QoS Enabled IP Transport in UMTS Networks

Applying QoS strategies on different interfaces along the UMTS datapath.

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UMTS is one of the third generation mobile systems being developed based on GSM and GPRS. GSM can only offer limited data services such as short message. The quality of service of these data services is provided by fixed circuit-switched architecture.

GPRS is an improvement of GSM to accommodate the huge data increase in mobile networks and handle the busy type of data flow. It can provide the end-to-end of wireless packet data services with much higher bandwidth up to about 144 kbit/s. SGSN and GGSN were introduced to consist its IP based backbone network. The QoS mechanism in GPRS is generally considered as not being fully defined from an end-to-end point of view. However under the control of a service provider, certain levels of QoS can be met in its IP core network by IP DiffServ.

UMTS enhances the GSM and GPRS from all aspects to provide a broadband multi-media mobile service whose data rate has a potential up to 2Mbit/s. Its infrastructure needs to accommodate various types of applications on the same medium. The requirements vary significantly for these types of traffic in terms of bandwidth, delay, and loss rate. These trends demand the use of an efficient and scalable end-to-end QoS mechanism.

3GPP defines an end-to-end bear service that is characterized by a series of QoS attributes in PDP context to provide UMTS QoS. The set-up of a QoS profile is initiated by the user equipments and negotiated along the datapath as a part of the PDP context establishment. There are four UMTS QoS classes: conversational class, streaming class, interactive class, and background class.

End-to-End QoS Solutions

UMTS products consist of three interacting domains: User Equipment (UE), UMTS Terrestrial Radio Access Network (UTRAN) and Core Network (CN). UTRAN is a combination of Radio Network Controller (RNC) and the Node-B. The Node-B complies 3GPP Release 99 W-CDMA specification. The interface between Node-B and RNC is ATM based Iub. The RNC connects to the 3G CN via ATM based Iu interface. The core network consists of two domains: Circuit Switched (CS) domain and Packet Switched (PS) domain. The CS service is provided by two components in the CN, namely MSC and GMSC. The PS service is provided by another two components: SGSN and GGSN.

UTStarcom deploys an expandable multi-chassis architecture in UMTS nodes including RNC, SGSN, GGSN, MSC and GGSN. The number of chassis is determined by the required capacity of the node and it can grow up to 20. This IP-based distributed system shall demonstrate a good extendibility if the 3GPP standard is being evolved from ATM based Release 99 to IP based Release 5. The transition can be easily realized by simply replacing ATM interfaces to IP interfaces because the packet transport is already IP based within each UMTS node.

QoS can be achieved by deploying over provisioning, InterServ or DiffServ techniques. In DiffServ, classification, admission control, and policy enforcement are applied at edge devices as well as queuing and scheduling are applied on the core network to provide a no-blocking wire-speed switching. This article focuses on the DiffServ application and presents a QoS solution in which the different QoS strategies are applied on different interfaces along the UMTS datapath. The details are summarized as follows:
&#149 For the traffic switched in a UMTS node, QoS is provided by VLAN 802.1Q.
&#149 QoS on Iub, Iur and Iu-CS interface are guaranteed at ATM level.
&#149 QoS for Iu-PS Bearer Service is offered by IP DiffServ over ATM.
&#149 QoS for UMTS CN Bearer Service is achieved by IP DiffServ over MPLS.
&#149 SLA for external bearer service.
The described QoS solutions are fully complied with the 3GPP standard TS23.107.

QoS Implementation within UMTS Nodes

UTStarcom's UMTS nodes including RNC, SGSN, GGSN, MSC and GMSC, all have a similar internal architecture in which all processing modules within a chassis are connected together via a switching board by using point-to-point fast Ethernet links. When a node spans across multiple physical chasses, a concentrator switch is used to connect the switch boards in different chasses via Gigabit Ethernet. QoS requirements are all met by Layer 2 VLAN 802.1Q. A logical architecture of RNC is illustrated as an example in Figure 1.

