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ABMP

ATM Buffer Manager Premium Delivers QoS for Next Generation Multi-Service Platforms

PXB 4330 Version 2.1

Wide Area Network

Never stop thinking.

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ABMP

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1 Document Overview

The ATM Buffer Manager (ABM) device, PXB 4330 V1.1, is well accepted in a variety of applications where extensive ATM Traffic Management capabilities are required, as in Enterprise and Central Office switches, Digital Subscriber Line Access Multiplexers (DSLAMs), and ATM linecards for routers and switches. The second generation ABMP PXB 4330 V2.1 targets the next generation of multi-service platforms with combined ATM cell and packet handling requirements.

Special features are implemented to allow performance-optimized interworking of ATM and higher layer traffic management and flow control schemes. These features include a new Enhanced Rate Control (ERC) unit that provides a powerful mechanism to achieve maximum link utilization by rate adaptive schemes such as Available Bit Rate-Explicit Rate (ABR-ER), ABR-Virtual Source/Virtual Destination (VS/VD) and Reactive Switch Control (RSC), and full Variable Bit Rate (VBR) shaping support.

This paper first describes the traffic management trend from the Internet Protocol (IP) perspective. Then, it identifies how ABMP can benefit network administrators and system designers. Afterwards, it analyzes the characteristics and requirements of three applications:

- Multi-Service Access Switches
- Digital Subscriber Line Access Multiplexers
- Third Generation Wireless Radio Network Controllers

Finally, this document shows how ABMP meets the requirements of these applications to establish it as an ideal solution for each of them.

The intended audience for this article includes system architects, hardware designers, and technical managers.

2 IP-Centric View of Traffic Management

In recent years, with the explosion of data traffic running on Internet Protocol (IP), IP services have been increasingly carried on Asynchronous Transfer Mode (ATM) networks to take advantage of the capabilities of ATM technology. ATM offers strong support for Quality of Service (QoS) and traffic management and, therefore, is deployed by most network service providers in their transport infrastructure and at service access points. With the dominance and growing trends of IP services, it becomes natural for service providers to discuss Service Level Agreements (SLA) with their customers in IP-centric terms. Service providers will also need a comprehensive IP-centric transport solution that delivers QoS and traffic engineering capabilities.

The Data Link Protocol (Layer 2) and the Transport Control Protocol (TCP, Layer 4) have their own flow control mechanisms. It is no longer sufficient to offer a QoS mechanism that works well only at its respective layer. The traffic management challenge is to make the TCP congestion avoidance mechanism aware of its effects on the ATM flow control scheme. This requires the coupling of Layer 2 and Layer 4 traffic management functions. With such provision, the interworking between ATM and IP networks (IP-over-ATM) affords service providers more flexibility to differentiate their services and to be more cost effective.

Two system devices especially demand interworking between ATM and IP networks:

- WAN Edge Multi-Service Switch
- Enterprise/campus Multi-Service Switch

The first one is WAN Edge Multi-Service Switch. In a typical multi-service network, carriers build edge routers around an ATM backbone that is used for router interconnection (**Figure 1**). The fact that ATM is designed to support multiple service classes makes it an excellent platform for a multi-service network. The WAN Edge MSS is located at the edge of the backbone as an interface to ATM networks aggregating different types of customer lines and services. In order to enhance the scalability and management of multi-service networks with this IP-over-ATM topology, the Internet Engineering Task Force (IETF) proposed the Multiprotocol Label Switching (MPLS) technology. Essentially, in an MPLS-enabled ATM network, the management employs IP addressing and routing algorithms to establish Label-Switched Paths (LSP) between ATM switches. The IP packets are then segmented into ATM cells and switched along the LSPs according to the labels. An MPLS-enabled Edge MSS has the function of adding labels to egress ATM cells and removing labels from ingress ATM cells. By means of Label Distribution Protocols such as RSVP, an Edge MSS is also able to request bandwidth from ATM backbones and guarantee the QoS requirements for IP-routed traffic. Thus, service providers can maximize service flexibility by utilizing the available bandwidth in the ATM network.

