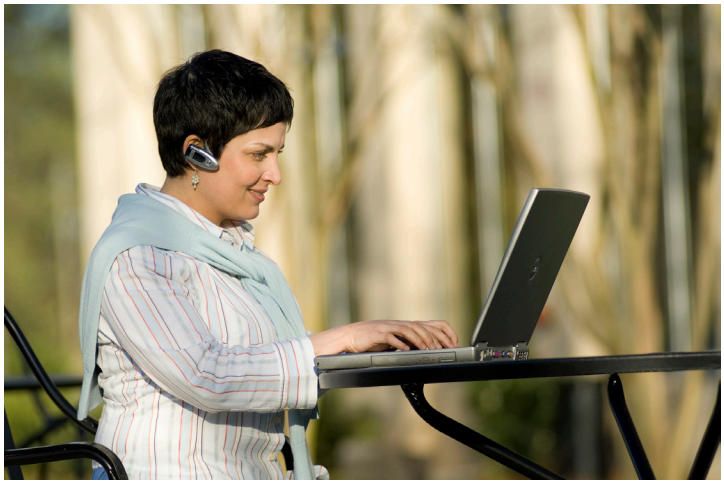
NORTEL

White Paper

The Evolution of the Wireless Packet Core

The availability of higher bandwidth wireless packet technologies coupled with competitive flat rate pricing is fueling an explosion in mobile broadband. As mass market broadband goes mobile, the impact to the underlying wireless core network is to demand the next generation of intelligent packet core technology. This new wave of packet core technology must provide a reliable, scalable, high density packet processing capability to meet the challenge of mass market adoption while reducing the overall cost of ownership for the operator. The new wave of packet core must also handle the complexities of multiple access technologies including seamless handover and mobility in order to meet wireless operators' demands for convergence, product consolidation and common end user service experience.

Nortel's new Advanced Telecom Computing Architecture (ATCA) based Access Gateway (AGW) is a common high density wireless routing and services platform that can be flexibly deployed as one or many of the key packet core functional elements. Configuration options range from next generation Serving GPRS (General Packet Radio System) Support Node (SGSN) and Gateway GPRS Support Node (GGSN) to the emerging Long Term Evolution (LTE) standardized functions such as Mobility Management Entity (MME) and Serving/PDN (Packet Data Network) Gateway. The same AGW can also be deployed to support non 3GPP access technologies such as WiMAX and WiFi. The porting of field proven SGSN and GGSN software onto Nortel's third party ATCA hardware provides a 'best of both worlds' solution that combines field hardened application software with leading edge Commercial Off The Shelf (COTS) hardware.



An explosion of mobile data

Global mobile data subscriber numbers show very strong growth

After a lackluster start, the number of users signing up for data service is now showing strong and explosive growth. Recent information from the World Cellular Database, March 2008 – Informa Telecoms and Media, shows that mobile data subscribers, excluding SMS only subscribers, has now exceeded 700 million globally, a number that has doubled in the past two years.

