Improving Service Delivery and Customer Experience using Mobile Network Data Integrity and Analytics

WHITEPAPER

VERSION 1.0

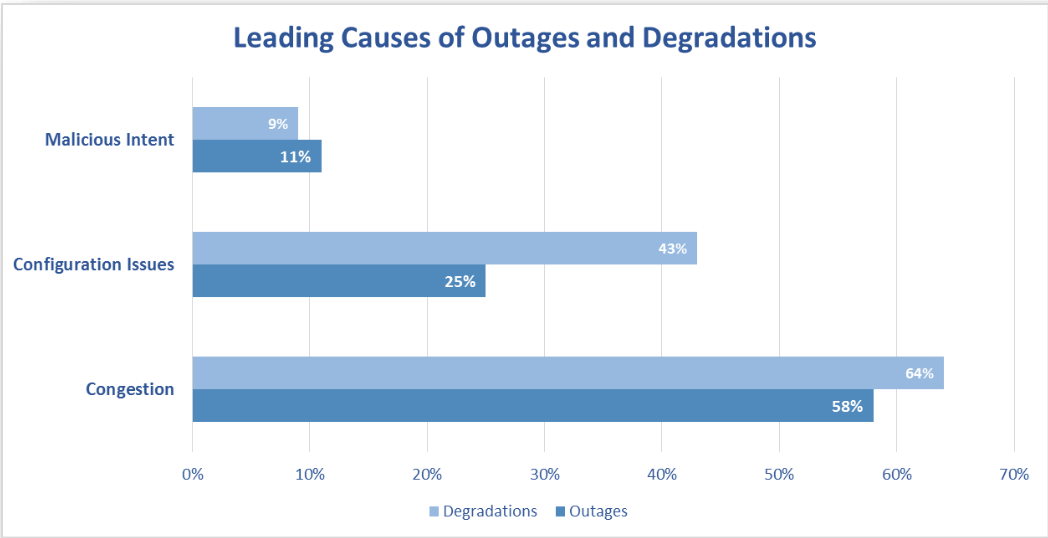
Navigating the Mobile Network Perfect Storm

Mobile service providers face growing operational challenges from new 3G, 4G and 5G technologies and massive radio access network expansion from small cells. Backhaul complexity has increased dramatically with the transition to Ethernet/IP. New business models resulting from Machine-to-Machine (M2M), Internet-of-Things (IoT) and Network Function Virtualization (NFV) further complicates operations while increasing customer expectations increases service assurance challenges. Operators are racing to introduce new services, maintain network quality, and improve costs. Moreover, network and service quality is directly linked to customer loyalty and operational efficiency is directly linked to profitability.

Mobile Operators spend ~$15B annually dealing with outages and degradations. This equates to roughly 1.5% of annual revenues. Globally, mobile operators experience approximately five network outages or degradations per year, or one every one to two months. The majority of these outages do not impact the entire network and can last 0.5 and 4 hours. In fact, 30% of outages or degradations last 1-2 hours. In developing markets, 43% of outages last 2-4 hours compared to 8% in mature markets

Configuration related issues are the cause for over 40% of outages and degradations, accounting for 25% of all outages and 43% of network degradations. A large percentage of congestion/overload scenarios are also as a result of poor or outdated network configurations. Some analysts, such as the Yankee Group have attributed 62% of network downtime to be the result of misconfigurations.