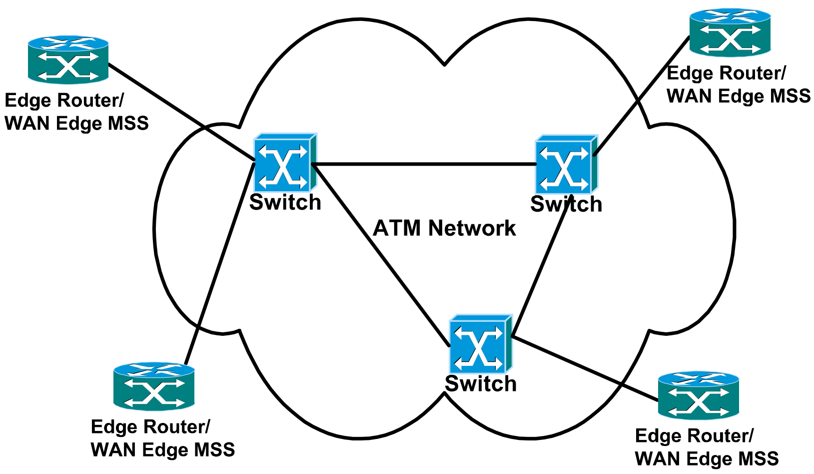

Figure 1 IP-over-ATM Network Model

Another type of equipment that requires flexible IP-over-ATM traffic management capabilities is the Enterprise/campus Multi-Service Switch. This kind of Multi-Service Switch (MSS) can be characterized as supporting service convergence in an enterprise environment. As shown in **Figure 2**, the typical goal is to converge different LAN networks with voice/fax services, leased lines or Virtual Private Networks (VPN) to external sites, remote access (dial-in) equipment, company proprietary systems, and the MAN/WAN uplink. Most Enterprise MSSs today are centered around an ATM cell-based backplane. There are two main reasons for this. First, it is easier to switch cells than packets. Second, the ATM Adaptation Layer (AAL) is highly flexible to adapt any technology that is in place to transport any traffic via an ATM backplane. An MSS also provides routing functionality, typically on a central packet forwarding module.

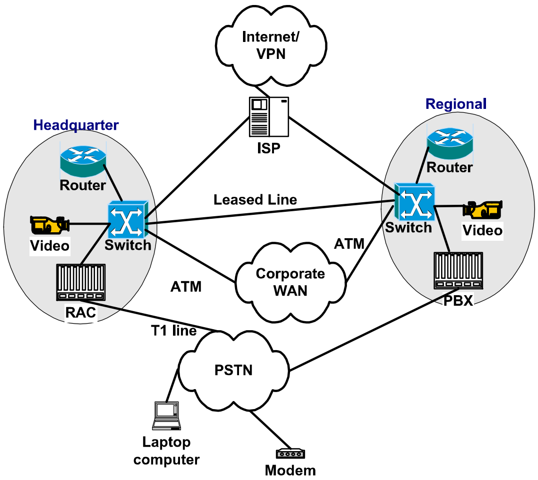

Figure 2 Typical Enterprise Network

As one might have noticed, the above-mentioned MSS systems require complex IP-ATM interworking functionalities as well as traditional ATM traffic and buffer management—including packet discard, rate adaptive services, traffic classes support, etc. Infineon Technologies' second generation ATM Buffer Manager Premium (ABMP) is targeted at the next generation of multi-service platforms with combined ATM cell and packet handling requirements. The ultimate goal of ABMP is to lower system complexity and, therefore, reduce the cost of traffic management schemes.

3 ABMP Features

The Infineon ABMP device, PXB 4330 V2.1, is well positioned with the functionality required in a variety of applications where extensive ATM and optimized IP-over-ATM traffic management capabilities are essential. **Table 1** summarizes the most important features and benefits to system manufacturers and/or service providers.