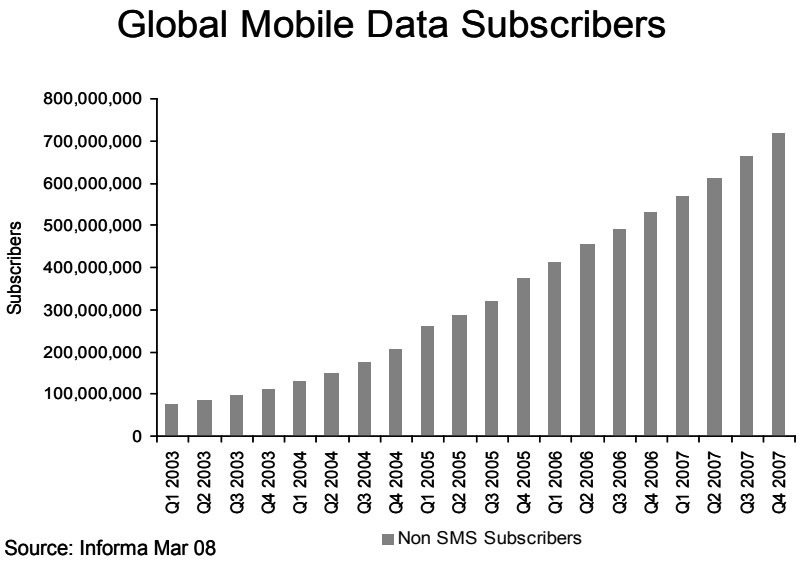


Figure 1. Explosive Growth of Mobile Data

Flat rate tariffs, PC cards and new radio technologies drive mobile data volumes

The widespread deployment of CDMA EV-DO in North America and the recent rollout of High Speed Downlink Packet Access (HSDPA) across Western Europe are leading to a significant increase in wireless data volumes both in terms of the total mobile data traffic as well as the monthly volume per subscriber. In addition to the increased availability of higher bandwidth wireless packet technologies, the increase in volumes can be attributed to the launch of 'all you can eat' flat rate pricing and the availability of affordable wireless pc cards. As an example, Vodafone UK reported a 56% rise in per subscriber Mobile Connect data Card (MCC) usage during 2006; attributed to the introduction of higher speeds and new tariffs.

Services such as Vodafone's MCC clearly signal the beginnings of a mobile broadband market. However, if the mobile broadband market is ever to obtain mass market adoption it must first move to a lower cost of ownership model. This is crucial to enable operators to price mass market mobile broadband attractively to a subscriber base that has become accustomed to competitively priced fixed broadband offerings. Equally as important to the overall business model is the need for operators to implement network infrastructure that can cost effectively scale to meet accelerating mobile broadband demand without simultaneously eroding operator revenues.

There are several different but often complimentary mechanisms for reducing the cost of ownership of a mass market mobile broadband service offering. A list of such mechanisms will typically include new and more efficient radio and core network technologies that utilize a flatter all-IP architecture, the restriction of low/no margin traffic types and the introduction of Femto cell technology that can reduce backhaul costs whilst cost effectively increasing radio coverage. In this paper, we will concentrate only on the packet core aspects and the key technology enhancements that constitute a new third wave of packet core technology as realized through Nortel's new Access Gateway platform.

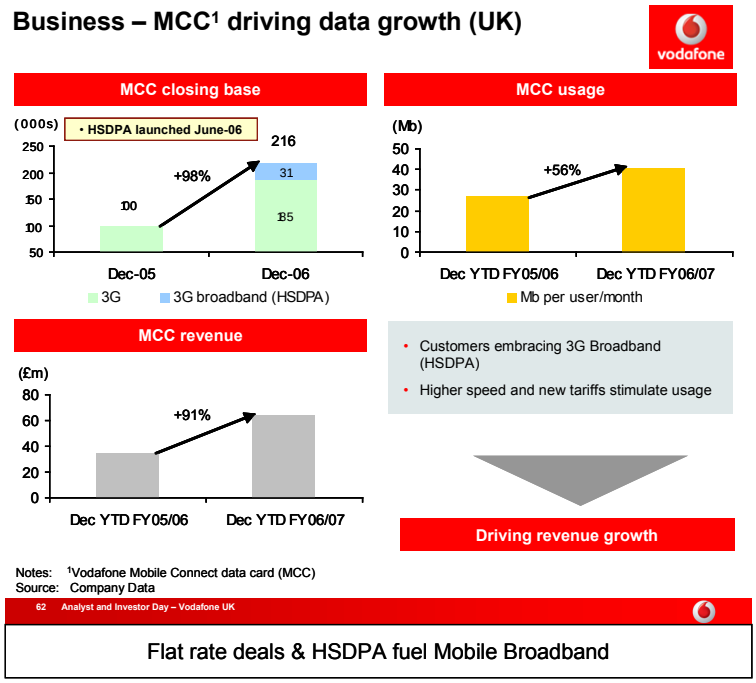


Figure 2. Services like Vodafone Mobile Connect data Card (MCC) show strong growth

An explosion of mobile broadband demands a 3rd wave of packet core products

The first wave of packet core

The initial wireless data service that was offered in the early days of GPRS can be characterized as a very low bit rate niche data service that can be considered as an adjunct to the main voice and text service offerings. The low number of data subscribers and the limits of 2G radios resulted in very low overall data traffic volumes that were insignificant compared to voice. This resulted in a first wave of packet core technology that used small scale enterprise class products that tended to be bundled with the sale of access equipment. The first wave of GGSN products did not contain significant features and services beyond basic mobility and connectivity. Services such as content based billing and security were implemented in separate adjunct 'Gi' boxes or were implemented by modifying the existing voice infrastructure, such as Intelligent Networks (IN) based prepaid, to also handle data. For Global Systems Mobile (GSM) operators the first wave of packet core was dominated by the leading GSM access vendors such as Ericsson, Nokia and Siemens.