FIGURE 1: MOST COMMON CAUSES OF MOBILE OUTAGES AND SERVICE DEGRADATIONS



Sources: HeavyReading, Netscout

Significant Business Impacts – Why This Matters

Subscriber churn is single biggest cost associated with network outages and service degradations. The impact is larger in developing markets. Globally, network quality is the 3rd most contributing factor to churn. Faced with increased competition from other operators, over the top providers, and more demanding subscribers acquiring and retaining customers is critical. Existing customers spend more, purchase higher margin products and services, and are more likely to refer additional customers. It costs an average of $250 for a mobile operator to acquire a new customer in developed markets. Many operators are losing around a quarter of their customers annually and so it is not uncommon to have to wait more than 12 months to break even on a customer. For a typical mobile operator, a monthly 2% churn rate means average customer life time of 50 months. If average revenue per user (ARPU) close to $30/month, the average lifetime value per customer is around $1500. Decreasing churn means increased lifetime and value. A 5% increase in customer retention has been shown to translate into between a 25% and 55% increase in profitability. For example: assume a mobile operator with 1.5 million net additions in the year, ARPU of $39 and a 3.5% quarterly churn rate. Decreasing churn to 3% would deliver an additional $40M of revenue and $22M profit in just 36 months.

It is important not to overlook backhaul network performance and quality. Inadequate backhaul capacity and poor quality backhaul are responsible for approximately 50% of network performance problems. Poor network service is responsible for 14 – 40% of churn depending on the operator. Strategy Analytics estimates that investment in better backhaul could reduce a Mobile Operator's churn rate by between 4% and 7% depending on the Region – a net reduction in churn of 1.2% to 2.1%. Need for more dynamic network reconfiguration to share (and steer) traffic load across multiple network links as traffic fluctuates - to ensure consistent Quality of Service (QoS) for end users.

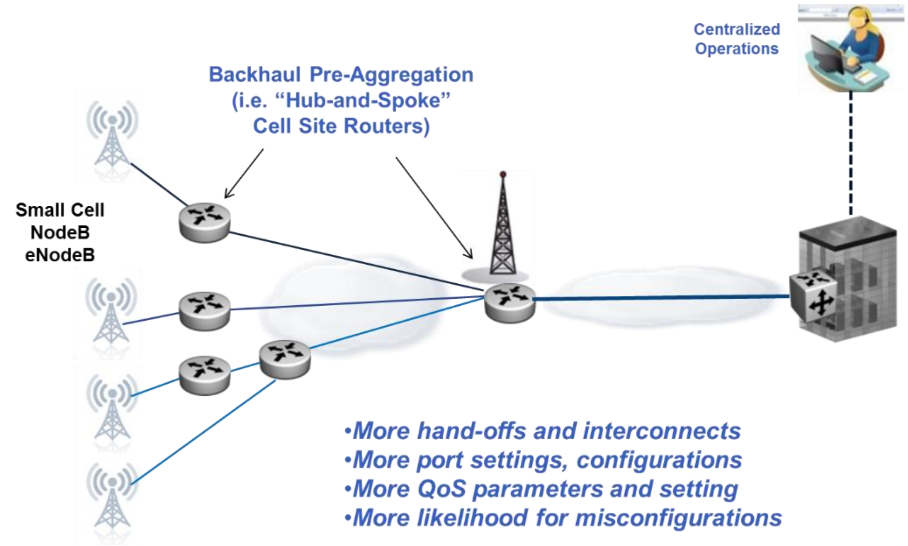
Mobile operators incur also high operational costs troubleshooting network configuration issues which are causing outages and degradations. Pinpointing the location and specific misconfigured parameter is time consuming, and usually requiring skilled, high cost network support personnel. Because service issues span multiple technologies, such as RAN and backhaul networks, often multiple subject matter experts are required.

Growing Mobile Network Complexity

The introduction of small cells increases network complexity and increases likelihood of network outages and degradations. Small cells introduce additional end points, deeper in the network and closer to subscribers, and for which backhaul networks need to be activated, monitored, optimized, and assured. In addition, there is a resulting need by mobile operators to audit the ongoing performance of backhaul services to ensure performance guarantees are met not only initially, but throughout the service lifecycle as backhaul-network demands evolve. This is both to ensure optimal network performance and to seek remuneration from backhaul providers in the event of SLA violations.