Table 1 Features and Benefits

ABMP Features	Benefits to Users
Dual leaky bucket shaping for VBR and full ABR support enables the most scalable IP-over-ATM transport service possible.	Service providers can maximize service flexibility and revenue opportunities; and offer reliable rate-adaptive QoS support.
Up to 16 traffic classes have individually selectable thresholds for service classes.	Service providers can differentiate and generate traffic classes that are not already defined or pre-configured to address specific needs of distinct users or applications. This can maximize service flexibility.
Per Queue Congestion Indication thresholds enable multi-layer TCP/IP performance optimized scheduling.	Manufacturers can coordinate cell discard function between Layer 2 to Layer 3/4 to take advantage of the TCP/IP optimized algorithms for congestion avoidance. This coordination results in fewer cell discards at Layer 2, and thus less retransmission of packets.
AAL5 SAR supports insertion and extraction of packets to/from ATM dataflow.	Manufacturers can eliminate an external FPGA or offload CPU bandwidth to handle AAL5 SAR functions for signaling and management purposes. This saves board development time and board space.
VC merge function for up to 128 merge groups allows efficient IP to ATM interworking and MPLS implementations.	Manufacturers can eliminate an external FPGA to serialize packets from different sources switching to the same label. This saves board development time and board space.
Speed up factor of 1.27 at Utopia upstream and downstream receive interface.	Manufacturers can save external memory to buffer occasional data bursts from PHY devices or backplane devices without the risk of dropping cells.

4 Applications of ABMP

This section analyzes the traffic management requirements in a Multi-Service Switch and describes how ABMP addresses those requirements. Additionally, the discussion extends to cover DSLAM and third generation (3G) Wireless radio network controllers.

4.1 Multi-Service Switch (MSS)

An MSS aggregates different kinds of services. Therefore, such a system needs to support a large variety of network modules or Line Interface Cards (LIC) with many kinds of physical port and protocol processing. Furthermore, the system must provide sufficient resources to perform a large set of protocol interworking and gateway functions. An example of an MSS is shown in **Figure 3**.