The second wave of packet core

The promise of higher bandwidth radio technology (UMTS, EDGE) coupled with the pressure on operators to find new, non voice sources of revenue led to a second wave of packet core technology. The second wave of packet core can be characterized by higher capacity carrier class equipment with integrated service mechanisms that removed the need for adjunct 'Gi' boxes. This second wave of packet core has often been referred to as the intelligent packet core mainly due to the flexible and flow based policy and charging mechanisms that are integrated into the GGSN. These intelligent mechanisms leveraged Deep Packet Inspection technology to enable such services as Content Based Billing and used more granular flow based technology for more precise QoS and bearer resource management. Consolidating everything into a single intelligent packet core node provides for capex savings over first wave packet core solutions in addition to a more coherent single point of awareness approach to delivering IP services.

Nortel's reputation in packet core was made through its technical, product and market leadership during the second wave of packet core. During this time Nortel was able to leverage the IP technology and services leadership from its acquisitions of both Bay Networks and Shasta Networks to jump ahead of the traditional wireless vendors in the move to the intelligent packet core. The second wave of packet core equipment was not generally bundled as part of an access sale but was procured on its own merits. This allowed Nortel's packet core products and especially the GGSN to be chosen by many Tier 1 GSM/UMTS operators for deployment.

The deployment of second wave packet core technology has enabled a dedicated mobile data market to

begin to emerge that is centered on the business user market segment. This segment is characterized by wireless enabled PC cards and high end integrated devices such as the Blackberry. The aggregate data traffic for these subscribers is growing strongly especially with the recent rollout of early HSDPA technology and the emergence of flat rate tariffs. Total packet data traffic is now approaching if not exceeding the total voice traffic.

During the deployment of the second wave of packet core, new access technologies such as WiFi began to emerge. When coupled with a general industry shift towards fixed mobile convergence this resulted in the need to add new access technologies to the wireless packet core in order to preserve services and the user experience (irrespective of the access technology). Several standards and technologies have since become available that enable new access technologies to be 'bolted on' to second wave packet core infrastructure such as unlicensed mobile access (UMA) and Interworking WLAN (I-WLAN). These solutions rely on new access technologies emulating the traditional GSM/UMTS access and packet core nodes in order that the second wave packet core installed base can add them transparently.

Although a viable business model has now begun to emerge for the niche business user mobile data service, it is clear that expanding this into a future mass market mobile broadband business requires significant changes. This is because a mass market mobile broadband service requires a dramatic reduction in the operator's cost of ownership to be a viable business proposition. Without radical changes the mobile broadband service will be uncompetitive on price against wireline or alternative wireless offerings (WiFi/WiMAX) and will fail to establish. If operators try and price competitively then it is likely that they will rather quickly suffer large negative impacts on their wireless data margins, especially if flat rate tariffing means revenues do not grow to pay for incremental traffic growth. There are many approaches to reducing the total cost of ownership including more efficient radio technology (HSPA+/ LTE/WiMAX), flatter all-IP network architecture, Femto cell technology, high density and highly scalable COTS hardware, service bundling, the upsale of revenue generating services, reducing no/ low margin traffic types and network consolidation. All of this means that a mass market mobile broadband service demands a third wave of packet core.

The third wave of packet core

The third wave of Packet Core is defined by its focus on lowering the operator's cost of ownership of mobile broadband service. The third wave of packet core is also defined by its inherent ability to natively support multiple access technologies. Nortel sees the third wave of packet core as an industry inflection point starting in the 2009 timeframe that has the potential to revolutionize the packet core market just as the migration to intelligent packet core did. The third wave of packet core supports both traditional GPRS networks as well as the emerging standards for more efficient radio (LTE/HSPA+) and a flatter all-IP based network architecture (System Architecture Evolution (SAE)/Direct Tunnel).