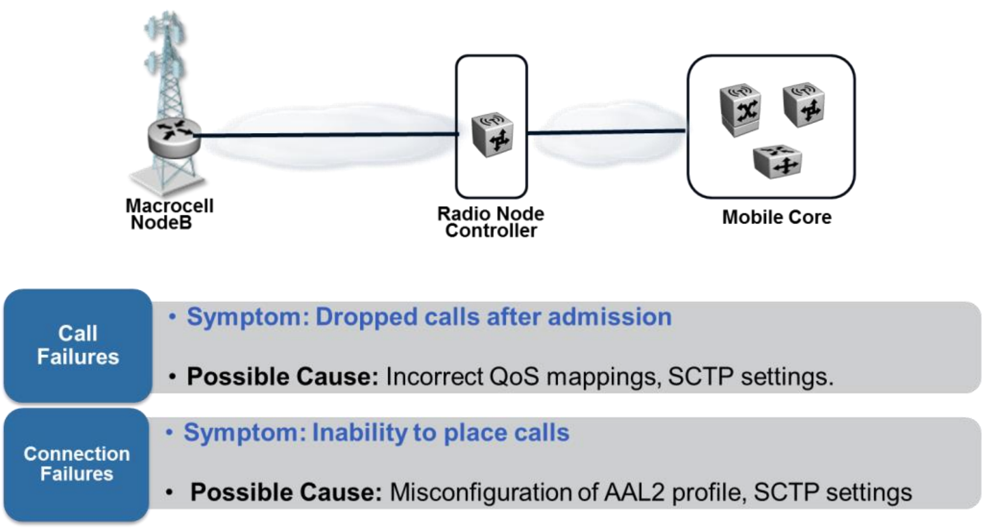
Small-cell backhaul introduces additional layers of aggregation in the backhaul network, creating hub-and-spoke topologies. Traffic is backhauled from outdoor small cells (spokes) to an aggregation point (a hub, often located at an existing macrocell) where it is combined with backhaul traffic from other spokes, aggregated, and backhauled to another aggregation point typically at a mobile switching center (MSC) or mobile core. Multiple hand-off points mean multiple service mappings/translations and potential for configuration errors.

FIGURE 2: COMPLEX MOBILE BACKHAUL NETWORKS



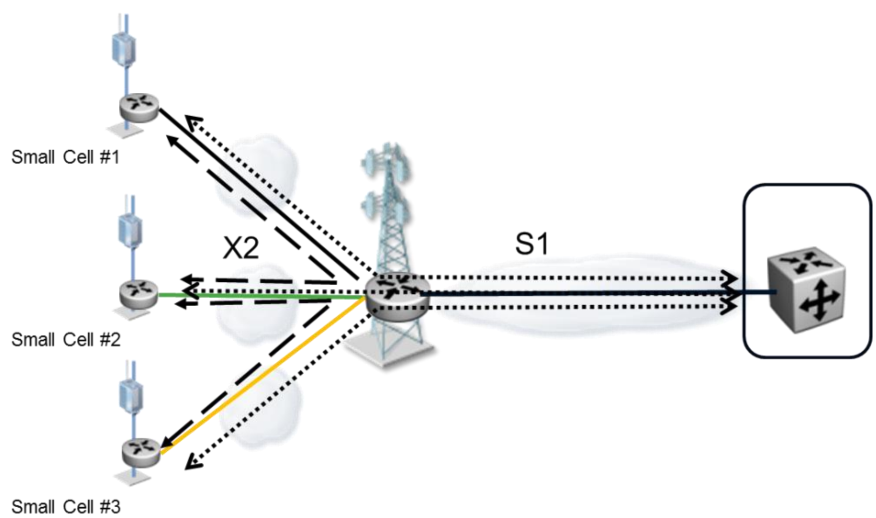
3G and 4G radio access networks, and the associated IP-based networks, are increasing in complexity. In 3G Networks, IuB congestion is the cause for the majority of outages or degradations. ATM is used to carry voice and data from cell sites to switching centers. The ATM Adaption Layer 2 (AAL2) and ATM Adaption Layer 5 (AAL5) carries control and user information. Depending on the volume of traffic per service or RAB (radio access bearer), certain QoS could be congested at the AAL2. All Radio Access Bearers are configured to use Class A or Class B. These are mostly impacted by congestion. Most of the time Class B is the first QoS to get congested leading to failures. After admission events, Iub congestion could also be caused by misconfiguration of AAL2 profiles at the Node B or Radio Node Controller (RNC).

