

Flexible Line Card Design to Meet Emerging Transport Standards in the Radio Access Network.

Author: Colin Alexander, C.ENG., M.IEE.

European Systems Engineering Manager, **Wintegra**
 Willow House, Strathclyde Business Park, Glasgow, UK.
 Email: colin.alexander@wintegra.com. Tel: +44 (0)1698 464199.

The wireless infrastructure is in a state of redevelopment, with operators deploying equipment armed with technologies like ATM AAL2, IPoATM, IPoHDLc to support the introduction of higher bandwidth data traffic whilst at the same time maintaining end-user Quality of Service for voice. One of the major challenges in the transition to the new Radio Access Network (RAN) is provisioning flexible, efficient transport interfaces between equipment. Designing the optimum multi-protocol transport line interface—one that provides operators both the flexibility to deploy diverse access interfaces and ‘upgrade ability’ to meet emerging standards—is a key challenge for designers choosing next-generation silicon and software architectures. The critical issue in RAN evolution is how to manage, terminate, and switch voice and data over a common transport network as technology moves from ATM to IP. The paper will overview how, in using state-of-the-art design techniques built with highly configurable network processor silicon, bus, and software architectures, line card designs that implement the lower layer transport protocols in the 2.5G/3G RAN can be realised by allowing the designer of the Iub, Iur and Iu transport interfaces to meet the conflicting requirements of cost, space, flexibility, performance, scalability and time-to-market in his design.

INTRODUCTION

The convergence of voice and data, and the demand for ‘information on the move’ is leading to a new set of wireless services that go beyond today’s second generation (2G) wireless services, to form what is commonly referred to as 2.5G and 3G services. GSM is the world’s leading 2G system. GPRS and EDGE are examples of 2.5G services, and UMTS is an example of an emerging 3G service. Figure 1 tracks the evolution of the wireless standards from 1998 to the present.

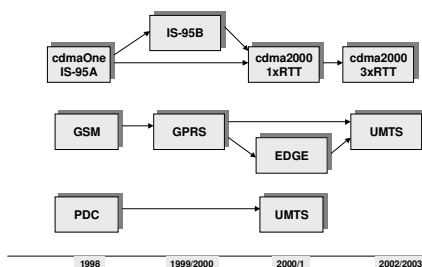


Figure 1: 2G to 3G Migrations Driving Requirements for New Transport Technologies.

The 3G-network architecture requires equipment manufacturers to adopt a reusable platform design in their equipment and to consider operation at the Iub, Iur and Iu interface level. The requirements of each one of these interfaces is very different in the control plane, but have many similarities in the transport layer in how the equipment manages a variety of resident protocols.

An equipment designer makes many important decisions in selecting the appropriate platform for the UTRAN, including how to manage the diverse protocol processing requirements between the NodeB, RNC, and Core Network, as well as how to identify, terminate, switch, and interwork disparate traffic types whilst not compromising Quality of Service in the form of latency through the different interfaces.

TRANSPORT NETWORK REQUIREMENTS FORCING MIGRATION

The transport network that links different pieces of network equipment in the UTRAN is the subject of much study in the different standards groups. At present, the 3GPP Release ‘99 specification utilises Asynchronous Transfer Mode (ATM) to apportion proper Quality of Service to traffic flows in the RAN.

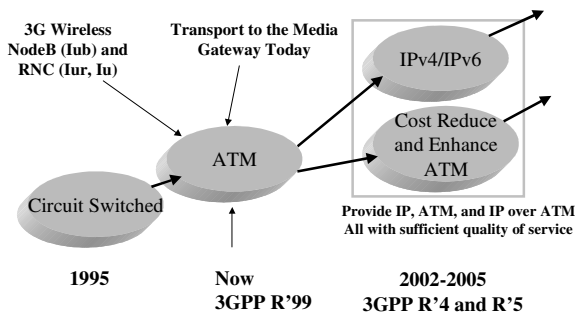


Figure 2: Co-existence of IP and ATM technologies in the RAN

As Figure 2 illustrates, standards bodies are also focusing on how to leverage the benefits of ATM with reduced costs and feature enhancements concurrent with efforts to anticipate raw 'IP technologies'. Investigating fragmentation, segmentation, and prioritisation schemes similar to those used in ATM will provide insight into how to administer adequate Quality of Service in an 'all IP' RAN.