To address the third wave of packet core opportunity Nortel's new packet core product, the Access Gateway (AGW) has been developed with specific focus on low cost of ownership and the support of multiple access technologies. Cost of ownership reductions come from the delivery of an integrated node that uses a common high performance COTS platform with field proven feature rich packet core software. Further cost of ownership reductions are enabled through the flexible deployment options that allow the Nortel AGW to be simultaneously deployed as a 2G-3G SGSN, 2G-3G GGSN, MME, Serving/PDN Gateway and Home Agent.

Nortel's new Access Gateway (AGW)

A common gateway for multiple access technologies

Nortel's new AGW provides a unique set of flexible and scalable deployment options and leverages

Nortel's leadership in porting field hardened software onto carrier grade COTS hardware. The new AGW inherits Nortel's intelligent packet core functionality while at the same time adding support for and mobility between multiple access technologies including the emerging 4G wireless technologies such as LTE.

The new AGW is based on Nortel's award winning third party ATCA platform which enables product performance to keep pace with Moore's Law and delivers industry leading performance in terms of pure processing capacity per blade. Moving to a blade-based architecture provides for flexibility in deployment and also means that the AGW is able to scale seamlessly to meet the explosion in subscriber numbers and traffic demand of mass market mobile broadband. In addition to common ATCA hardware, AGW uses the same open-source operating system and standards compliant middleware that Nortel has successfully applied to other carrier grade telecoms products.

Nortel's AGW allows operators to provide 'Intelligent Services at the Edge' to every subscriber independent of the access technology over which the subscriber connects. This is achieved by integrating key enablers like Deep Packet Inspection onto a common access independent AGW blade that is also responsible for providing the routing function.

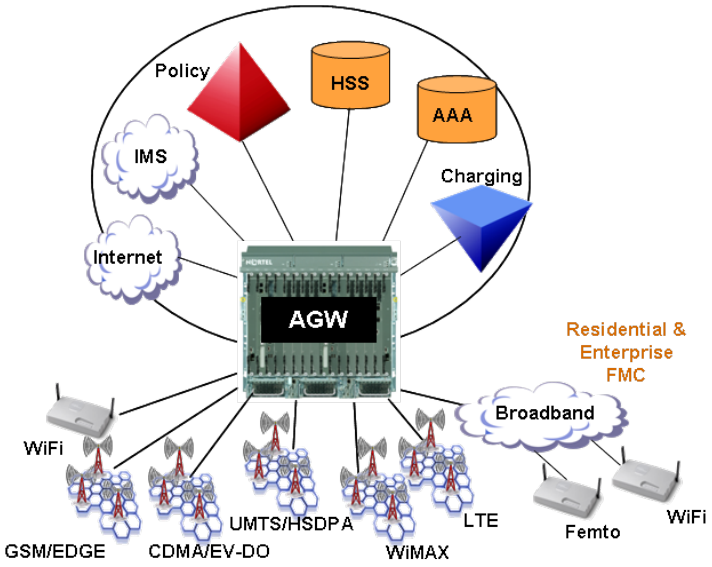


Figure 3. Nortel AGW at the heart of wireless

Nortel's new AGW implements 3GPP standardized functions including GGSN, SGSN, LTE MME, Serving Gateway (S-GW) and Packet Data Network Gateway (PDN-GW) as well as alternative access technologies such as WiFi and WiMAX together with a Mobile IP Home Agent. All the AGW functions are implemented with full standards compliance for end to end interoperability. The AGW supports packet core enhancements such as direct tunnel and network initiated bearers. These mechanisms help reduce the total cost of ownership through more efficient and targeted management of the bearer plane and its associated QoS characteristics. Support for new access protocols, IP multi-media sub-system (IMS) core interfaces and diameter based policy and charging control (PCC) ensures that Nortel's new AGW is ready for both 4G and IMS.

One product - many functions

Nortel's AGW can be configured in many different ways to meet particular market and operator requirements. For GSM/UMTS operators AGW can be deployed as a Next Generation SGSN or GGSN through a straight-forward network upgrade to new future proof third wave packet core technology. For small scale operators the SGSN and GGSN can be combined, which might also be attractive to larger operators wishing to regionalize their network. Both SGSN and GGSN functions support direct tunnel and HSDPA access. To meet 4G radio evolution requirements the LTE MME can be added to the AGW based SGSN and S/PDN Gateway can be added to the AGW based GGSN. Alternatively a Greenfield LTE operator can deploy just the LTE functions either in dedicated or combined nodes.