FIGURE 3: 3G MOBILE NETWORK PAIN POINTS



4G/LTE introduces additional unique challenges such as increased signaling traffic. Signaling protocols, such as S1 and X2 which are needed for call set up and inter eNodeB handoffs, are sensitive to network performance such as packet loss, jitter, and latency. LTE networks are complex, and as a result configuration parameters must be precise in the RAN as well as the backhaul network. LTE's all-IP architecture creates complex quality of service (QoS) mappings and dependencies.

FIGURE 4: 4G/LTE SIGNALING COMPLEXITY



The Stream Control Transmission Protocol (SCTP) plays a crucial role in enabling signaling in both 3G and 4G networks. Advanced devices and applications are consuming more signaling resources and affecting signaling plane throughput. Meanwhile increasing numbers of connected devices and base stations limit scalability because each connection requires significant signaling capacity. It is important that SCTP configurations are properly tuned in order to achieve optimal performance. In 3G networks, Iub congestion is often caused by route flapping in the IP backhaul network. This has been linked to different elements being set with different SCTP parameters. A mismatch will cause unnecessary retransmission, which will cause congestion during high-volume traffic. This type of error will only occur under high traffic and would not be detected until network performance and customer experience is impacted, or unless a network data configuration audit has been performed.

With the introduction of Voice over LTE (VoLTE), a 10-fold increase of signaling load on the control plane. With the addition of non-voice application services such as streaming video and online gaming, the signaling load increases further making it vital that SCTP parameters be properly configured throughout the network. With the all-IP nature of LTE, flow-based QoS informs network resources of quality requirements to ensure call quality. With voice services now sharing the data pipe with other data services like web browsing, video streaming, and social media, the ability to manage the speed, quality, volume and diameter signaling associated with VoLTE is critical to providing a positively differentiated experience.

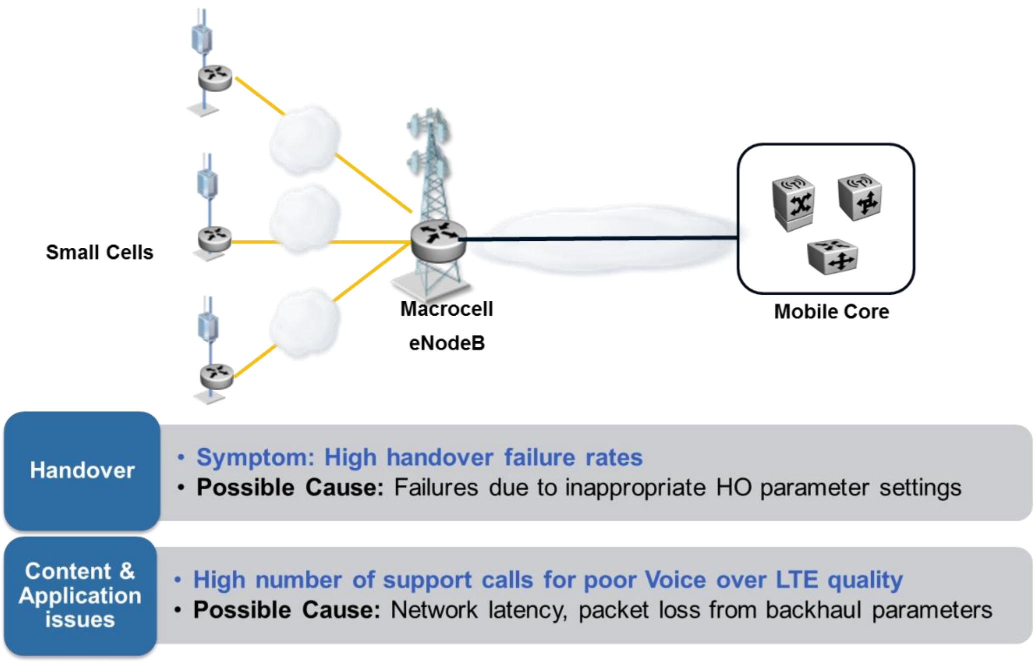
In LTE, the QoS Class Identifier (QCI) helps ensure that that bearer traffic is allocated the appropriate Quality of Service (QoS). Different bearer traffic requires different QoS and therefore different QCI values, with 9 different QCI values currently specified. The relationship between LTE QCI and other priority mappings is shown below.

