A QOS MANAGEMENT ARCHITECTURE IN HETEROGENEOUS WIRELESS NETWORKS ENVIRONMENT

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Abstract: This paper describes an architecture for the provisioning of QoS for mobile terminal in the heterogeneous wireless environment. The core network will be an enhanced DiffServ network providing several dynamically manageable traffic classes with specific QoS parameters, per hop behavior, and other requirements that realize different traffic handling for different network services to be requested. In order to provide the QoS support for end-user, the overall architecture for QoS management is required in heterogeneous wireless environment, where various hosts are connected to the different access network through the core network. The proposed architecture is based on the differentiated services, in that traffic are aggregated and forwarded in core network based on per hop behaviors. This paper also proposes the QoS management functions which are the IAQM and the AQM to provide consistent QoS management over an integrated wireless access network environment. And we evaluate the performance of proposed QoS mapping mechanism. The simulation result shows that the QoS for each session is guaranteed more effectively and this mechanism provides an end-to-end QoS between different access networks.

1. INTRODUCTION

Future heterogeneous wireless environments will be characterized the coexistence of a large variety of wireless access technologies, with different protocol stacks and supporting a number of applications and services with different QoS requirements to be provisioned to terminals with different degree of multi-mode capabilities to access the available networks [1]. Each mobile station and radio access network characterized by the specific air interface technology, cell size, multiple access scheme, coverage, mobility type, etc [2].

In addition to that, the future wireless system will depend on the concepts and technology innovations in architecture and in efficient utilization of spectral resources. There will be a substantial need for more bandwidth as wireless applications become more and more sophisticated. This need will not be satisfied by the existing frequency bands being allocated for public mobile radio even with very evolved and efficient transmission techniques. The measurement results have shown that wide ranges of potential spectral resources are used only very rarely. In the presented approach that is called spectrum pooling, different spectrum owner bring their frequency bands into a common pool from which rental users may rent the spectral resources. The spectrum pool was first mentioned in [3], which reflects the need for a completely new way of radio resource management. And many materials discuss the spectral efficiency gain that is obtained with the deployment of spectrum pool [4].

In this heterogeneous environment, the Always Best Connected (ABC) concept points out a seamless communications experience, in which users specific their personal preferences and connectivity is provide through the particular access network. Recent advancement within research and standardization provide the key enabler of such seamless heterogeneous communication systems including advanced handover mechanism, radio QoS solutions, context transfer, and cross layer optimization with L1 and L2 trigger support.

In a heterogeneous wireless network environment, the user applications performance could easily deteriorate due to various reasons and fluctuation of performance could not be acceptable. Hence, the QoS, which aims to hide lower layers’ variation from applications and provides necessary service guarantees, comes to the core.

There is a growing consensus within the industry and the academia that future wireless system will be based on access technologies that may be different in terms of QoS/mobility capabilities, availability, capacity, cost and other features. At the
network layer, there is the Internet Protocol (IP) as an integration technology that allows application developers and service providers to offer an increasing variety of services. The IP is already a universal network-layer protocol for the Internet and is becoming a promising network layer protocol over all wireless system as well. It provides unique addressing and packet routing services and acts as a common platform for service and applications. Therefore the IP is the solution that integrates all the wireless access networks.

To provide the QoS in the wireless network, many unique issues related to heterogeneity and mobility should be studied. Moving from on access network to another, users might interact with different service operators which differ from the network capacity, channel characteristics, a QoS management mechanism, and policies.