For LTE the AGW supports both GPRS tunneling protocol (GTP) and proxy mobile IP (PMIP) variants for the handling of layer three mobility. Simultaneous support of both GTP and PMIP mobility means that an operator only needs to deploy a single pool of PDN Gateways that can serve both home subscribers and roamers. The use of common processing hardware on the AGW for both control and data provides the potential for a more efficient approach to processor pooling and over capacity engineering. This is because processing resources could be engineered to handle both control and data, should an overload or failure conditions occur. This is more efficient than having to engineer two dedicated processor pools, one for control and one for data.

To address Fixed Mobile Convergence Nortel's AGW will also support WiMAX Access Service Network (ASN), Home Agent, WiFi packet data gateway/packet data interworking function (PDG/PDIF) and Femto cell applications.

Intelligent Services at the Edge

Single point of awareness for optimized service delivery

Nortel's new AGW builds on the intelligent services at the edge philosophy that underpinned the move from the first to the second wave of packet core. Intelligent services at the edge mean that IP services are integrated into the IP edge router rather than being implemented in one or more adjunct boxes. Invoking all the IP services at a single point in the network means that service decisions can be made in a coherent and intelligent manner. The intelligent aspect of Nortel's AGW comes from the fact that the AGW is access, subscriber and content aware. The AGW can be considered as a single point of awareness at the services edge which means it is the optimal point in the network to deliver services such as policy, charging and security.

Dynamic policy control and flow based charging are implemented on the Nortel AGW in accordance to the 3GPP standardized Policy and Charging architecture (PCC). In fact the PCC standard, which Nortel played a major part in defining, is now largely the same intelligent packet core solution that Nortel achieved such strong market traction with, as the second wave of packet core emerged. The PCC architecture allows both static and dynamic PCC rules to be applied to individual service data flows in a subscriber, content or application specific manner. This very granular and flexible approach means that PCC based solutions are able to support highly contextual charging schemes, sophisticated traffic gating and finely tuned Quality of Service (QoS) control.

The Nortel AGW provides the real time policy and charging enforcement point that is defined in 3GPP PCC as the Policy and Charging Enforcement Function (PCEF). The PCEF is controlled from above by a Policy and Charging Rules Function (PCRF) over a diameter based interface (Gx). The Diameter protocol is also used to interface the PCEF with the various online and offline charging systems (Gy and Gz).

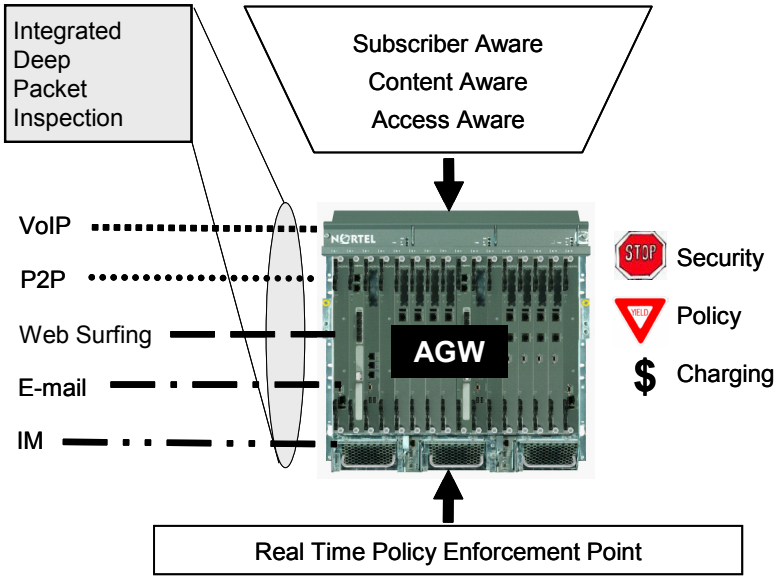


Figure 4. Intelligent Integrated IP Services at the edge

Deep Packet Inspection (DPI) is the engine that enables the AGW to be content aware. DPI means that IP packets passing through the AGW are inspected and classified by content type (VoIP, P2P, web, e-mail, IM etc). Being content aware enables the AGW to support 'high touch' services such as Content Based Billing (CBB) and P2P traffic control.