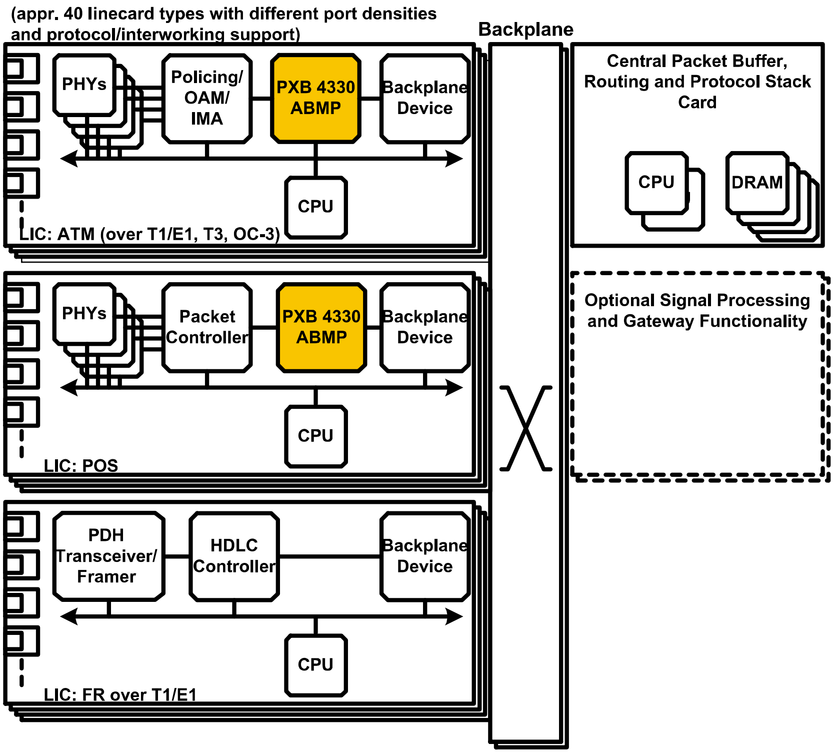

Figure 3 Multi-Service Switch

Typical IP-based applications include voice, video, file transfer, web browsing, and emails. These applications can be easily mapped to ATM traffic classes. In order to fulfill QoS requirements, real time applications (such as phone calls or video conferencing) are given higher priority to use the network. Remaining un-utilized bandwidth will be shared among other lower priority applications (such as web browsing). The amount of un-utilized bandwidth needs to be indicated to the sources to enable adjustment of the rate of transmission. These applications belong to the Available Bit Rate (ABR) service category that uses an ATM Layer control loop to convey bandwidth information along a connection. The transmission rate at the source adapts to the congestion of the network and, hence, efficiently utilizes the network bandwidth. In addition to ABR and five other service categories defined by The ATM Forum, network administrators often differentiate themselves from competitors by offering new services that have traffic descriptors different from the pre-defined CBR, VBR, etc. This requires the transport infrastructure (ATM in this case) to have the ability to support non-native traffic classes, such as “packet hop behaviors” without much difficulty. Moreover, to fully optimize IP-over-ATM traffic, the lower ATM Layer must notify the upper TCP Layer about the condition of the network. This enables the TCP Layer flow control scheme to control the rate of packets passing to the ATM Layer and, therefore, reduces the chances for the ATM Layer to discard parts of packets in congested situations. Packet discard triggers re-transmission, which may further aggravate congestion.

In MPLS implementations, an MSS requires different Virtual Connections (VC) to merge on packet boundaries at the switch ingress and overwrites cell headers with a new VCI value or label at the switch egress. This function is generally referred to as “VC merge”. Another MPLS requirement is for MPLS traffic to have different queues on the switch from other ATM traffic. This means the MSS must handle queues that directly support the MPLS “Class of Service” concept and ensure QoS for delay-sensitive traffic while meeting strong fairness criteria.

The ABMP is designed to work well inside a Multi-Service Switch for several reasons:

- VC Merge function is supported
- The Enhanced Rate Control unit supports all ABR feedback options
- The Queue Congestion Indication (QCI) provides a serial interface to pass congestion information to an upper layer packet scheduling unit
- Flexible queuing and scheduling configurations adapt to changing traffic profiles and new MPLS classes of service

VC Merge Support

The ABMP supports the VC merge function. Users can establish up to 128 logical VC Merge groups. A connection can be assigned to a queue which is in the group. A new egress label is optionally overwritten to all the connections in the group.

Enhanced Rate Control Unit

The ABMP has a dedicated Enhanced Rate Control unit to support all feedback options of ABR behavior as described in the Traffic Management Specification 4.1 [1] of The ATM Forum. These options are summarized in **Table 2**. The complexity of the option increases from top to bottom.

Table 2 ABR Support of ABMP

Feedback Options	Description
Explicit Forward Congestion Indication (EFCI) Marking	Setting the PTI bits in the user cell header to “congestion experienced”
Relative Rate Marking	Setting CI and/or NI bits of forward and/or backward Resource Management (RM) cells to 1 (binary feedback)
Explicit Rate Marking	Reducing the Explicit Rate (ER) field of forward and/or backward RM cells
Reactive Switch Behavior	Explicit rate marking and additional reduction of the transmission rate of user cells to the ER
Virtual Source/Virtual Destination (VS/VD) control	Segmentation of the ABR control loop using a virtual source and destination

For ABR traffic, special cells—called Resource Management (RM) cells— are inserted at regular intervals by the source of a connection or by virtual sources. All switches along the connection update the congestion information fields of RM cells using one of the options (except the first one) shown in **Table 2**. At the receiver end of the connection and the virtual destinations, the RM cells are switched back to the source.