The DAIDALOS project [5] aims at providing an integrated architecture for multiple network technologies, both wired and wireless, with quality of service capabilities under a common authentication, authorization, accounting and charging framework. The AQUILA project [6] proposes the architecture of QoS over IP network, it also defines and evaluates the QoS architecture including extra layer for resource control. In [7], the authors propose the research issues related QoS management and the state-of-art QoS techniques over heterogeneous environment. It also summarizes the standardization activities and the framework for QoS management over heterogeneous environment. The G. Karnal et al [8] presents a new architecture would help in achieving end-to-end QoS requirements of an application which is being served in IEEE 802.11e/WiFi network. In [9], the policy-based multi-domain QoS management architecture is proposed and UMTS and WLAN interworking scenarios are described. The Park et al [10] propose the end-to-end network QoS architecture engaged in IEEE 802.11e MAC, emphasized that different QoS granularity between DiffServ and IEEE 802.e should be resolved by hierarchical QoS architecture using two-level priority queues.

This paper presents the next generation wireless network architecture, especially focuses on the QoS management architecture and the QoS mapping mechanism in heterogeneous wireless network environments. Then we simulate the QoS management mechanism and evaluate performances of the QoS mapping mechanism between UMTS and WLAN as an example. The rest of this paper is structured as follows. In section II, a description of the system architecture and the QoS management structure are present in heterogeneous wireless network environment. The QoS mapping mechanism between access network and IP core network is described in section III, we explain the QoS mapping mechanism between WLAN and UMTS, especially. In section IV, we describe simulation environment base on NS-2 and performance evaluation of the proposed QoS management mechanism. Finally, conclusion is given in section V.

II. PROPOSED SYSTEM ARCHITECTURE

A. System Architecture

The system interworking concept of emerging wireless network is convergence and heterogeneity. The core of the next generation infrastructure is expected to be the IP based multi-service network that provides connectivity and transport thorough radio access technology, including legacy 3G, 3G LTE, WiMax, WLAN, and emerging technology. The multi-access infrastructure supports services and users having a wide variety of multi-access capable terminals. The Common Radio Resource Management (CRRM) is responsible for coordinating and managing the radio resources between access networks. The Cognitive/Common Pilot Channel (CPC) server and CPC BS broadcasts the deployed information of radio access network provided by the spectrum broker, the spectrum broker manages the spectrum allocations and spectrum usages according to the operator’s policies and regulations. Figure 1 illustrates the system architecture in heterogeneous wireless network environment.

B. Policy based QoS management Architecture

Since the users in next generation wireless networks are expected to be mobile user, the QoS architecture should support mobility aspect and the QoS protocol should not cause high signaling overhead nor cause roaming users to experience sudden QoS degradation because of moving to a new access network. For the given requirements, it is necessary for a network operator to guarantee the QoS of services and effective QoS management architecture.
The QoS architecture is required to ensure inter-operability of each access network QoS mechanism with external networks, and to provide a simple and flexible method to guarantee the required service quality. It should be easily extensible with minimum affecting of the inter-operability between access networks.

Based on these requirements, we propose the QoS architecture for next generation wireless network based on DiffServ model. The system architecture proposed in this paper is composed of the Access Network QoS Manager (AQM) controlling local QoS in each access network and Inter-AQM (IAQM) controlling QoS between heterogeneous access networks. Through the architecture having hierarchical relationship between IAQM and AQM, an optimal QoS and service continuity could be provided. The IAQM which are proposed in this paper may be located in Policy and Charging Rule Function (PCRF) and interface with other functions in 3GPP evolution system. And the AQM may be located in each access network to manage QoS and resources.

As mentioned above, the AQM is in charge of control QoS for specific access network. Therefore, it interfaces with radio resource management and session management functions to manage QoS of network resource and all the sessions. In contrast to that, the IAQM is in charge of a QoS coordination function between heterogeneous access networks in case of inter-access network handover. The IAQM interfaces with AQMs and other functions to check resource allocation status of target access network as well as degree of network congestion. It also interfaces with other functions to take subscription information and user preference. And the IAQM deduces an optimal QoS parameter set for ongoing session based on previously described conditions. In addition to that, it instructs some kinds of handover preparation procedures (e.g. authorization in target access network) to other functions to reduce the overall handover delay. The IAQM also interfaces with other IAQM managed by different operator to provide functions described previous paragraphs. The Conceptual Model described in this section is illustrated in Figure 2.