Every equipment manufacturer has preferred platforms they utilise in their current NodeB and RNCs. Many have combined their engineering efforts with others in an attempt to control costs and share technology. However, all seek to lower costs and improve performance of their existing equipment by supporting different layer 2 protocols over transport media such as E1/T1/J1, E3/T3, and STM-1. Across the board, many look to collapse different "line cards" with chips from multiple vendors into one simple product development in order to provide their operators a way to migrate to IP today or whenever they are ready.

UTRAN COMPONENTS

The UTRAN comprises three main interfaces to interconnect NodeB's and Radio Network Controllers (RNC). This architecture is shown in Figure 3, which represents line card functions within the Media Gateway, RNC, and NodeB. Each of these line cards are required to handle some form of protocol processing, whether this be termination within the box, switching from one port to another of the same traffic type, or interworking from one port to another or different traffic types. An RNC is required to handle and manage calls being set up from several Node B's. In R'99, all the traffic on the Iub interface is required to be ATM; however, in R'4 and R'5, this traffic can be ATM, IP, or IP frames carried over ATM using ATM Adaptation Layer 5 (AAL5). For example, the line card highlighted 'I' in Figure 3 must

support a number of different configurations to meet the requirements of a 3GPP specified network. 'I' could be required to:

- Terminate ATM traffic from multiple NodeB's either through a series of E1/T1/J1 or SDH/SONET physical interfaces;
- Switch ATM cells or IP traffic running over HDLC from E1/T1/J1 or SDH/SONET physical interfaces; or,
- Interwork ATM and IP traffic or IP traffic carried as AAL5 cells over ATM from E1/T1/J1 or SDH/SONET physical interfaces.

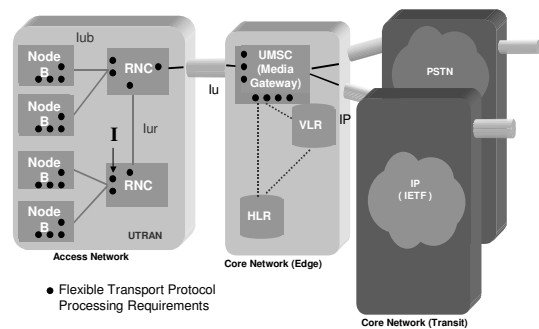


Figure 3. 2/3G Component Design Requirements

In the UTRAN, the transport network is used to carry three 'planes' of information: User, Control, and Management. Although the characteristics of these planes differ, they all share the same transmission network and can interfere with each other. Additionally, in the NodeB, the Iub interfaces must be configurable to handle ATM or IP traffic to and from the user equipment over the air interface.

QOS PROVISIONING IN THE UTRAN

In order to perform service class definition and congestion control management, a series of mechanisms have to be adopted to secure appropriate QOS. In addition, the Transport Network (Iub, Iu and Iur) has to be engineered to support the QOS requested by the RNC for the Radio Network. As such, bandwidth-optimising techniques have to be adopted to allow efficient utilisation of potentially low bandwidth links on the Iub and Iur interfaces especially.

Figure 4 illustrates the techniques that should be considered in any line card design.

In R'99, ATM is the default transmission technology and is utilised to manage QOS. A layer 2 technology, ATM

contains inbuilt techniques that allow traffic shaping; ATM utilises a small, fixed 53-byte cell structure to help manage QOS over low bandwidth (e.g., E1/T1/J1) links. ATM allows traffic shaping by addressing traffic into VC/VP channels and allocating priority to each link by associating each to one of CBR (Constant), VBR (Variable) and GBR (Guaranteed Bit Rate) as referenced by the ATM Forum-TM4.1.

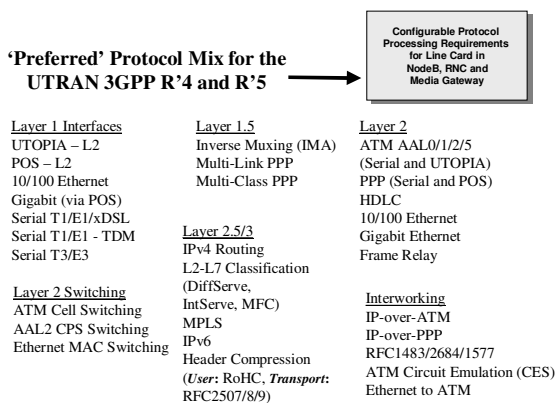


Figure 4. Configurable Protocol Processing Requirements for Line Cards

In 3GPP R'4 and R'5 specifications, IP as well as ATM can be utilised as over the Transport Network. IP is a layer 3 technology and generally utilises much larger frame lengths. Unlike ATM, it has no inbuilt traffic shaping techniques, and to utilise IP over the transport medium effectively, one has to rely on additional fragmentation and segmentation techniques.