Queue Congestion Indication

The Queue Congestion Indication (QCI) of the ABMP provides a serial interface to pass congestion information of up to 8192 queues to an upper layer packet scheduling unit. Queue status information can generally be obtained by reading on-chip registers. However, for a large number of queues and typical time constraints of control loop mechanisms, software-based queue monitoring is not feasible.

Flexible Queuing and Scheduling Configurations

The ABMP has extremely flexible queuing and scheduling configurations that can adapt to changing traffic profiles and new MPLS classes of service. The service classes are not hardcoded to specific queuing and scheduling functions in the device. Hence, if additional traffic classes are defined, users can program the device such that a connection is assigned to one of the 8192 queues, which in turn are individually assigned to one of the 128 schedulers per direction. The queue thresholds are freely selectable per traffic class, and the schedulers have a wide range of data rates. Weighted Fair Queuing ensures that the appropriate share of data rate is allocated to each service class and prevents starvation of any service class. Scheduling can be applied on the aggregate of MPLS connections that share the same service class.

Figure 4 shows an application example of ABMP on a Multi-Service Switch linecard.

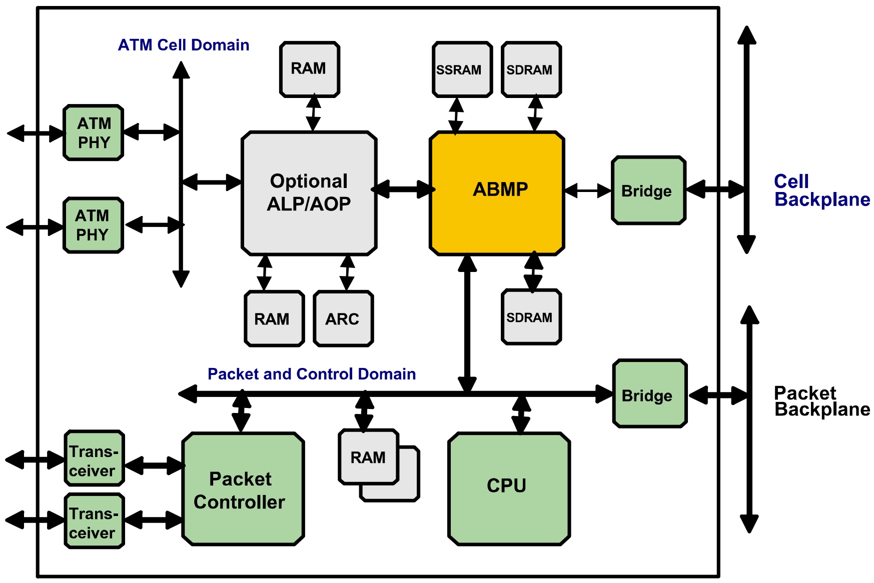

Figure 4 ABMP Application Example: Multi-Service Linecard

4.2 Digital Subscriber Line Access Multiplexer (DSLAM)

There are two main categories of traffic management architecture in Central Office DSLAM equipment: Centralized and Distributed. **Figure 5** shows a typical Centralized DSLAM system in which the traffic management functions—policing, buffering, scheduling, etc.—are entirely contained on the OC-12 uplink card. There are 20 xDSL linecards with 12 ports each. No traffic management takes place on the linecards. This architecture reduces the cost of the linecards and minimizes the software complexity of the system.

