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White Paper

The State of 4G Deployments & the Importance of Analytics

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Global LTE Deployment Status

Mobile operators worldwide are making significant financial commitments to deploy all-IP mobile broadband (MBB) networks. The race is driven by operator competition to capture market share among the most advanced subscribers with new smartphone devices and applications that are driving mobile data traffic growth. Operators are now deploying mobile broadband networks and services to reduce the cost to handle this traffic growth and economically extend broadband coverage to rural areas. Based on the latest GSA Evolution to Long Term Evolution (LTE) report (October 2011), 185 firm LTE network deployments are planned or in progress in 66 countries, and 248 operators in 87 countries worldwide have committed to implementing LTE as their path to mobile broadband. LTE network deployments are driven by the rapid growth of mobile broadband traffic in Asia/Pacific, Europe and North America. As indicated in **Figure 1**, these operators have launched 30 commercial LTE networks and services in some 20 countries. LTE will be deployed first in developed markets first where more customers are willing to pay for better service, with wide-scale deployments in emerging markets expected after the cost for equipment, devices and handsets begin to decrease. Operators in emerging markets will deploy LTE at least a year behind those developed markets, and will do so with limited geographic coverage

Figure 1: LTE Commercial Network Deployments 2011

Region	Country	MNO LTE Deployments	Band	Date
N. America	USA	MetroPCS Verizon Wireless AT&T Mobility	AWS 1.7/2.1 GHz 700 MHz 700 MHz	2010 2010 2011
N. America	Canada	Rogers Wireless Bell Mobility	AWS 1.7/ 2.1 GHz	2011 2011
W. Europe	Sweden	Telenor/Tele2 Telia Sonera	2.6 GHz 2.6 GHz	2009 2009
W. Europe	Norway Finland Denmark	Telia Sonera	2.6 GHz 1.8 GHz	2010
W. Europe	Germany	Vodaphone Deutsche Telekom Telefonica 02	2.6 GHz 1.8 GHz 800 MHz	2010
W. Europe	Austria	MA1 Telekom Austria	2.6 GHz	2011
E. Europe	Poland	CenterNet/Mobyland	1.8 GHz	2010
E. Europe	Estonia Lithuania Latvia	EMT Omnitel LMT	1.8 GHz	2010 2011 2011
Middle East	Saudi Arabia	Mobily STC Zain	2.3 GHz 1.8 GHz	2011 2011 2011
Central Asia	Uzbekistan Kazakhstan	Mobile TeleSystems (MTS) Ucell - TeliaSonera Beeline/VimpelCom/KarTel	2.5-2.7 GHz 700 MHz	2010 2010 2011
Asia Pacific	Japan	NTT DOCOMO	2.1 GHz	2010
Asia Pacific	Hong Kong	CSL Limited	2.6 GHz	2010
Asia Pacific	Singapore	M1	1.8 & 2.6 GHz	2011
Asia Pacific	South Korea	SK Telecom LG U+	800 MHz/1.8 GHz 2.1 GHz	2011 2011

Source: Heavy Reading, GSA and Company Information

A recent survey conducted by *Heavy Reading* interviewed over 100 service providers that are planning LTE deployments over the next three years. The following are a few key points that are highlighted.

- The early adopters, representing 25 percent of operator respondents, launched a data-only service using USB modems before the end of 2010.
- Although 2011 and 2012 are the key years for commercial launches, 28 percent of respondents don't intend to launch commercial LTE services until 2013 or later.
- Phase 2 began in mid 2011 as the first wave of LTE smartphones, tablets and embedded netbooks were introduced, and the first dual-mode devices supporting both FDD and TDD are being introduced.
- The threshold for mass-market LTE appears to be in 2014 when 46 percent of respondents believe more than 20 percent of subscribers will have an LTE device.
- By 2016 76 percent of operators expect more than 20 percent of subscribers to make use of LTE services.
- LTE coverage will be focused on urban areas to provide a highly scalable infrastructure to support the exponential growth of mobile broadband traffic.
- 25 percent of operators are targeting an aggressive nationwide rollout, including rural areas that lack the wireline infrastructure to support DSL or fiber optic fixed broadband networks.

