost

LTE technology brings with it efficiency in collapsing the circuit switch and packet network into one common IP core network. The EPC is a high-performance, high-capacity, all-IP core network for LTE which brings with it increased complexity in isolating problems. The challenge for many frontline support personnel will be correlating vast amounts of event and performance data to identify the root cause of subscriber problems. Virtual monitoring of the vEPC is necessary to address the dynamic management of mobility, policies, data bearers and the interoperability with legacy 3G/2G systems. The MME manages thousands of eNodeB elements, which is one of the key differences from requirements previously seen in RNC/SGSN platforms. The MME is the key element for gateway selection within the EPC. It also performs signaling and selection of legacy gateways for handovers to other 2G/3G networks. The ability for the real-time analytics system to perform fast processing of virtual network functions with the EPC (MME, SGW, PGW) and filter out superfluous event data will help first-line support technicians to resolve calls faster and, in many cases, proactively identify problems to avoid inbound calls.

Understand subscriber usage to more effectively market new services

Personalized data monetization offers can be enabled via the use of analytics, campaign management systems, online charging systems and PCRF in the mobile network. Many CSPs are actively evaluating how to use smart charging based systems that leverage subscriber usage based data analytics to drive effective campaign management offers. The 3GPP Release 12 introduces system enhancements on top of the existing Policy and Charging Control (PCC) framework to fulfill application-based charging for the detected applications. In the future, application based charging will allow the CSP to increase revenue for premium based services that provide guaranteed QoS for specific products. Virtual monitoring of the EPC provides session, bearer, flow, and transaction level data which can be utilized by real-time analytics systems to drive the right offer, at the right time, to a specific subscriber.

RECOMMENDATIONS

It's no secret that the telecommunication industry controls some of the most valuable raw data about customer usage, location, and social patterns than any other industry vertical. The challenge for telecommunication executives is to make use of subsets of the data in different segments of the business to improve conditional outcomes impacting critical parts of the business. Fast data capture and real-time analytics can facilitate measurable improvements in key areas of the business. Success will be predicated on a solutions approach that blends real-time and batch analytics in a complete telecom data analytics platform.

Appledore Research Group finds that most CSPs, in their journey towards virtualization, intend to first focus on the mobile core network. The economic benefits are compelling enough that we expect CSPs to cap legacy investments in the mobile core network and target new investments in virtualizing the EPC to gain network efficiencies. More importantly, CSPs have the opportunity to deploy new services more rapidly and at a lower operational expense ratio to existing legacy physical EPC deployments.

In making this journey, CSPs must consider how to test, troubleshoot, support, and understand the impact of a much more complex mobile packet core network. Real-time analytics and the ability to capture complete data sessions must be considered before moving towards implementation.

Some recommended actions to help navigate this journey include:

Baseline the tools and processes in place today to support the current network architecture and identify any gaps.

Document the future network architecture and migration approach toward virtualization which includes Operation, Administration, and Maintenance (OA&M) tools to manage the future network and services. OSS and service assurance tools are evolving to support real-time analytics as an advanced set of capabilities that will be used outside of traditional network operations and planning.

Challenge suppliers on their ability to manage and support the virtualized EPC. As pointed out earlier in this document, it will be necessary to understand the implication of full packet mirroring in the virtual switch. We still maintain that some solutions may increase I/O requirements or degrade the capacity of the virtual network function for the EPC. CSPs should test and validate performance benchmarks to understand any constraints in acquiring event data records that will be necessary for data acquisition to be used in real-time analytics applications.

Implement the solution based on established business practices, business models, software systems, and network architecture in your existing environment. Radical changes are fraught with risk and any implementation should facilitate – not inhibit – your business strategy.