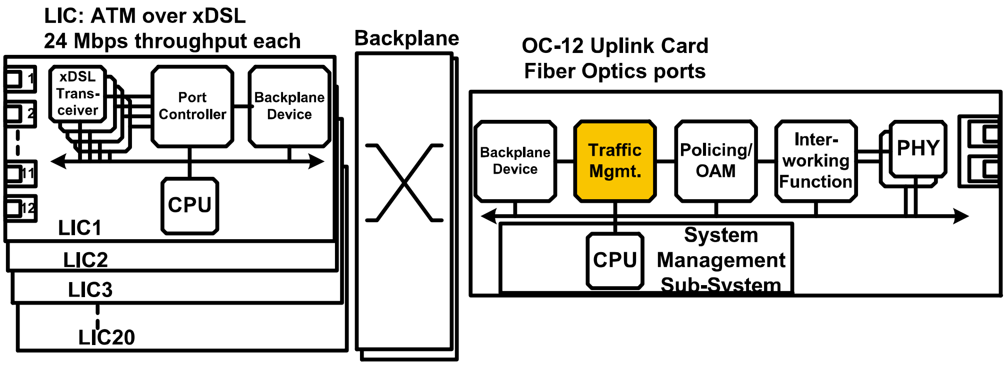

Figure 5 DSLAM Centralized Architecture

The other DSLAM solution uses a distributed approach in which the traffic management functions are implemented on some linecards as well as on the uplink card, as shown in **Figure 6**. The distributed architecture offers easy upgrade and scalability to the system. The buffering on linecards allows the aggregate sum of user traffic to exceed the maximum throughput of the uplink card.

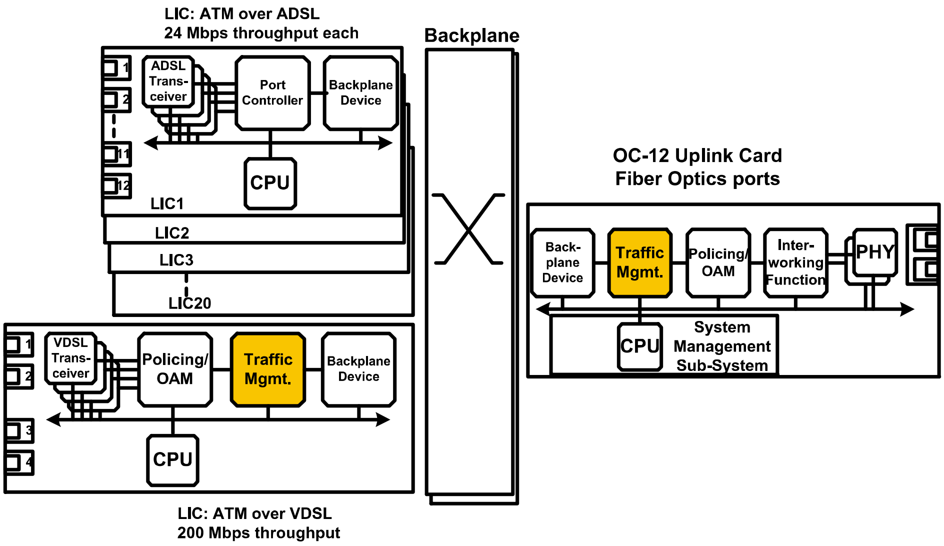

Figure 6 DSLAM Distributed Architecture

With VDSL and SHDSL gaining popularity, DSLAM is going to carry more than voice and data frames. There will be more high speed Variable Bit Rate (VBR) applications such as real time streaming video. No matter which architecture is used, the traffic manager must be able to handle CBR (voice), VBR-rt (video), VBR-nrt (interactive video), GFR (data frames), and UBR (low priority data) services. Thus, the ideal traffic management functions should include VBR shaping for VBR traffic and packet discard for GFR traffic to ensure QoS. For a centralized architecture, a higher number of schedulers is desirable to allow more ports on the linecards.

The ABMP satisfies all of the these requirements. For shaping of VBR connections, the ABMP provides an optional Peak Rate Limiter and Dual Leaky Bucket shaper for individual queues as part of the scheduling function. The leaky bucket algorithm is used to measure the cell traffic coming from the user and conforms to the parameters specified in an SLA. When GFR traffic is served, the Early Packet Discard (EPD) and Partial Packet Discard (PPD) functions can be enabled on a per-class basis. The “selective cell discard” mechanism, based on the CLP bit in cell headers, guarantees QoS for high priority traffic by discarding low priority packets in buffer overload situations. The ABMP looks at the PTI bits of the cells to determine the packet borders of the upper SAR Layer.