Fig. 2. A conceptual model for the QoS management

As described in previous paragraphs, the main functions of AQM and IAQM are as follows:

- AQM:
  - Local QoS manager
  - QoS Context manager

The AQM consists of local QoS manager and QoS context manager to perform QoS management in specific access network. The local QoS Manager performs resource allocation/management and session management for each service. And the QoS context manager manages the QoS profile for each service. These QoS profiles are transferred to the IAQM in case of inter access network handover.

- IAQM:
  - QoS negotiator
  - QoS parameter manager

The IAQM consists of QoS negotiator and QoS parameter manager to provide service continuity between heterogeneous access networks. The QoS negotiator performs coordination function for ongoing services between access networks in case of inter access network handover. It interfaces with AQM located in serving access network to get QoS profile for a specific ongoing service and AQM located in target access network to check network resources for requested ongoing services. It also interfaces with other functions in core network to initiate handover preparation procedures such as authorization for requested services. The QoS parameter manager deduces optimal QoS parameters considering target access network status and other conditions. It also maps the optimal QoS parameters to QoS parameters being used in target access network, and transmits them to UE for QoS negotiation in target access network in case of inter access network handover. In addition to that, the QoS parameter manager may perform a mapping function between QoS mechanism in specific access network and IP QoS mechanism.

III. QoS MAPPING MECHANISM

A. QoS support in IEEE 802.11e

Basic IEEE802.11 a/b/g standards offer only the Best Effort (BE) service to an application flow using the channel access functions like Distributed Coordination Function (DCF) or Point Coordination Function (PCF). But the IEEE802.11e standard proposes new enhanced mechanisms, which ensure the QoS to an application depending on its traffic category. The IEEE802.11e standard proposes two type of QoS mechanism, which is the prioritized QoS and the parameterized QoS, respectively. The prioritized QoS mechanism can prioritize the QoS type as 8 step classification, and the 8 step classification may be further defined by 4 step Access Category (AC) by the service. In parameterized QoS mechanism, the Hybrid Coordinator (HC) controls the media access using the various parameters according to the traffic characteristics.
The IEEE802.11e has been proposed two different types of QoS provision mechanisms, which are the Enhanced Distributed Channel Access (EDCA) and HCF Controlled Channel Access (HCCA). The EDCA is the basis for the Hybrid Coordination Function (HCF) and provides differentiated, distributed access to the wireless medium. The QoS provision is performed with AC.

The MAC Service Data Unit (SDU) will be delivered through multiple back-off instances, each back-off instance parameterized with AC-specific parameters. A station can have multiple transmission queues with different QoS parameters that determine their priorities. The EDCA has four types of channel access, each of them are AC_VO, AC_VI, AC_BE, AC_BK, respectively and each queue has its own AIFS and back-off counter. Figure 2 depicts the channel access function on EDCA.

Fig. 3. Four Access Categories (ACs) for EDCF

B. QoS Support in UMTS

The 3GPP has taken approach to the QoS provision by defining four separate QoS classes that have their own QoS attributes. The UMTS achieves QoS management using a layered architecture, with Bearer Service (BS) established between UMTS module at different layers. Each BS deals with the control signaling, user-plane transport, and QoS management. The end-to-end QoS control is possible by interworking TE/MT/BS, and external BS. To provide service differentiation, a UMTS network supports different BS that correspond to similar differentiation to that applied in the IP Core Network (CN). For QoS control with an external IP network, 3GPP dictates use of an IP BS manager within the UMTS GGSN node. The IP BS manager provides QoS control for an IP core using IP QoS mechanism. The IP QoS provision mechanism on 3GPP uses DiffServ mainly but also optionally could use resource reservation protocol (RSVP) to support end-to-end QoS. The QoS classes provided by 3GPP are conversational class, streaming class, interactive class, and background class, respectively. The conversational class provides strict delay guarantees, while the background class offers no qualitative and quantitative guarantees. The streaming class is slightly relaxed in terms of delays, to which other streaming services could to be mapped. The interactive traffic follows a request/response pattern and can only justify provide qualitative guarantee, the background class is similar to the best effort traffic consisting of bulk and asynchronous traffic flow. The end-to-end QoS mechanism on UMTS is shown Figure 1, which consists of various bearer services.