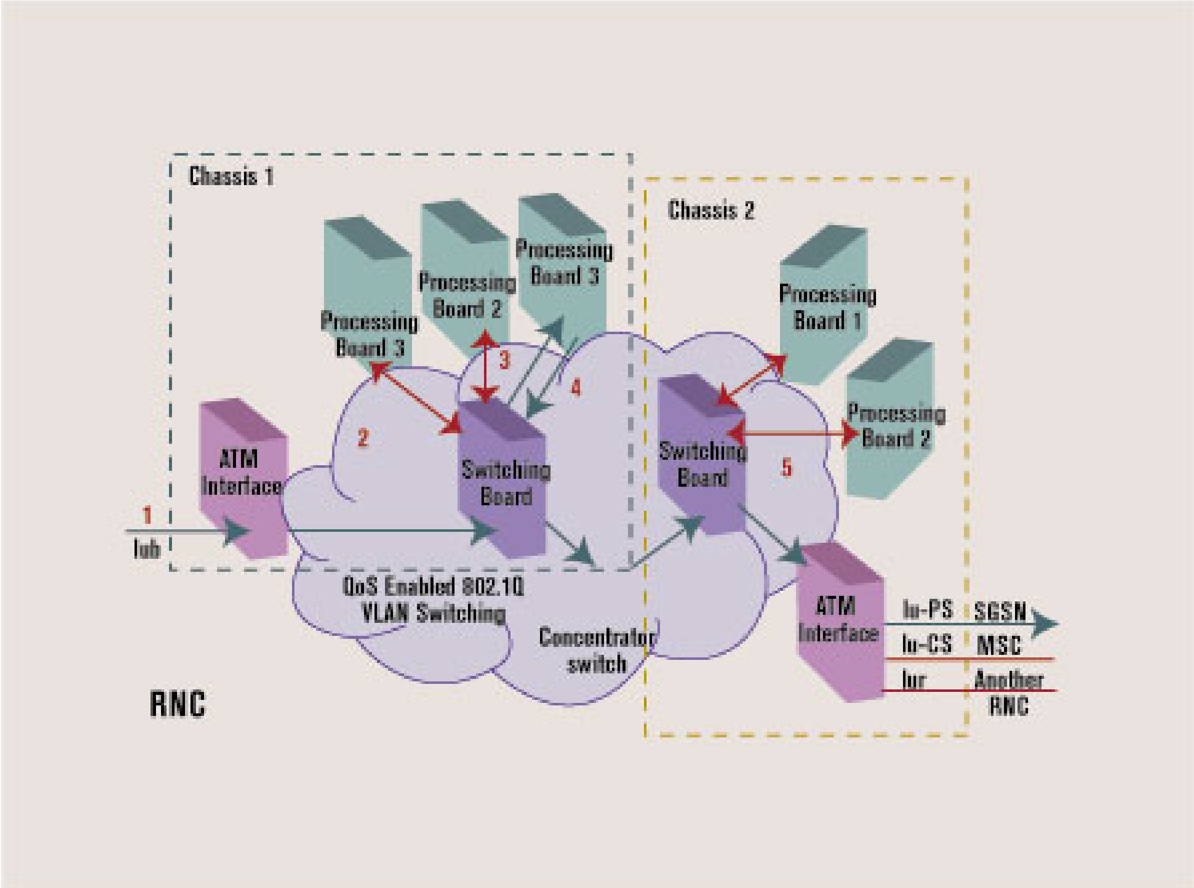

Figure 1. Architecture of RNC and its QoS Solution.

The frame processing alone, the datapath, in RNC is shown in Figure 2.