The sophistication of the packet inspection engine determines the type of services that can be implemented at the AGW. Nortel's focus on Packet Inspection technology leadership as part of the new AGW enables operators to more easily evolve their existing IP services as well as add new ones. The next key services which Nortel is targeting are Intrusion Prevention, Virus Scanning, Worm Filtering and behavior based mobile advertising.

Key enablers for service differentiation

The rich set of IP services available on the Nortel AGW provides a means by which an operator can create service differentiation. The key enabling functions that drive service differentiation broadly fall into the categories of policy, charging and security. Policy services keep operators in control of their network, charging services facilitate flexible and innovative service offerings and security services provide protection for both subscribers and networks.

Staying in control of the network

The enforcement of policy at the network edge enables operators to control and shape the traffic that is admitted and traverses their network. Policy enables a more intelligent approach to Call Admission Control meaning that decisions can be made in real time and based not only on network resource availability but also on user subscription profile, the current access technology being used and the particular application layer service requested. Deep Packet Inspection further extends the service capability of policy by including content aware information into the decision process.

The 3GPP PCC based policy solution is often referred to as flow based policy. This is because policy can be enforced on individual service data flows rather than limited to the aggregate flow or bearer level. Flow based policy means that traffic control can be more granular and therefore optimized and targeted to the particular service data flows of interest.

There are many applications of the policy enabler but perhaps the most important is the ability to prioritize high revenue service flows such as operator VoIP ahead of low/no margin P2P traffic that might be taking advantage of flat rate tariffing. P2P traffic does not need to be dropped but it can be traffic shaped to meet available network resources and given the lowest priority marking to ensure it does not take priority over other revenue generating traffic.

Another key aspect of the AGW policy solution is the ability to provide network control of dynamic QoS and Bearer Management. Dynamic QoS and Bearer Management can be used to match a subscriber's bearer resources and QoS settings with a particular application like operator VoIP. In this way operators can ensure that a subscriber obtains the desired quality of experience for a particular service ensuring customer satisfaction and reducing churn.

Creating flexible charging schemes

Nortel AGW supports standardized diameter based interfaces for both online and offline charging. This means that with Nortel AGW operators can support both post and pre-paid charging schemes including the ability to offer real-time authorization.

In addition to traditional time and volume based charging the AGW is also able to enable more flexible and intelligent charging solutions such as Content Based Billing (CBB), Flow Based Charging (FBC) as well as tiered and event based charging. Content Based Billing leverages the Deep Packet Inspection technology

within the AGW while Flow Based Charging builds on the service data flow granularity provided by a 3GPP PCC compliant architecture. The Nortel DPI engine support both static and stateful protocols which makes aggregated charging schemes possible. Nortel AGW integrates all the key charging enabling technologies into a single point of awareness on the Nortel AGW. This provides operators with a finely tunable charging toolkit that can support the flexible charging schemes that are needed to support new and innovative marketing-led service offerings.

Protecting subscribers and networks

Security can mean many things to many different people but from an AGW perspective the key security functions focus on the protection of both end subscribers and the operator's network.

Subscriber protection on the AGW is achieved primarily through the integration of a per-subscriber personalized and stateful firewall. Additionally, the DPI capabilities of the AGW can be leveraged to enable the detection and blocking of inappropriate content such as spam, Malware, viruses and adult content.

Network protection on the AGW consists of Denial of Service (DoS) prevention and protection against abusive use of network resources such as the threat from P2P traffic. An explosion in P2P traffic if not closely managed has the potential to quickly push networks into overload as well as providing a possible exposure of the operator to the regulatory and legal issues associated with services such as illegal file sharing.

Nortel products converge to ATCA

1st to market with 2nd generation of 3rd party ATCA

ATCA which stands for Advanced Telecom Computing Architecture heralds the coming together of the telecom and IT hardware communities. ATCA provides a standard to which IT equipment vendors can build telecom grade products. Nortel has embraced the move from proprietary to open standards based hardware starting with PCI and more recently through the early adoption of ATCA. Moving to a COTS based product strategy provides easier access to faster hardware evolution cycles, volume manufacturing benefits, integration of third party software building blocks and allows telecom vendors like Nortel to focus on the application rather than the enabling pieces.