The ABMP has 256 schedulers (128 in the upstream direction and 128 in the downstream direction). When the chip is used in a DSLAM distributed traffic management architecture, the ABMP on the uplink card can schedule up to 128 linecards in Bi-directional Mode with 2 x 622 Mbps throughput or it can schedule up to 256 linecards in Uni-directional Mode with 622 Mbps throughput. Up to four ABMP chips can be cascaded to expand the number of supported linecards. Similarly, the ABMP on a linecard can schedule up to 128 or 256 ports, depending on the directional mode.

In a centralized architecture, the ABMP can be configured to Uni-directional Mode, as shown in **Figure 7**. In this example, each xDSL device is assigned to a separate scheduler. Thus, 255 xDSL devices can be connected. The 256th scheduler will be occupied by the T3 uplink to the public network. The assignment of the schedulers to the PHYs is totally independent and even a strong asymmetrical structure can be supported.

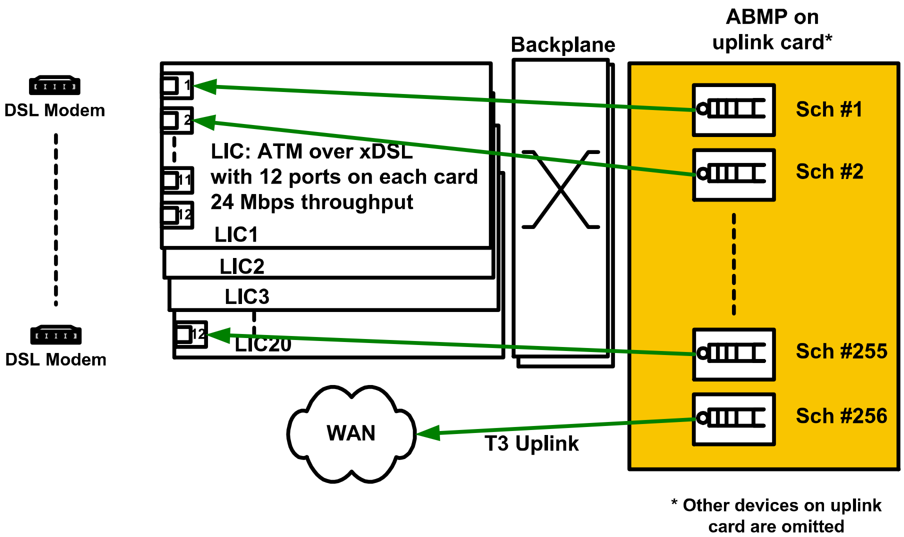

Figure 7 ABMP Application Example: DSLAM

4.3 Third Generation Wireless Radio Network Controller

Figure 8 shows the basic third generation (3G) wireless infrastructure. The Base Transceiver Stations (BTS) transmit and receive radio signals to and from cellular devices. The Radio Network Controller (RNC) links to multiple BTS and other network elements. The user data is carried between the RNC and the BTS using ATM cells running on T1/E1 lines, DS3 lines, or SONET rings. At the RNC, various linecards or Exchange Terminals (ET) terminate different types of physical transmission lines and frame/map the data stream.