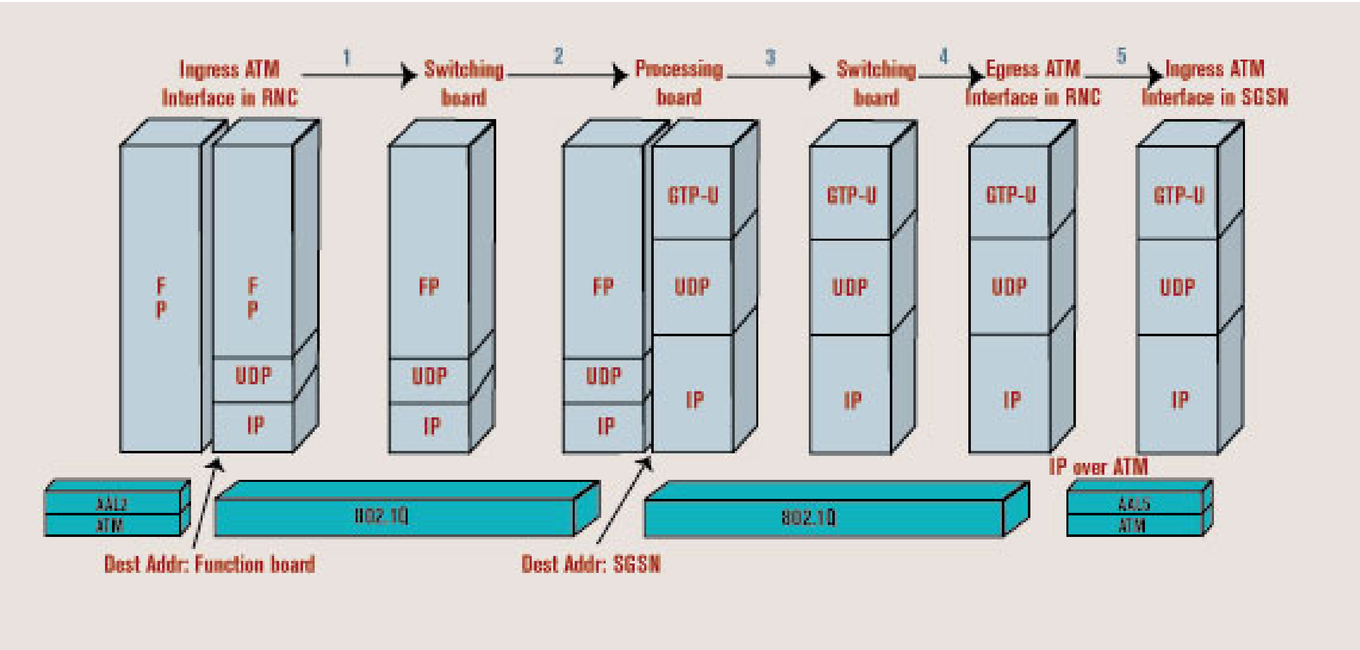

Figure 2. Frame Processing in RNC

For uplink user data flow, the packets come in from Iub through the ATM interface board. Ingress port of the ATM interface performs layer 2 VC-based classifications because the VCs are respectively pre-allocated for signaling, voice or data. The arriving packets will be assigned a DSCP value provisioned on the ingress port. The packets will be then forwarded to a processing board. This processing board performs the actual user plane processing in RNC. Voice and data packets will be split here for being dispatched to MSC and SGSN separately. It also maps UMTS bearer service attributes in PDP context to DSCP value. If the ATM interface board and destination processing board are not in the same chassis, the packets will be switched by a concentrator switch.

VLAN 802.1Q standard specifies a tag that appends to a MAC frame. The VLAN tag carries VLAN information and the tag has two parts: the VLAN ID and prioritization that allows packets to be grouped into 8 different traffic classes. VLAN has many benefits such as flexible network segmentation and increased performance. These benefits can be achieved by using an optimized VLAN partition. With the described QoS and VLAN mechanisms, the layer 2 switching ability in a UMTS node can be greatly enhanced.

QoS Implementation on Iub, Iur and Iu-CS interface

QoS requirements are met at the ATM level for Iu-CS, Iub, and Iur interfaces in Release 99. ATM has a rich set of QoS provisioning and enforcement mechanisms. It offers QoS and traffic management capabilities that will be suited for certain types of service by controlling over the bandwidth, latency, jitter, and cell loss. To control the various types of network traffic, ATM standards define four types of service categories: CBR, VBR, ABR, and UBR. These can be deduced and mapped from Radio Access Bearer attributes.

QoS Implementation on Iu-PS interface

Even ATM has its claims to provide QoS assurance, it however cannot do anything above layer 2. In other words, ATM cannot differentiate all layer 3 flows that have been aggregated together.

IP over ATM can implement finer granularity in the control of traffic flows in layer 3. It uses ATM high-speed ability to provide for better wires between IP members. In IP over ATM, IP datagrams are encapsulated in AAL5 using IETF RFC1483 LLC/SNAP encapsulation as the default. Up to four virtual circuits can be created for ATM Iu-PS interfaces. Each of these VCs are provisioned with a different set of QoS parameters that control how traffic for the VCs share the resources such at node buffer space and link bandwidth on the path of interface. Upon network congestion, traffic assigned to a VC with a lower service priority will be dropped before traffic assigned to VCs with higher service priorities.

QoS Implementation in UMTS Core Networks

The combination of DiffServ and MPLS presents a very attractive strategy to core networks. DiffServ provides edge-to-edge QoS while MPLS provides fast packet forwarding and evenly distribute traffic load.

MPLS is an integration of layer 3 routing with its proven scalability of network size and layer 2 switching with its high performance. It can offer traffic engineering to control the flow of packet across a layer 2 infrastructure and support load balancing.

In the IP DiffServ over MPLS model, the 3-bit precedence field of the IP header is copied into the 3-bit ESP field in MPLS header. This allows the router to support up to eight service classes within the MPLS network. All appropriate QoS operations including matching, marking, policing, shaping, dropping, queuing and scheduling will be invoked by a given EXP value. SGSNs and GGSN in the UMTS core networks are configured as DiffServ edge router and MPLS Label Edge routers. This solution provides the strong IP DiffServ and MPLS functionalities.

Mapping Between UMTS QoS Classes and DiffServ DSCP

DiffServ defines the following Class of Service: Expedited Forwarding (EF) class, four independent Assured Forwarding (AF) classes, and Best Effort Forwarding (BEF) class. Within each AF class, three levels of drop precedence are defined. EF can be used to build an end-to-end service with assured bandwidth to simulate a virtual leased line. The mapping from UMTS traffic classes to DSCP is performed on a processing board in RNC. Table 1 shows a default mapping relationship.

SLA for External Bearer Services

To realize a certain network QoS, a bearer service with clearly defined characteristics and functionality is to be set up from the source to the destination of a service. If the service crosses different networks, SLA needs to be established on the borders (GGSN or BG) for interoperability. SLA is an integral part of the DiffServ architecture. It establishes the policy criteria and defines the traffic profile. It is expected that traffic will be policed and smoothed at egress points according to the SLA.

Conclusions

As an end-to-end UMTS solution provider, we present a complete QoS solution in which different QoS mechanisms are applied on the different interfaces to achieve a best customer satisfied service. QoS on Iub, Iur and Iu-CS interface are met at ATM level. IP DiffServ over ATM is implemented on Iu-PS interface. In UMTS core network, QoS are guaranteed by using IP DiffServ over MPLS. In addition, UTStarcom deploys an IP-based distributed system where layer 2 QoS is provided by VLAN 802.1Q within each UMTS node. This architecture shall demonstrate its good flexibility and expendability when UTRAN is moved from ATM based to all IP based.