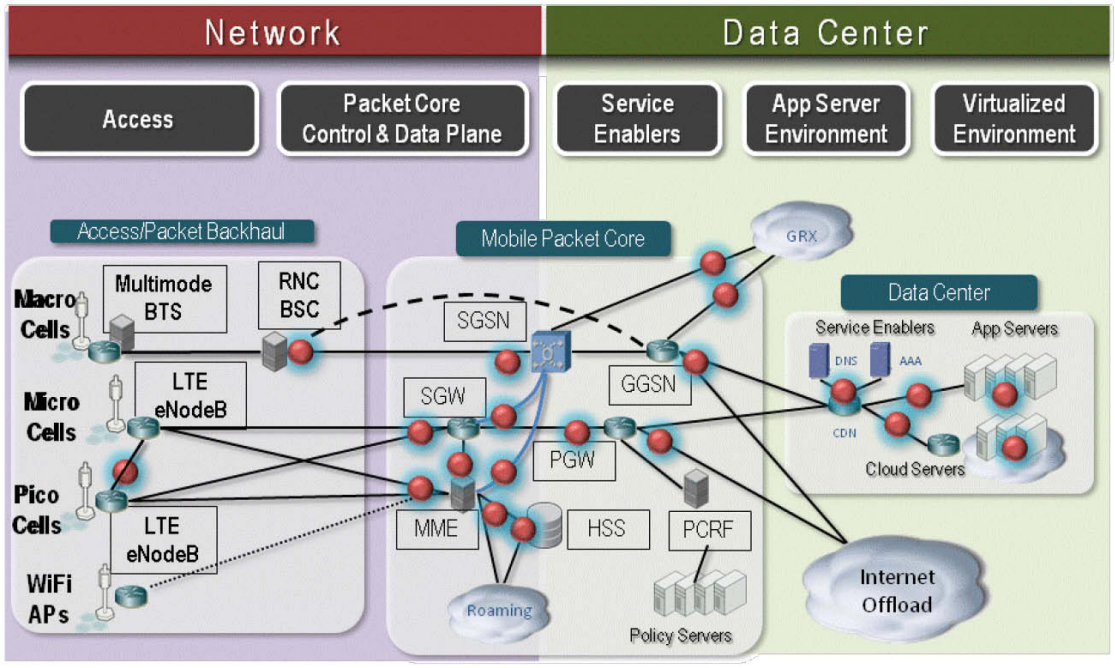
LTE Success Depends on RAN Evolution & Robustness of SON Solutions

Radio access network (RAN) architecture and infrastructure has remained the same for many years, making it difficult for the operators to meet user demand. Radio architecture is now evolving to provide operators with enhanced flexibility, capacity, coverage and scalability. The RAN vendor ecosystem is gearing up to bridge the gap between legacy technologies and LTE by offering next-generation, multimode and small cell base stations. Some of the major changes we see happening around 4G LTE deployment especially in the RAN that signal major changes in the traditional approach to base stations, include:

- Multimode and multi-standard base stations and antenna
- Integrated radio (AIR) systems – compact, tower-mounted solutions for 3G and 4G macrocells
- Compact base stations – microcells, picocells and femtocells
- Distributed, flexible approaches to radio access networks including cloud RAN infrastructure and baseband pooling
- Heterogeneous network management
- Active antenna systems

Figure 2 illustrates the complexity of a 4G mobile broadband network that operators have to manage seamlessly.

Figure 2: 4G Mobile Broadband Network



New multi-mode RAN infrastructure solutions by leading vendors promise operators improved coverage and performance, lower power consumption and operating cost compared to legacy single-mode base stations. Different generations of 3GPP radio access technologies will continue to exist and operators will have no choice but to be able to manage these generations in parallel. Developments such as multi radio, common network management and seamless handover between these technologies are some of the key approaches that will help operators to not only manage their network but also to ensure that the investments they have already made are protected and upgrades are evolutionary. Operators are under tremendous pressure to reduce cost per bit of delivering data services and, as such, heterogeneous (Het Net) network consisting of femto, pico, micro and macro cells is imperative for optimal coverage and capacity.

