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3G to 4G Core Network Migration

By Renuka Bhalero, System Architect

With operators worldwide starting to deploy High Speed Packet Access (HSPA) services, 3G has finally arrived and is now gaining momentum. As 3G enjoys its success, the evolution in the radio and core network space continues with Long Term Evolution (LTE) and Evolved Packet System (EPS) leading the way forward to the 4G revolution. The heralded "anytime, anywhere" access and entertainment medium shall become a reality with 4G.

The mobile video and mobile TV era, with "always on" expectations, brings in the need for a robust and modular network infrastructure that can help get new voice and data services to market at lower cost and in less time than in the current reality. But, while the 4G revolution is focusing on the air interface and access network side of the equation, the core network also has to revive itself with new architecture enhancements in order to keep up with seemingly unrealistic data speeds and related issues. How the evolved core sustains the challenge will be key in determining the user experience of new services.

This paper talks about the shift of existing infrastructure for 3G core to 4G, and the benefits and impact on the communications industry of AdvancedTCA on the wireless core network.

3G Core Network Realities

Today's wireless industry aims at providing voice and data services in the next generation of converging communications networks. The goal is the performance gain to meet the demands of ever increasing data speeds and network traffic at lower operational costs. The specific requirement is to build stable and flexible infrastructure that leverages open, standards-based interfaces that enable "Triple Play" voice, video, and data. Before we discuss implementation specific, however, let's start with an overview of 3G core network functional elements.

The 3G packet core architecture consists of the Universal Mobile Telecommunications System (UMTS) packet-switched (PS) domain – or General Packet Radio Service (GPRS) Support Nodes (GSN), the Gateway

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GSN (GGSN) and the Serving GSN (SGSN). These elements constitute the interface between the radio system and fixed networks for packet-switched services. The GSN performs all necessary functions in order to handle the packet transmission to and from the mobile stations.

The SGSN (Serving GPRS Support Node) supports mobility management functions within the network. The signaling and packet data from the access nodes, namely the Radio Network Controller (RNC), is forwarded to the SGSN. The SGSN handles functions of data packet processing, such as forwarding, tunneling the data to the GGSN in the user plane, along with the control plane functions of authentication, SS7 signaling to the HLR, and mobility management.

An SGSN platform requires computing capability for processing the signaling messages as well as network interface modules to handle intensive control protocol processing and to support the interfaces to the other network elements. An SGSN platform also needs high performance packet processing capacity to tunnel the data in the user plane. Similarly, a GGSN (Gateway GPRS Support Node) has to take care of intensive packet processing, channeling the data in and out of the wireless network to the external packet data entities.

A good mix of general-purpose processing, packet processing, and networking I/O makes an ideal platform for these network nodes. The data plane typically includes line cards that can process the high volume of data for millions of subscriber data sessions in the Open Systems Interconnection (OSI) Layer 2 and 3 transport protocols. The control plane, on the other hand, takes care of following three functions:

- *Signaling:* handling the registration, call setup, teardown, and session establishment protocols
- *Shelf Management:* shelf, chassis, rack, and system management, performance statistics, and high availability
- *Applications:* Control of the core network functionality

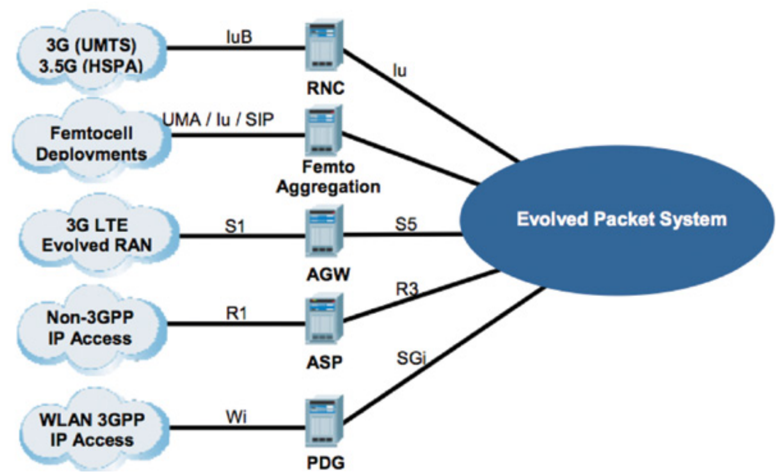

Figure 1.

The Shift From 3G To 4G

In today's market, the subscriber / end user is at the center of everything, and the services are driven by user demands. Initially more focused on short message service (SMS), multimedia message service (MMS), and content downloading, the 3G market has moved rapidly toward video sharing, mobile video, and IPTV, all of which require very high data throughput and highly efficient radio.

The latest UMTS evolution brings improved spectral efficiency at lower latency and higher data speeds with almost 100 times improvement from 3G – the new promise known as 4G. To achieve this, the air interface is making use of new modulation techniques which effectively target the issues seen with 3G, such as symbol efficiency. The radio interface has adopted some best-in-class methods for the air interface, namely Orthogonal Frequency Division Multiplexing (OFDM) and Multiple-Input Multiple-Output (MIMO) systems.