Nortel's AGW is implemented on the same ATCA platform that is employed on many other Nortel products. Nortel ATCA is already used for GSM/UMTS Mobile Switching Center (MSC) Server/ MGCF and Home Location Register/ Home Subscriber Server (HLR/ HSS), CDMA mobile switching center (MSC) Server/Media Gateway control function (MGCF) plus Nortel IMS. Standardizing on a common ATCA platform for multiple products provides saving in terms of spares, support and staff training as well making possible innovative 'network in a box' solutions. Nortel's ATCA products are already supporting live revenue generating traffic in several markets with the first GSM/UMTS MSC Server in live service since July 2007.

Nortel AGW is formed through the introduction of a new high performance ATCA routing blade and the integration of third party market leading routing software on to the standard Nortel ATCA platform. AGW also leverages the new ATCA option nine switch fabric (Ethernet option) which enables the realization of protected flows through the box without over provisioning.

Nortel has worked closely with ATCA partners and standards to improve the initial first generation designs by adding additional telecom grade functions that have resulted in a second generation of ATCA standards and products that provide improved reliability, operability and serviceability. These extensions are not all hardware based as they also address deficiencies in traditional IT based middleware and operating systems resulting in for example Nortel Carrier Grade Linux (NCGL). NCGL takes open-source Linux and then adds carrier grade enhancements. NCGL has already been deployed in live revenue

generating networks for several years and is now being re-used across all Nortel ATCA based products. Nortel ATCA products utilize Service Availability Forum (SAF) compliant high availability middleware which enables the coordination of redundant resources availability within a cluster. The software used on Nortel ATCA products has also been enhanced to incorporate improved reliability mechanisms such as self-stabilizing and fault tolerance. Self-stabilizing software means that the system will more readily converge to an error-free state autonomously. This has been achieved through higher coverage of hardware and software faults, an approach that is derived from Failure Mode, Effects, and Criticality Analysis (FMECA) military standards. Nortel's approach to fault tolerance is to focus on fault containment by mitigating the fault, rather than allowing a "knee jerk" reaction. This is achieved by implementing a more granular set of available responses to a fault. In this way fewer unnecessary high risk actions such as switching blade activity or software roll-backs are invoked especially for small, low impact faults.

It is also important to understand that Nortel's ATCA platform strategy is truly third party COTS based. All of Nortel's ATCA hardware is manufactured by a third party and none of the individual ATCA components (blades and chassis) are provided exclusively to Nortel. This means that both Nortel and operators are able to benefit from the efficiencies of scale that come with the generic computing market both in terms of an ability to keeping pace with the technology curve and for providing security of supply. Single-sourced ATCA equipment made by other telecom vendors does not provide any of these business benefits to either vendor or operators. For this reason ATCA can be considered to only add value if it is genuinely third party COTS.

Designed for world of mass market Mobile Broadband

Meeting subscriber expectations

In the new world of mass market mobile broadband, subscribers expect network operators to meet levels of service that call for a new third wave of packet core equipment. Service requirements cover not only those directly related to the bill paying customer but also the needs of their dependent family. For themselves, subscribers demand 'dial tone' availability, toll quality voice, protection from service attacks, safeguards from fraud and the blocking of malicious content such as SPAM and viruses. For their children, subscribers demand additional mechanisms to block adult and other inappropriate content together with safeguards against over spending.

Meeting operators' needs

The new world of mass market mobile broadband opens up many opportunities for a network operator but also many potential threats. The increased end user bandwidth available with mobile broadband technology can provide the framework for the sale of new revenue generating incremental services. These new services can be coupled with flexible flow based charging and DPI based content awareness to provide new and innovative marketing-led service offerings and charging schemes. However, to take advantage of these new opportunities network operators must defend against new and emerging threats such as denial of service attacks and the potential for P2P traffic fueled by flat rate tariffs that push networks and network spending into overload.

Nortel's new AGW is designed to meet mass market mobile broadband subscriber needs as well as those of the network operator. The combination of field proven software with new third party COTS hardware reduces total cost of ownership without risking service availability. The new AGW leverages a feature-rich, services at the edge architecture together with a full set of standardized and open interfaces. This provides the key policy, charging and security enablers needed for service differentiation whilst protecting subscribers and networks from the threats posed by the new world of mass market mobile broadband.

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