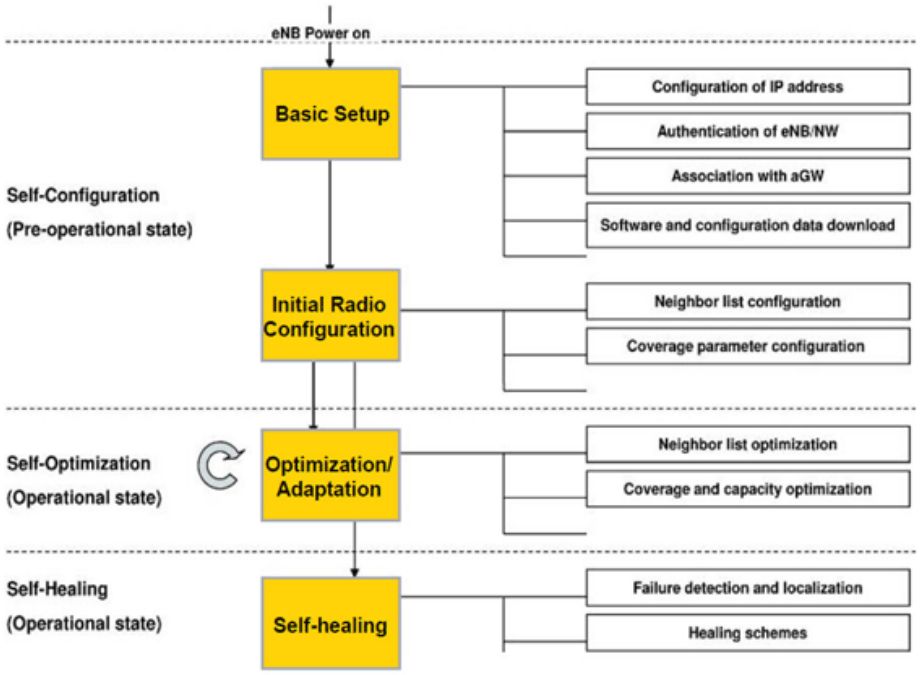
Self-organizing networks (SON) is a major wireless industry buzzword. SON, as a concept, is especially more potent in the context of 4G LTE. As mobile network complexity increases – in time perhaps reaching tens of thousands of base stations per mobile broadband operator in some markets – SON simplifies everything from network deployment to the complex processes of network planning, optimization and maintenance, enabling operators to cut back on capex and opex. Under the explosion of mobile broadband traffic, mobile operators are likely to face significant increases in operational costs. While data traffic is growing exponentially in many markets, competition is driving ARPUs down. Mobile operators are under pressure to cut or at least control opex to stay profitable even in the short term. Investments in LTE (or other 4G-type) networks are required, and many operators will be forced to operate multi-standard, multi-band and perhaps multi-mode broadband networks spanning various technologies and frequency bands. The degree of operational complexity – and the associated opex – will increase, unless concerted efforts toward increased automation are successful. Many see SON as the solution to this challenge.

The most important specific drivers for SON adoption are:

- A projected vast long-term increase in the number and type of base stations deployed in 4G (LTE and LTE Advanced) networks, including femtocells, picocells and other types of cell structures leading to ubiquitous so-called heterogeneous mobile networks. Such complex network structures are required to meet the boom in data traffic and to ensure optimal utilization of available frequency bands, which are dwindling.
- Big increases in the number and type of technical configurations and radio resource parameters used to manage and run mobile networks (currently many hundreds of parameters are used to configure a single base station for a single technology).
- Increase in network complexity to support multiple standards (GSM, WCDMA, HSPA, HSPA+, 3GPP LTE, LTE Advanced, etc.) and the use of multiple, disparate frequency bands to meet a projected increase in demand for mobile broadband services.
- The increased risk of a range of traffic-related quality problems, including reduction in mobility, increased radio frequency interference, etc., as mobile broadband traffic, subscriber density and the number of device types continue to increase.

Figure 3 shows the step-wise, conceptual framework for SON functions as viewed by the 3GPP standardization body. Available SON features fall mainly into self-configuration and self-optimization categories.