For slow links, like those used for the Iub and Iur interfaces, fragmentation is required to prevent short, time-sensitive packets from being delayed by large packets in front of them in the link. IP Fragmentation allows the splitting of a packet into multiple segments so that smaller segments can be mixed with the higher priority traffic. IP fragmentation does not automatically address the problem of delay-sensitive traffic, since IP fragmentation is based only on the size of packet that a link can handle. This packet size may not be small enough to allow the efficient use of the link when delay-sensitive traffic is present. It could be possible for networks to set the MTU of the link to a smaller size than necessary to facilitate delay-sensitive traffic. However, this can affect the efficiency of the higher speed links along the path.

One trade-off that must be made when engineering the RAN is whether to address slow link problems only over the slow link or over the entire path. One option is to handle segmentation as a lower layer issue. As an example, for PPP, the fragmentation capabilities in multilink PPP (ML-PPP) can be used for this purpose.

With multiclass extensions (MC-PPP), multiple flows can be identified within a PPP stream.

Various other QOS schemes, such as flow classification and header compression, could also be applied to IP networks in the RAN.

With the usage of IPv6 mandatory and IPv4 optional, different header compression techniques are important. Each IPv6 header is 128 bits long so compression of these headers is a consideration for managing QOS.

The IP TOS (Type of Service) field can be used to classify some traffic classes. This field is used in core Diffserve routers to deliver Per Hop. L3/L4 fields in IP header and Transport Protocol (UDP, TCP, and SCTP) contain additional fields that can be used to classify IP packets and sort traffic into prioritised queues. The most commonly used fields are IP addresses, Transport Protocol ports, and Protocol Identifiers of IP headers. These classifiers are called Multi-Field Classifiers.

This flexibility to adopt wide-ranging, changing standards of various bodies like the IETF and 3GPP and the ability to mix and match standards that allow NodeB and RNC equipment to meet QOS and performance requirements are essential in the design of 3G equipment technology.

LINE CARD DESIGN REQUIREMENTS

In designs for NodeB for 3GPP R'99 through R5, there is a requirement to meet ATM, IP and IPoATM. Disparate line card designs have traditionally been developed to accommodate either one of these technologies. It has not been possible to mix and match technologies and mix QOS techniques on one card. Designs have been built around either ASIC or ASSP technology, so that the line card or the whole system had to be re-engineered whenever a designer needed to migrate to new standards.

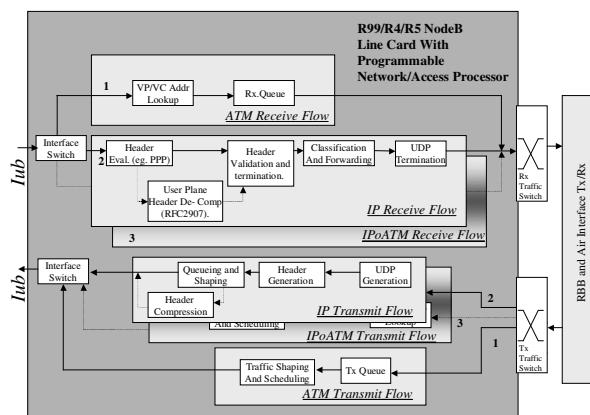


Figure 5. NodeB Design with Flexible, Programmable Network Processors.

New Network Processor (NP) silicon and associated software architectures have increased the flexibility that can be achieved in 3G equipment line card designs. Silicon devices with interfaces like POS and UTOPIA allow programmable selection on the TNL of either IP or ATM traffic types through Layer 1 PHY devices. The availability of appropriate bandwidth and new parallel processing techniques allow tasks to be apportioned in the processors to allow power consumption and board space constraints to be managed effectively.