FIGURE 5: 4G/LTE QUALITY OF SERVICE MAPPINGS

LTE QCI	VLAN PCP	MPLS TC	IP DSCP	802.1	Traffic Type
-	7	7	56 (CS7)	7	IEEE 1588 (PTP)
-	6	6	48 (CS6)	7	(not used)
1	5	5	46 (EF)	6	Voice chat (VoLTE)
5	4	4	34 (AF41)	5	Signaling (EPC/IMS)
2	3	3	26 (AF31)	4	Video chat
7	2	2	20 (AF22)	3	Video streaming
-	1	1	10 (AF11)	1	OAM
8/9	0	0	0 (BE)	0	Data/Default

Each QCI value has a unique profile in terms of maximum delay and packet loss. As packets traverse networks, QCI values have to be mapped correctly to Layer 2 and Layer 3 QoS settings supported by the network devices in the RAN, backhaul, and mobile core. Common configuration related issues include unexpected QoS combinations based on equipment variations. For example, timing protocols such as IEEE 1588 may use IP DSCP CS7 but not VLAN priority bit 7. Similarly, incorrectly classified traffic could result in increased latency, packet loss and jitter, which results in eroded application performance leading to poor customer experience. Key configuration parameters include Committed Information Rate (CIR), queues, and Committed Burst Sizes (CBS) buffers. Unexpected VLAN ID combinations could cause packet loss scenarios, while incorrect port settings like duplex settings and maximum transmitted units (MTU) settings all may contribute to poor network and service quality.