Figure 3: Self-Organizing Framework



Source: NSN, 3GPP, Heavy Reading, 2011

All mobile network operators employ some form of centralized network management systems to oversee and manage optimal functioning of the network. Because the radio medium is notoriously difficult to manage (aggravated by the vast increase in spectrum usage, the explosion of users and traffic, as well as multi-standard, multi-mode scenarios, etc.) such support systems are complex. Typical network management systems connect all network elements and sub-elements – even reaching to the plug-in unit eNodeB level – to a centralized server system that reacts to network changes or errors usually based on some level of operator intervention. Such server parks run hundreds of processes related to network fault monitoring and handling, creation of logical network elements, management of quality through key performance indicators (KPIs) and much more. Thousands of engineers and technical managers are employed worldwide with the task of keeping mobile networks running smoothly from their respective operations and maintenance centers (OMCs).

Until now, network rollout, planning and optimization processes have required a lot of operator intervention. In some cases mobile operators use offline or partly automated systems that assist in management and planning. But generally operational processes are resource intensive.

Hence the key promises of SON look very attractive:

1. Automating day-to-day tasks of an army of operational engineers.
2. Simplified network deployments (self-configuration for faster rollout).
3. Networks with SON can optimize and even heal themselves in case of problems (self-optimization and self-healing). These tasks will be managed and executed not only from the centralized OMC level, but also by automated, intelligent actions carried out by the eNodeBs.

The concept of SON implies that 4G networks must be increasingly self-optimizing, with cells automatically managing how they interact with one another (adjusting their power to minimize interference while maximizing bandwidth and coverage), managing their power consumption and how they load balance traffic and handover traffic between cells. They will be able to do this much more effectively if advanced analytics can augment network performance information with contextual user experience information in specific areas, how that user experience varies according to the different types of services they might use and typical patterns of user behavior throughout the day. For instance, if analytics can show that although reducing the power on one cell in favor of another cell might improve the overall network, but that the experience of a small set of high-value customers who typically use demanding services at a set time of the day will be reduced, then a decision can be taken about the best way to sustain quality of service (QoS) without destroying customer satisfaction. Use of advanced analytics will become table stakes in order to fulfill the key promises of SON. In the next section we will see in detail how advanced analytics will be crucial underpinning for the success of 4G.

Promises & Challenges of 4G

4G promises to catalyze profitable business models. The expectation is that services like Advanced UC (unified communications including video conference, telepresence, etc.), cloud-based services, collaboration services, mobile video, mobile advertizing, etc., will flourish as a result of widespread deployment and adoption of 4G. However, there are many challenges surrounding customer experience management, capacity planning, service assurance, network resource management, etc., that operators need to decode, which will help them to profit from their LTE deployments. Use of advanced analytics becomes crucial in addressing these challenges, as well as keeping up with self organizing capability of SON that is used to denote a plethora of functions and features to be used by mobile operators as tools for increased operational efficiency in the management and control of increasingly complex mobile broadband networks.

Lets us look at some of the key uses cases that highlight the reasons why advanced analytics will play a pivotal role in the success of 4G:

Managing RAN congestion. RAN congestion is emerging as a major problem for service providers. Backhaul also is a major problem area that results in congestion issues. Another major issue is smartphones – not just for the amount of bandwidth they consume, but for the signaling traffic they generate. One of the worst-case scenarios thus far was a single Android IM application that generated so much signaling that it nearly crashed T-Mobile USA's radio network controllers (RNCs) in multiple markets. Although RAN congestion is rightly perceived as a data-centric problem, it also affects voice. For example, once the LTE industry decides how to route voice traffic natively over LTE (as opposed to falling back to 3G or 2G), then voice becomes another form of IP traffic competing with video, email and file transfers for RAN and core network resources. The effective use of advanced analytics can help alleviate some of this problem. Advanced analytics has the potential to play pivotal role in this context by being able to receive real-time feeds from network and back office systems and adjust customer's services, rate plans, tiers, etc., so as to help communications service providers (CSPs) maximize revenue from network assets.