As shown in Figure 5, a line card can now be configured in at least three different ways that meet the requirements of the latest 3GPP specification. The silicon can be programmed to support Options 1, 2, and 3 (ATM, IP, or IPoATM). All of these options are highly configurable in themselves, as illustrated in Figure 6. In this illustration, each arrow represents an interface on the line card. The outer layer of the circle represents the physical interfaces on the NP chip; the inner layers represent functionality that can be programmed into the device. As a result, it is possible to configure any type of ATM traffic using Adaptation layers 1, 2 or 5 to switch to other ATM traffic or to interwork to IP traffic that may be running over HDLC, for example. Each of the interfaces may run as TDM traffic (for example, E1/T1/J1 interfaces) at up to 50Mbps, or over the UTOPIA/POS interface rates of up to 622Mbps. From the diagram, it is possible to support IPoATM traffic and to terminate or interwork this with other Iub interfaces at the line card.

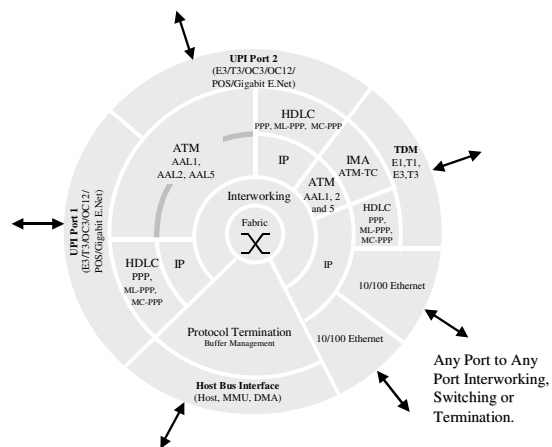


Figure 6. Termination, Switching, and Interworking of Traffic.

Different classification schemes can be soft configured on the device, which can operate at the IP (L3) level or at the TCP/UDP level (L4), prioritising and classifying the traffic into different flows. This is particularly useful for the interworking function requirement called for in 3GPP R'4 and R'5, where this function can reside either in an interworking box or in the RNC itself.

Figure 7 below illustrates a typical line card architecture where NP silicon is used in this case to manage traffic from an SDH/SONET ring interface to the NodeB. The NP classifies the traffic and determines if it is destined for a terminal controlled by this particular NodeB. If so, the traffic is routed over the gigabit interface to RBB and Radio Rx/Tx circuitry. When the payload is not destined for the particular NodeB, the Network Processor either routes the payload back out on the SDH/SONET interface or routes the traffic onto E1/T1 interfaces that in turn are interfaced to additional NodeB's.

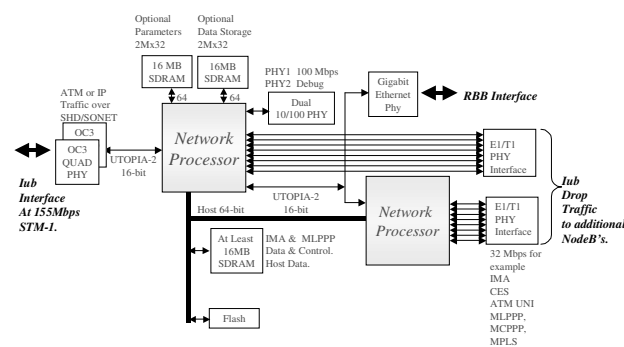


Figure 7. Line Card Architecture for 16 E1/T1 to OC3 Interworking (capable of handling IP and ATM Traffic)

Similar techniques can be used in the design of high density Media Gateway equipment for the RAN where aggregation and interworking of payload traffic is required between the incoming interfaces and the Digital Signal Processors (DSPs) handling transcoding and processing or voice signals.

Conclusion

Providing end-to-end QOS to support a variety of applications has become of major importance to operators in their roll out or 3G-equipment. Since the perceived QOS has an impact on user perception of service, QOS will be a differentiating factor for operators offering UMTS services. By adopting flexible, NP based line card designs, equipment suppliers can provide operators a way to upgrade their NodeB and RNC equipment in the field to support ATM and IP transports on Iub, Iur, and Iu interfaces, and to allow usage of new QOS management techniques as they become available as standards.

References

- (1) 'IP Transport in UTRAN Work Task Technical Report', 3GPP Recommendation TR 25.933

About Wintegra:

Wintegra is a leading provider of access processing semiconductors enabling the delivery of new services for the evolving communications network infrastructure. Its access processors and networking software provide the essential intelligence and upgradeability for infrastructure equipment to support the emerging networks based on the convergence of voice, video, data and wireless services. Wintegra based solutions are available for a wide range of communication platforms used by many of the leading telecom and networking equipment manufacturers worldwide.

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