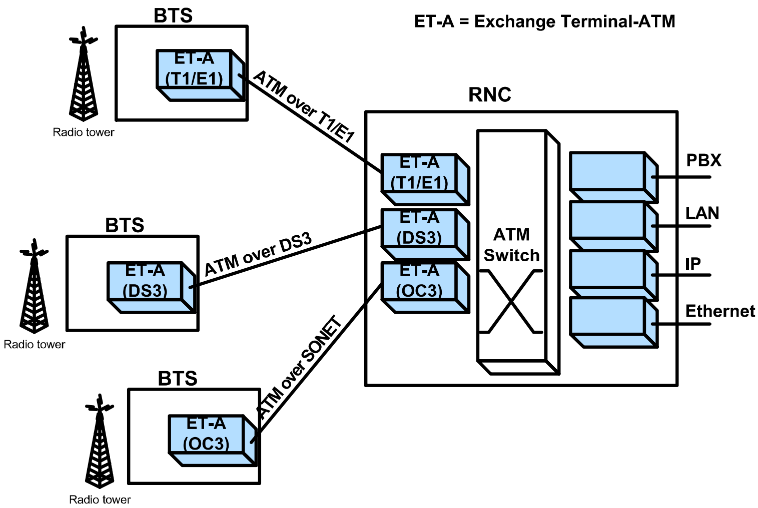

Figure 8 Basic 3G Infrastructure

On an STM-1 linecard, such as shown in **Figure 9**, buffering and scheduling are done in the downstream direction towards the BTS because there is limited receive buffer in mobile devices and there is limited radio link bandwidth. In the upstream direction towards the ATM switch, typically buffering and scheduling are not necessary because the uplink bandwidth is higher. Therefore, only policing is provided by the ABMP chip to guard against abusive resource usage. The ALP chip is Infineon's ATM Layer Processor for policing and header translation. The AOP chip is Infineon's ATM OAM Processor. An external device processes AAL2 and AAL5 data before switching it to the appropriate data or voice networks.

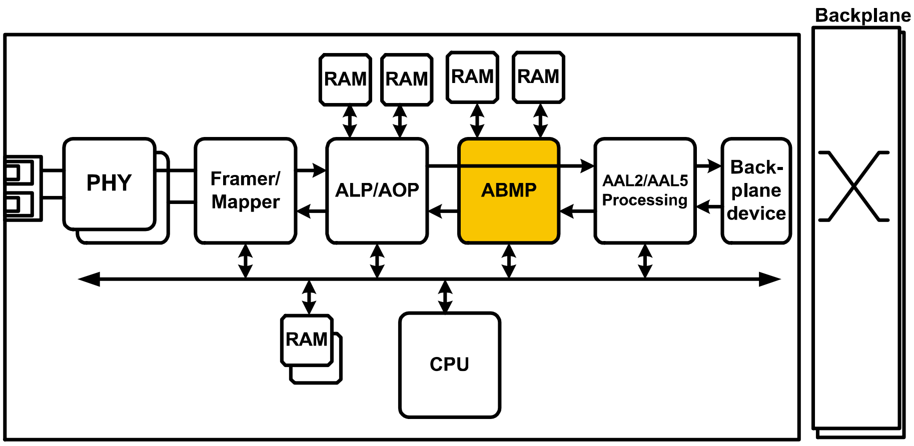

Figure 9 ABMP Application Example: RNC Exchange Terminal

The 3G infrastructure has similar traffic characteristics and buffer management requirements as in DSLAM. Thus, the ABMP is very well suited to RNC linecards.

In all ATM applications, connections are set up using signaling protocols that are routed on AAL5 packets. To facilitate the AAL5 SAR process and to offload the microprocessor, the ABMP has an AAL5 Assistant Unit that allows insertion and extraction of AAL5 segmented packets from and to the Microprocessor Interface. The unit then duplicates or strips the ATM cell headers and completes or checks the AAL5 trailer. Minimal software configuration is required on the ABMP or the microprocessor.

5 Conclusion

Today, specific traffic management mechanisms are used to satisfy certain QoS requirements, typically within individual network domains. In order to deliver a robust solution to service providers, it is absolutely mandatory to support interworking of different network element traffic management schemes. The ABMP PXB4330 V2.1 provides exceptional ATM traffic management capabilities and optimizes IP-over-ATM traffic. It fully addresses the combined ATM cell and packet handling requirements in next generation multi-service platforms including Multi-Service Switch, DSLAM, and 3G Radio Network Controllers. For further information about this device, please visit our web site at www.infineon.com/atm or contact Infineon Technologies representatives worldwide.

6 References

[1] ATM Forum Technical Committee, "*Traffic Management Specification Version 4.1*", AF-TM-0121.000, March 1999.