Cloud and application performance management (APM). With the rapid adoption of 4G, we expect greater proliferation of cloud-based services. Application management becomes a critical component for the success of cloud services. So why is the application level so important? Simply put, the application level is where the customer spends all its time using the solution. The application is where the customer is making transactions and if the customer is not happy at this level, then the customer will not be satisfied. A cloud provider will have to keep the demands of the customer in mind when creating application-level service level agreements (SLAs), this will be a key differentiator.

Applications in the cloud have to perform reliably, be cost-efficient and allow scalability and flexibility while working in a multi-tenant environment. However, the application layer can be complex in that it entails layers of both applications and business logic. Additionally, this architecture is run on virtualized systems and, with billions of business transactions being processed, it is inevitable that there may be issues/errors. So, the key will be use advanced analytics in order to create and monitor application-level SLAs with these possible issues in mind. Quality application-level SLAs must keep in mind the high expectations of the cloud customer

whose demands are constantly increasing. However, because of the potential issues as mentioned above, creating application SLAs can be challenging. The key to fulfilling SLAs in cloud environment will be the careful monitoring of the application layer. APM allows application monitoring via dashboards in real-time and enables cloud providers to observe applications running on their network. As a variety of applications with varying degrees of quality expectation, sensitivity to latency, capacity and complexity all migrate to a single set of IP pipes, operators must have granular network-facing application awareness, as well as subscriber-facing service awareness. This means visibility into Session Initiation Protocol (SIP) servers, application servers, performance and transaction management relating to BOSS systems and transport-layer network elements. As network capacity constraints become increasingly dire, matching the proper levels of quality and service expectation to each individual application will become increasingly important. Again advanced analytics coupled with real-time data warehouse solutions will play an important role by tying this disparate information, correlating those in real-time allowing operators to take pre-emptive actions in order to deliver on expected QoE.

Real-time IP service assurance. Advanced analytics will be the key foundation block enabling real-time service management: As service providers move into the next phase of build-out of their IP networks to launch 4G by adding scale and new applications, the development of a good service assurance program based on advanced analytics is imperative. Many are recognizing the need to focus on subscribers to ensure that whatever service assurance platform they choose provides value to the customer. Service management system development will vary depending on the type of service provider, but some of the key characteristics that are considered include:

- Real-time and historical analysis of services offered
- A combination of active and passive monitoring solutions
- The ability to gather information on signaling, including how calls are set up, the percentage of completion, etc.
- The ability to analyze traffic delivery in detail, including by class of service (CoS) and end-to-end
- The ability to gather information about various media, including how the network is supporting calls, videos, etc.
- Negative testing in the lab to ensure that applications won't fail when problems occur in the network
- Deep understanding of content, such as whether its quality is as good at the core as it is at the endpoints, and why
- A method for cleanly showing service quality, both at an aggregate level and at a service level
- A scalable and flexible solution that allows for growth and the introduction and support of new technologies
- Coverage from the core of the network to its edge
- Device agnosticism, permitting development of a network that supports many different vendors' solutions to permit selection of the best of breed
- The ability to cost-effectively segment and locate problems in the network to solve them

In the context of IP service assurance areas where role of advanced analytics is extremely critical are:

- **Cross-layer correlation.** Automatically correlating the session, the network topology and the media statistics for each session in real time as it is in progress provides service assurance solutions with real-time path analysis for each session. This path analysis provides hop-by-hop visibility into the dynamics of real-time sessions as they transit the network. For each session, the operator can see the path it took, as well as any performance degradations caused by congestion, routing events or QoS failures. Such automated and correlated root-cause analysis is critical to IP assurance solution and will need to have an underlying advanced real-time analytics fabric. It helps in identifying the reasons for failure of service objectives and quickly localizes network resources and subscriber services degraded by network events so that corrective measures can be taken rapidly.
- **Historical playback.** IP assurance solutions require session path analysis for services occurring in real time and for those that occurred in the past, for monitoring the service state and for troubleshooting previously impaired sessions. Traditionally, detecting and isolating problems that have already occurred meant recreating the problem during the troubleshooting phase – a process that is extremely difficult in routed networks because the network maintains no record of past traffic. IP assurance's ability to perform historical "playback" of the sessions and the associated network events enables solution of the problem without the need to recreate it.
- **Real-time KPI and alarming.** IP assurance solutions must also be able to monitor the network and generate alarms and KPIs to gauge the overall network performance. IP assurance solutions must capture a variety of information from the sessions, the network and the media and correlate them to produce specific KPIs that can be used to generate alarms and network health indications based on operator-defined thresholds.