FIGURE 6: 4G/LTE MOBILE NETWORK PAIN POINTS



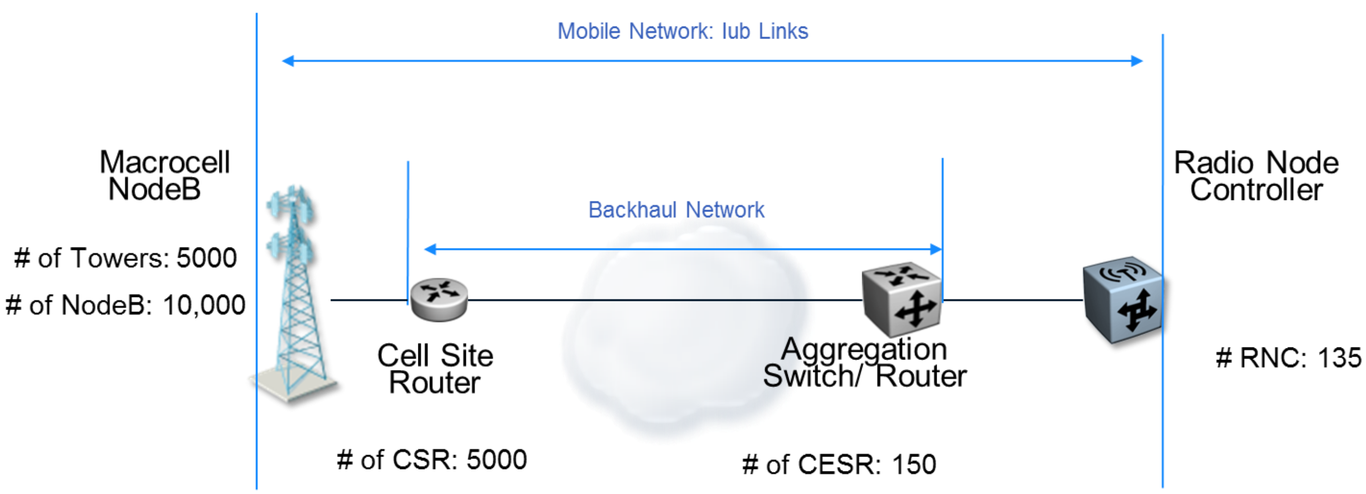
Growing Cybersecurity Risks

A 2009 report from BT and Huawei suggests that human factors, either inadvertent or intentional are estimated to cause between 10% and 30% of network outages. A review of Annual Incident Reports published by the European Union reveals that 25% of reported incidents in 2013 were the result of human error or malicious actions. The report cites that incidents caused by malicious actions, had long recovery times (53 hours) on average resulting in 11,600 user hours lost. Configuration errors enable 65% of cyberattacks and cause 62% of infrastructure downtime according to a recent article published in Network World. Another separate report by BT and Gartner estimate that 65% of cyberattacks exploit systems with vulnerabilities introduced by configuration errors. Moreover, most operators do not correlate the relationship between malicious attacks and outages. The all-IP nature of modern mobile networks creates an expanded attack surface to exploit security vulnerabilities. Often these vulnerabilities are the result of misconfigured network security policies.

Analysis from the Field

Data analytics from Nakina's work with a national mobile operator suggests that network configuration issues contribute significantly to operational costs and impaired network performance. Serving approximately 40 million 3G mobile subscribers, the operator maintains a network of approximately 10,000 NodeBs and from approximately 5000 mobile towers. Each macrosite serves on average approximately 4000 mobile subscribers. On average, two NodeBs share the same tower, and so 5000 cell site routers (CSRs) are deployed for backhaul to radio node controllers (RNCs). Approximately 150 backhaul aggregation carrier Ethernet switch routers (CESRs) are used to aggregate backhaul traffic from the 5000 CSRs. The mobile operator has implemented approximately 135 RNCs network-wide, each supporting approximately 75 NodeBs.

FIGURE 7: EXAMPLE 40 MILLION SUBSCRIBER 3G MOBILE NETWORK



Nakina's NI-CONTROLLER network data integrity and analytics solution audits close to 10,000 Iub links between NodeBs and RNCs. Over 27 million configuration parameters used in over 15,000 network elements from multiple equipment suppliers, spanning mobile and backhaul networks are collected, analyzed, and compared to gold-standard definitions. Over 2 million of these parameters are associated to Iub links. Analytics identifying parameter misconfigurations helps the mobile operator correlate customer experience trouble tickets and prioritize remediation actions.

Virtually all of the service paths between a NodeB and RNC, including the CSR and aggregation CESR, included misconfigured parameters. Because Iub congestion is the leading cause of 3G call admission failures or drops, by analyzing critical service affecting parameters more closely reveals that of the roughly 155,000 SCTP parameters, 4% (roughly 6200) were misconfigured. Approximately 40% of Iubs from a single RNC included at least one misconfigured SCTP setting, potentially causing intermittent performance degradations in 30 of the 75 NodeBs served by that RNC, or roughly 120,000 subscribers. Assuming a number of NodeBs are serving high value regions, such as business districts, government locations, and affluent regions, network performance degradations may result in higher customer churn and associated loss revenues. Network wide, this equates to 16.2 million subscribers, or 41% of total, potentially impacted by SCTP misconfigurations.

Backhaul network misconfigurations are equally probable and problematic. For instance, misconfiguration of QoS settings were commonplace. As latency sensitive, real-time interactive mobile applications increase, QoS misconfigurations in the backhaul factor heavily into poor application performance and customer experience. Part of the mobile operator's equipment commissioning process is to disable Telnet and other settings to reduce the potential for unauthorized network access. Interestingly, 95% of the CSRs deployed exhibited incorrect security parameters, namely involving Telnet being enabled. Given increasing public awareness to cyber security risks and breaches, weak security policies also affect consumer perception and increases churn risk.