To support the evolved UMTS Terrestrial Radio Access Network (UTRAN) with OFDM at radio access, the core has adopted a flatter IP-based architecture that gives better data performance. The 4G core shall support an open framework, allowing any kind of mobility protocol, quality of service (QoS), and Authentication, Authorization, and Accounting (AAA) services with support for multiple access technologies, and be able to provide value-added services which are personalized and context-aware.

Components In The 4G Core

The new 4G architecture is evolving with fewer nodes and a flatter structure, thus giving lower latency. That brings in for a requirement of an all-IP-based core network to support the high data throughput and is general enough to be accessed by the different radio access networks through gateway interfaces.

As a result, 4G is not so much about all new standards, but is instead based on existing technologies (e.g., WLAN, 2G, 2.5G, 3G, and satellite) being used to better advantage. 4G is the evolution beyond 3G which addresses the limitations seen so far while working to enhance the quality of service and increase the bandwidth to make better use of resources.

The Evolved Packet System (EPS) architecture supports a base station and a core network component. The EPS supports 3GPP (3rd Generation Partnership Project) as well as non-3GPP access. The flexibility of providing access to different radio types makes it possible for the core to evolve independently from access as a cost-effective IP environment.

The 4G core addresses mobility, security, and QoS through reuse of existing mechanisms while still trying to work on some mobility and handover issues. This IP-based core architecture enables location and QoS-based services for the users. The radio networks access the core through IP; circuit switching is totally absent. Voice service will be transferred over IP as packets along with the signaling and data. The IP-based infrastructure translates into lower setup cost.

The 4G Gateway

The core network data plane node is the Gateway (GW) – Serving / Packet Data Network (PDN) Gateway – and the control plane entity is called the MME (Mobility Management Entity). The MME and GW are separated by an open interface known as S11. The basic architecture is shown below.

The MME takes care of Non Access Stratum (NAS) signaling, which includes protocols used for control purposes such as network attach, authentication, setting up of bearers, and mobility management. The GW manages the data plane, routing and forwarding the data packets and also storing and managing user context. The packet routing functions include:

- Packet screening
- IP header compression
- Ciphering
- Integrity protection
- Policy enforcement
- Lawful intercept

The figure below describes the new architecture of 4G EPS:

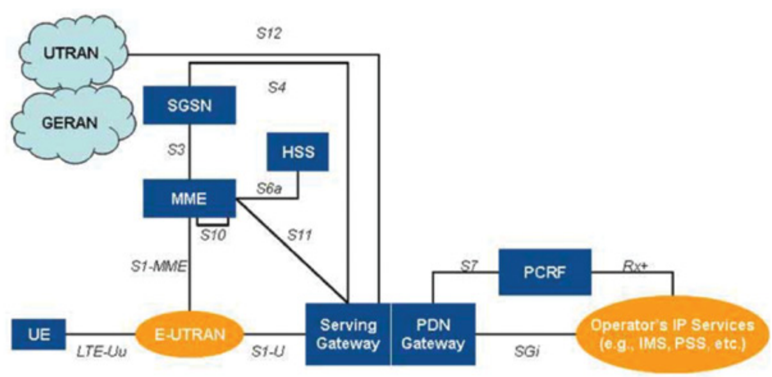

Figure 2.

Requirements For The Serving Gateway

The approach for support of fast and smooth handover, AAA, QoS, and radio access define some of the key Serving Gateway requirements. Other factors include:

- Unified approach to mobility
- Seamless handover from one access mode to another while maintaining the connection and avoiding loss of data (and thus efficient resource utilization)
- AAA management
- QoS management
- Security and packet screening to provide extra transparency required for the support of new services

4G Network Security

In the current mobile networks, operators are in complete control of radio access and backhaul, but this will change with 4G as that architecture allows for all-IP backhaul and multiple access networks due to increased risks of security intrusion and attacks.

Security and privacy become more and more important as services touch more of commercial aspects, and thus accountability is required but not to the point of compromising identity. On the untrusted backbone of IP networks, users will need more end-to-end security achieved through efficient techniques as well as encryption of content and stored data.

As the environment becomes more complex with a variety of services at subscribers' disposal, data protection and extra authentication will be even more important. Also critical will be location privacy, protection against attacks like malicious calls, eavesdropping, and traffic deviation / re-routing.

4G Demand On Platform Hardware

The Serving and PDN GW type of nodes will require IPv6-based mobile core network platforms handling mobility, security, and QoS among the key areas.