Real-time capacity management. Capacity management will be a critical issue in 4G networks. Network operators need to plan, adjust and load balance their network. This needs to be done in advance of new service introductions (and indeed operators are already increasing the capacity of their backhaul networks in anticipation of further data surges caused HSPA network rollout). As services are introduced, however, and as self-optimizing wireless networks will be readjusting themselves constantly, operators will also need to undertake pro-active real time analysis of their capacity assets and loading. They will need to receive feeds from network inventory, activation and other operation support systems (OSS), traffic data from Deep Packet Inspection (DPI) systems, routers and switches and network management systems. Based on past capacity utilization, marketing demand forecasts, as well as service consumption trends analytics solution can provide network operations the tools to efficiently plan, process and predict network growth. As services are introduced, and as self-optimizing wireless networks readjust themselves constantly, operators will be forced to undertake pro-active real time analysis of their capacity and have the right tools and insight to mitigate RAN, access and core network congestion. Advanced real-time solutions are needed that can play pivotal role in this context by being able to receive real-time feeds from network and business support systems (BSS)/OSS and

adjust customers' services, rate plans, tiers, etc., so as to help operators maximize revenue from network assets.

Real-time offer management, customer loyalty, personalized promotion & effective campaign management. In an increasingly competitive market, marketing campaigns need to be more focused and influence buyers with targeted offers. Campaign management must involve analytics to confirm which promotions are successful. Next-generation BSS vendors need to provide not only a dynamic (real-time or near-real-time) offer management capability based on subscriber network usage, but also traffic-based promotion, loyalty points, event-based promotion and rules-based promotion. Promotional offers for early adopters, cross-product promotions, loyalty will be critical in driving value-added services (VAS) adoption, which will be provided by operator themselves or by partnering with over-the-top (OTT) players. Operators should evaluate their options on how to provide loyalty points to customers based on their total spending or spending on specific services. Insight into effectiveness is essential for gaining and retaining profitable customers. Companies are starting to look outside of their existing customer base to determine the profitability of prospective customers. These efforts revolve around using customer profitability analytics strategies to optimize value-driven marketing and sales activities. Companies also need to tailor pricing appropriately to strategic customer segments for both new and renegotiated contracts. Advanced analytics based pricing strategies help to assess the different combinations of customers, products and offerings. Customers need their providers to commit to better offers and interactions for high-quality products and services. One obvious key factor here is agility as differentiating and building a competitive edge in communications industry demands quick time-to-market changes. Fast translation of advanced analytics results into operations will make a timely and sizable difference when acquiring new customers and reducing attrition risks with informed interactions. Customer profitability based advanced analytics strategies, strategically leverage all data directly or indirectly related to customer demographics and behavior to adeptly understand and improve customer profitability without undermining core business objectives or processes.

Spotlight: Ericsson ENIQ. Ericsson has created ENIQ Analytics, where OSS and BSS merge to create value that customers can experience. This means one system that covers from data collection all the way to the improved user experience. The strength of ENIQ Analytics based on Sybase IQ, is that operators can deliver the services that their customers expect and value, with greater confidence. It is not a substitute for the creative and innovative people who conceive, shape and craft service offers but the ability to filter your data more effectively to understand your customers' wants and needs.

With ENIQ Analytics you know what is possible to deliver and are able to monitor what you actually do deliver. With such self-knowledge, self-awareness and assured confidence you decide what to promise and offer. You will still need to be creative, innovative and hard working to shape your offers but the combined OSS/BSS analytics will help you in very near real time to see real world changes in your data. By identifying who was impacted and how, you can take the appropriate actions.