Measurable Business Benefits from Customer Retention

Automated analysis of configuration and service parameter anomalies can dramatically improve resolution of incidents and visibility into network deployment. Data-driven analytics helps prioritize remediation, allowing operators to focus resources and attention appropriately. This insight enables operators to predict and proactively refine network configurations (such as SCTP settings) to drive maximum network stability and performance. By improving quality, operators can ready networks for new, revenue generating services such as voice and video over LTE, while reducing customer churn to preserve revenue.

Consider the following scenario as an example: a mobile network operator with 40 million subscribers generating an average revenue per user (ARPU) of $40/month experiences high customer churn at a rate of 3% annually as a result of poor network quality, leading to poor customer experience. Using industry typical assumptions for cost per gross add (CPGA) and blended cash cost per user (CCPU), the life time value (LTV) of mobile subscribers can be calculated using a three year period.

FIGURE 8: REVENUE IMPACT FROM HIGH CUSTOMER CHURN RATE

Mobile Customer LTV		Year 1	Year 2	Year 3
Customers		40,000,000	38,800,000	37,636,000
Churn Rate		3.0%	3.0%	3.0%
Retention Rate		97%	97%	97%
Blended ARPU (month)		$40	$40	$40
Revenue (annual)		$19,200,000,000	$18,624,000,000	$18,065,280,000
CPGA (annual)	$ 250	$ 10,000,000,000		
Blended CCPU	$ 23.00	$ 11,040,000,000	$ 10,708,800,000	$ 10,387,536,000
Database Marketing (annual)	$ 0.50	$ 20,000,000	$ 19,400,000	$ 18,818,000
Total Other Marketing (annual)	$ 1.50	$ 60,000,000	$ 58,200,000	$ 56,454,000
Total Cost		$ 21,120,000,000	$ 10,786,400,000	$ 10,462,808,000
Gross Profit		($1,920,000,000)	$7,837,600,000	$7,602,472,000
Discounted Rate		0.00	0.30	0.30
NPV - Gross Profit (000's)		($1,920,000,000)	$6,028,923,077	$5,848,055,385
Cumulative NPV - Gross Profit (000's)		($1,920,000,000)	$4,108,923,077	$9,956,978,462
Mobile Customer Lifetime Value		($48.00)	$105.90	$264.56

By implementing network data integrity auditing and analytics, the service provider can both ensure the quality of new network expansions as well as improve the quality of existing networks, addressing both RAN and IP backhaul networks. Reducing customer churn rate from 3% to 1.5% over 3 years by eliminating service quality issues caused by network misconfigurations, the mobile operator can preserve over $140M in revenues over this period, while reducing operating costs.

FIGURE 9: REVENUE IMPACT FROM HIGH CUSTOMER CHURN RATE

Mobile Customer LTV Calculator		Year 1 - Acquisition Year	Year 2	Year 3
Customers		40,000,000	38,800,000	38,024,000
Churn Rate		3.0%	2.0%	1.5%
Retention Rate		97%	98%	99%
Blended ARPU (month)		$40	$40	$40
Revenue (annual)		$19,200,000,000	$18,624,000,000	$18,251,520,000
CPGA (annual)	$ 250	$ 10,000,000,000		
Blended CCPU	$ 23.00	$ 11,040,000,000	$ 10,708,800,000	$ 10,387,536,000
Mobile Data CCPU	$ -	$ -	$ -	$ -
Pre-paid CCPU	$ -	$ -	$ -	$ -
Database Marketing (annual)	$ 0.50	$ 20,000,000	$ 19,400,000	$ 18,818,000
Total Other Marketing (annual)	$ 1.50	$ 60,000,000	$ 58,200,000	$ 56,454,000
Total Cost		$ 21,120,000,000	$ 10,786,400,000	$ 10,462,808,000
Gross Profit (000's)		($1,920,000,000)	$7,837,600,000	$7,788,712,000
Discounted Rate		0.00	0.30	0.30
NPV - Gross Profit (000's)		($1,920,000,000)	$6,028,923,077	$5,991,316,923
Cumulative NPV - Gross Profit (000's)		($1,920,000,000)	$4,108,923,077	$10,100,240,000
Mobile Customer Lifetime Value		($48.00)	$105.90	$265.63
Delta Improvement - Cumulative Gross Profit (NPV)		**$0**	**$0**	**$143,261,538**