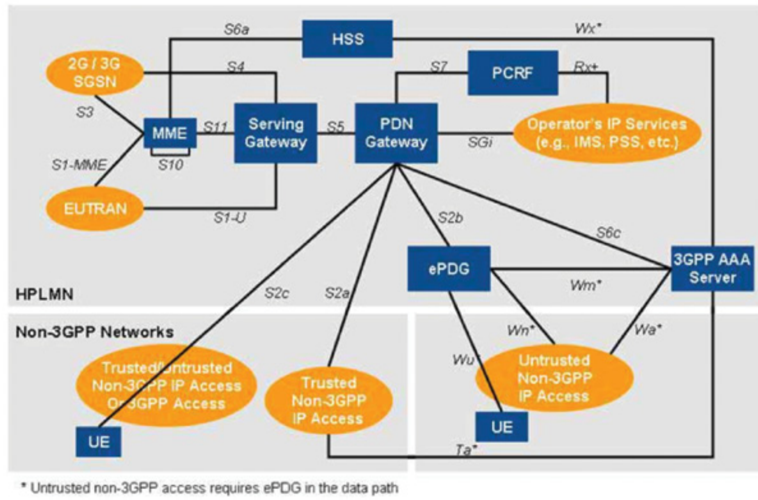

Figure 3.

The system needs to take care of management of user profiles as well as the service aspects of reliability, deployment, and flexibility. With the end-to-end IP network, all data traffic has to pass through the GW and hence the factors like scalability, robustness, and performance will be significant.

Similar to the SGSN, the 4G GW platform needs compute power for control signaling around AAA and QoS management and also needs efficient packet processing capability to match the demand for high-speed data. Also important will be the support for data protection, ciphering, and extra authentication to guard against security threats.

ATCA's Role In 4G

Advanced Telecom Computing Architecture (ATCA) is fast becoming a widely deployable standardized platform in the communications industry. More and more telecom equipment manufacturers are selecting ATCA as the platform of choice for their next generation product lines. The highly modular and scalable architecture of ATCA-based systems is no doubt more suitable for the new network infrastructure needed to support today's voice and data services. Deployments are taking place across the network with key progress in wireless and IP Multimedia Subsystem (IMS) network infrastructure.

ATCA is a specification from the PCI Industrial Computers Manufacturing Group (PICMG) that provides for an open, standards-based platform which is also cost-effective. ATCA provides for a common platform which is scalable, flexible, and carrier grade, thereby making it suitable for variety of telecom and computing applications. The framework is based on industry standards and specifically focuses on the needs of the telecommunications market.

All ATCA systems come with a Gigabit Ethernet base interface. The introduction of 10 Gigabit Ethernet support at the backplane provide tremendous fabric capacity to overcome the switching limitation, making ATCA-based platforms even more suitable for high-bandwidth applications. Advanced Mezzanine Controller (AMC) modules provide additional processing and I/O capability.

Platforms taking care of the complete hardware solution – consisting of chassis, backplane, switching fabric, line cards, and packet processing blades – provide telecom equipment manufacturers significant advantage in terms of time-to-market. Being a modular platform, it is easier to deploy, upgrade, support, and update. Thus the modular, open interface-based ATCA platform with required compute blades and storage capacity represents an ideal base platform giving time-to-market advantage and enabling TEMs to put more focus on application development to provide more differentiation and value for service providers.

Many Tier 1 TEMs have already developed ATCA-based SGSNs and GGSNs, and others are also following the way. With similar functions and objectives and a standard ATCA-based platform as the foundation, it will be relatively an easy transition from 3G to 4G core infrastructure.

Radisys: Defining The Next Generation Platform

The network is still evolving, however the trends are visible and thus the need for a common platform addressing deep packet inspection (DPI), bandwidth management, personalization, and security is evident. The new network will support of plethora of services which are increasing every day, and needs a “content aware” network platform which can inspect each packet and manage it based on its specific needs while also addressing the requirements for security, QoS, billing, and policy enforcement.

Radisys has exactly the solution for that in terms of its ATCA systems complete with packet processing, compute blades, and up to 10GbE network interfaces. In particular, Radisys’ ATCA-PP50 packet processing blade, which provides two NetLogic Microsystems XLR 732 packet processors on a 10GbE (PICMG 3.1 option 9)-enabled ATCA blade, is ideally suited to such packet-intensive applications. The solutions are engineered to meet the application needs of next generation infrastructure including IPTV servers, RNCs / PDSNs, security gateways, session border controllers, WiMAX base station aggregation, and wireless xGSNs.

The Radisys 10GbE ATCA traffic management and network security system delivers very high performance DPI capabilities to allow TEMs to rapidly develop and deploy content-aware platforms. The system comes in two standard configurations to support different network capacity requirements. Example applications include IP edge routers, CDMA or 3G BTS aggregation devices, femtocell aggregators, and WiMAX ASN gateways.

Conclusion

End-users want more services and applications delivered faster and at low cost with reliability – and of course with a customized and personalized approach. Service providers want infrastructure which can fulfill this promise at lower cost and, at the same time, reduce time to market, allow rapid development, and deliver new value-added services to gain more revenue. The wireless telecom industry is migrating to a single converged IP network and the ATCA-based platform will become a backbone for this infrastructure. The ATCA-based systems with open, standards-based architectures, high compute powers and desirable DPI technology are no doubt well positioned for this challenge.

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Corporate Headquarters

5435 NE Dawson Creek Drive
Hillsboro, OR 97124 USA
503-615-1100 | Fax 503-615-1121
Toll-Free 800-950-0044
www.radisys.com | info@radisys.com