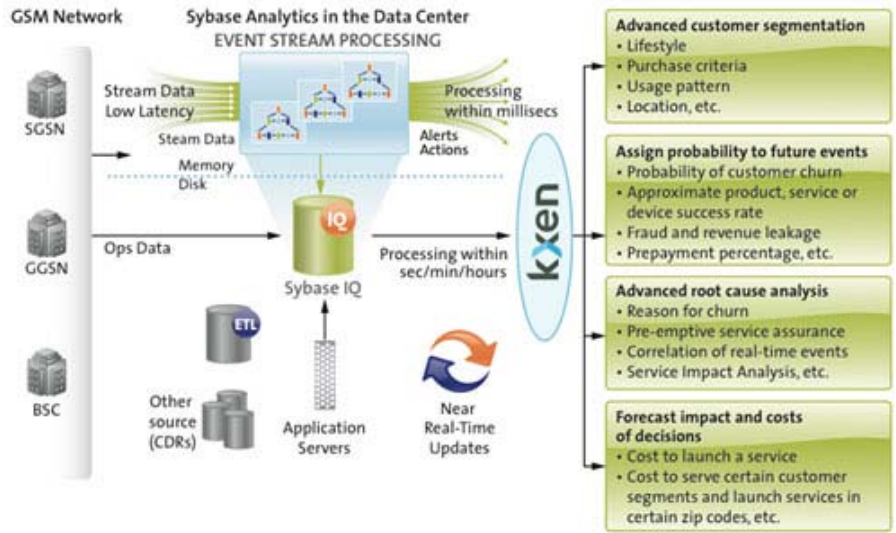
Social network analysis. The concept of social network analysis (SNA) is becoming extremely popular among wireless operators. This concept will play a critical role as operators rollout their 4G strategy. SNA examines customers' social habits and

usage to get an under-standing of all these customer care elements. This helps to stifle churn and lets CSPs analyze CDRs to identify calling patterns and the influencer in a specific social group. If that influencer churns, what happens to the rest of that social circle and how likely is it that they will churn, as well? After determining the customers they want to actively keep, CSPs must execute compelling marketing campaigns and offers to communicate with potential churners within 48 hours of the influencer's churn event. The churn event for the rest of the social circle typically occurs within four to seven days after an influencer leaves for another provider, so time is of the essence when providing proactive retention offers or general communications to potential churners. Identifying calling circles and communities based on CDRs is a first step, but it isn't the last step when it comes to the next generation of churn reduction. Before sending an offer to a potential churner, CSPs must incorporate additional data feeds to identify customer management KPIs through analysis, handset analytics, customer satisfaction and network performance, to name a few. SNA can then be extended beyond churn reduction to actual revenue generation by identifying which customers are best targeted for new product adoption. By helping target influencers, SNA helps CSPs overcome the challenge of viral marketing or "word of mouth" promotion of new products. The algorithm used in SNA helps analyze who is most likely to influence and spread the word of new products causing a ripple effect and viral spread of a CSPs new product or service. This effective pinpointing of influencers helps to optimize viral marketing efforts making the whole process more efficient and cost effective.

Spotlight: Sybase advanced analytics and KXEN. Sybase advanced analytics solutions combine Sybase ESP real-time monitoring, in-database analytics and large-scale data management. The Sybase ESP analyzes high volumes of live data streams contained in systems such as routers and network switches. Sybase IQ mines massive amounts of data found in CDRs, and processes answers in seconds. The goal of this speed is to allow for a real-time aspect that supports a more intelligent service delivery approach that is needed in SNA. Sybase IQ includes the PlexQ Distributed Query Platform (DQP), a Massively Parallel Processing (MPP) architecture that accelerates highly complex queries by distributing work to many computers in a multiplex grid configuration. Unlike shared-nothing MPP architectures, PlexQ utilizes a shared-everything approach that dynamically manages and balances query workloads across various compute nodes. PlexQ DQP can improve the performance of a query by breaking it up into pieces and distributing those pieces for concurrent execution across multiple server nodes.

Sybase advanced analytics handle the data infrastructure, but predictive analytics and models are needed to complete the real-time analytics architecture. KXEN, a Sybase partner, helps CSPs use predictive analytics to make decisions, especially in the area of SNA. KXEN's predictive analytics platform, called InfiniteInsight™, extracts the data that is stored in Sybase IQ and Sybase ESP to provide SNA. With this architecture, CSPs can scale their SNA environment to support tens of thousands of users, hundreds of terabytes of data and concurrent mixed workloads – without any reduction in data loading and query performance.