Significant Operational Savings and Efficiencies Possible

As misconfigurations are the root cause for between of 25% to 40% of service degradations or outages, a key first step in the troubleshooting process is to collect network configuration data. Multiple network devices, both physical network elements such as eNodeBs and cell site routers as well as virtual network functions like virtual evolved packet cores are part of the service delivery network. Typically, service delivery networks span multiple technologies and vendors, As such, specialized Tier 2 or 3 vendor and/or technology support engineers to access, collect and analyze configuration data. Industry benchmarks of the average cost per trouble ticket, vary greatly with Tier 1 support being most cost-effective with vendor support being the highest. The time and cost associated with network configuration analysis is significant.

FIGURE 10: AVERAGE SUPPORT COSTS PER TROUBLE TICKET BY TIER

Support Tier	Cost per Ticket
Tier 1	$22
Tier 2	$62
Tier 3	$85
Field Technicians	$196
Vendor	$471

Sources: NetMetrics

Automated service-oriented network configuration auditing has the potential to significantly accelerate trouble ticket resolution rates, minimize troubleshooting time and reduce costs. If an operator's service and network operations center processes 20,000 trouble tickets annually, time required to collect and analyze parameters for the estimated 25% of issues attributable to network misconfigurations can easily average 4 hours per case. This this time reduced to 30 minutes and be performed by more cost-effective Tier 1 support personnel, rather than specialized subject matter experts, the mobile operator has the potential to save $1.6 million or more annually, or $5 million over 3 years.

FIGURE 11: SIGNIFICANT OPERATIONAL SAVINGS CAN BE REALIZED

Operations Costs	Assumptions	Total	
Annual Number of Service Center Calls		**20,000**	
Number of calls due to Network Config Issues (estimated)	**25%**	5,000	
Esimted Time Spent manually identifying, accessing and changing configurations (hours)	**4**	20,000	
Estimated loaded cost per engineer per hour	$85	**$ 1,700,000**	
Potential Savings with Automated Configuration Audits			
Estimated time with automated audits (hours)	**0.5**	2,500	
Estimated loaded cost per engineer per hour	$22	**$ 55,000**	**3 Year Savings**
Total Estimated Annual Savings		**$ 1,645,000**	**$ 4,935,000**

Improving Network Performance Service Delivery, and Revenues

Mobile service provides must improve operational efficiency, increase network performance, maintain secure networks, and enable new services. A service oriented view that spans the entire service delivery chain, including radio access and backhaul networks is essential. Solutions must provide data collection of run-time network parameters, deliver customized data analysis, and be able to pin-points details such as vendor, network element or function type. Detailed analytics outlining mismatched network and service configuration parameters, alerting network operators to potential service impacting conditions or incorrect network configurations unable to support existing, evolving or new service levels must be available.

Extending network behavior analysis to include security related events becomes increasingly desirable and necessary as IP continues to proliferate and networks become virtualized. By correlating real-time service performance, network parameter changes, and network access events, operators can determine not only which configurations may have changed, but when, by whom, and understand potential associated network performance impacts.

The need for network data integrity auditing and analytics only increases in importance with the continued evolution towards virtualized radio and mobile backhaul networks. Technologies such as Cloud RAN has the potential to improve mobile network efficiency and performance, but creates greater likelihood for performance impacting configuration mismatches and an expanded attack surface for security vulnerabilities.

By proactively auditing network configuration data at the time of new network commissioning and as part of a continuous operations best practice, operators can proactively identify misconfigurations and obtain data integrity analytics to optimized and network performance. This helps ensure networks are ready for VoLTE, video, and new services. Assuring network configuration integrity helps operators ensure service level agreements with subscribers and partners, such as over-the-top providers, can be achieved.