Figure 4: Real-Time Customer Intelligence Architecture



Mobile analytics. 4G is all about connectivity, video based services and speed. Rapid deployment of 4G will act as harbinger of mobile broadband and catalyze proliferation of various types of mobile devices. Mobile analytics will play a significant role in answering various questions of service providers, including how many people use particular operating systems, the types of devices they use, how long they spend on sites and more. One significant advantage of mobile analytics over standard Web analytics is that it provides location-based data. Standard Web analytics only provides a general location of visitors. Mobile analytics provides much more precise information, enabling service providers and site owners to better target users. Mobile is a social tool – always on, always with the user. As such, understanding the consumer is paramount; it is not just about counting impressions, clicks and page views. Without mobile analytics, mobile campaigns and applications effectively are running blind.

Developers can utilize mobile analytics to gain insight on how their mobile applications are performing, who their users are and how much ad revenue they are generating. Other benefits of mobile analytics include:

- Measuring the mobile channel as part of the total online marketing budget
- Optimizing mobile websites or mobile applications to improve engagement and conversion levels
- Justifying marketing spend on mobile initiatives
- Accurately measuring usage trends
- Gaining feedback on marketing campaign performance and insight into consumer needs
- Enabling operators to intelligently personalize tiered pricing plans to better meet subscribers' needs, while increasing average revenue per user (ARPU)
- Generating a new revenue stream from ad networks and third parties

Spotlight: Sybase Operator Analytics 365. Sybase Operator Analytics 365, an advanced reporting, monitoring and mobile data analytics service, has been deployed to more than 50 operators worldwide and it anticipates working with more than 90 operators. Sybase Operator Analytics 365 is backed by Sybase IQ, enabling extreme performance with the ability to return results on billions of records in just seconds to enable operators to quickly make mission-critical decisions. With the continued growth of mobile messaging data, operators need greater visibility into their network and inter-operator messaging traffic. Sybase addresses this requirement by providing operator customers a cost-effective, hosted solution allowing real-time deep analytics so they can make informed decisions about their network activity, location-based data, available resources and ultimately drive revenue.

There are several unique capabilities that Sybase Operator Analytics 365 provides because it is a totally hosted environment; customers don't have to make that infrastructure investment in place on their own. It also provides them with both a real-time view of messaging traffic, as well as the historical data that is collected and stored about that traffic. Providing ease-of-use and efficiency, the service can be deployed with minimal effort and allows mobile operators the ability to run intensive analytics on their messaging traffic, deliver the data necessary to better understand their messaging operations, improve QoS and save money by reducing customer support costs. Faster, easier access to data means that problems can be identified, diagnosed and resolved more quickly, helping mobile operators improve QoS.

Conclusions

Operators face some fundamental challenges relating to an increase in capex and opex, and they have to balance cost with their revenue expectations. Key challenges for operators that are centered on LTE deployment are:

- Balance investment between existing HSPA+ networks and deploying LTE technology during the next two years
- Phase in next-generation, IP-based LTE technology into existing HSPA+ RAN, packet core and backhaul
- Converge 3G HSPA+ and LTE commercial networks leveraging single RAN multimode base stations
- Leverage LTE technology to rapidly deliver affordable and scalable broadband networks nationwide especially in rural areas
- Cost-effectively add LTE TDD to an existing WiMax network leveraging the same 2.5/2.6 MHz spectrum
- Develop a business case with a low TCO and a near-term ROI based on new MBB services enabled LTE

Accurate capacity planning and streamlined network resource optimization will be critical for operators to manage their opex costs. Advanced analytics will play a very central role arming operators with the right tools to make intelligent and cost effective decisions around planning and build out. In an era of 4G it will also be critical for service providers to be able to tap into and make informed decisions based on their subscribers' context and usage information. Real-time BI and advanced analytics will play a pivotal role as it will help service providers to not only process and correlate event stream processing, but also use advanced analytics modeling techniques to gain the best insight into customers' behavior in order to provide personalized offers, run focused campaigns and targeted customer loyalty programs.