Fig. 4. End-to-end QoS Architecture in UMTS

C. QoS Support in IP core

There are two kinds of QoS management model in IP network, which are IntServ model and DiffServ model, respectively. The IntServ model provides individually QoS guarantees to each flow. For such, it needs to make resource reservation in network elements intervening in the communication. For resource reservation, the RSVP (Resource Reservation Protocol) is used. The DiffServ model embodies the approach where the flows are aggregated in service class according to specific characteristics. The packets belongs to specific classes are forwarded according to their Per Hop Behavior (PHB) associated with the DiffServ Code Point (DSCP), which included in the field Type of Service (ToS) of IP header. The PHB is classified as Best Effort (BE), Assured Forwarding (AF), Expedited Forwarding (EF). The AF has four types of class and each of class uses three types of drop precedence and the code point which could be assigned in DS field is described in RFC 2597.

D. QoS mapping mechanism

In this section we describe the QoS mapping mechanism for heterogeneous wireless network environment through a proposed QoS management mechanism. As previous described, each wireless access network is connected to the IP core network, mobile node which wishes to communicate with correspondent node (CN) should use the wireless access network and core IP network. In this architecture, we propose the QoS mapping mechanism through IP QoS mechanism such as the DiffServ mentioned previously. Namely, The QoS mapping
operation is performed between wireless access network with each QoS mechanism and IP core network with the DiffServ mechanism.

The QoS mapping operation may be occurred for end-to-end QoS provision at session setup and at attachment change in case of the vertical handover. In session setup period, the AQM configures the QoS parameters to edge router such as GGSN in each wireless access network. In vertical handover period, the IAQM interacts with source AQM to get QoS context and the target AQM to pass the QoS context for edge router configuration. This enables the access networks and IP core network to be managed through accurate end-to-end QoS control required by user applications.

In this paper, we consider IEEE 802.11e WLAN and UMTS for evaluating the proposed QoS mapping mechanism. The selection of WLAN and UMTS is only an example and other wireless access networks can be used for evaluating proposed QoS mapping mechanism according to the characteristics provided by each access network.

We use the EDCA mechanism in WLAN system, and 4 types of classes of UMTS for provision of end-to-end QoS supporting. Table I depicts the QoS mapping rules between the WLAN QoS classes and the DiffServ QoS classes. In this case, since IP packets are policed and shaped in the network layer, the QoS control can support the range of DiffServ as well as WLAN.

TABLE I
THE QOS MAPPING RULES BETWEEN WLAN AND IP CORE NETWORK

<table>
<thead>
<tr>
<th>WLAN QoS</th>
<th>DiffServ QoS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC_VO</td>
<td>AF4</td>
</tr>
<tr>
<td>AC_VI</td>
<td>AF3</td>
</tr>
<tr>
<td>AC_BE</td>
<td>AF2</td>
</tr>
<tr>
<td>AC_BK</td>
<td>AF1</td>
</tr>
</tbody>
</table>

Table II shows the QoS mapping rules between the UMTS QoS classes and the DiffServ QoS classes.

TABLE II
THE QOS MAPPING RULES BETWEEN UMTS AND IP CORE NETWORK

<table>
<thead>
<tr>
<th>UMTS QoS</th>
<th>DiffServ QoS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversational class</td>
<td>AF4</td>
</tr>
<tr>
<td>Streaming class</td>
<td>AF3</td>
</tr>
<tr>
<td>Interactive class</td>
<td>AF2</td>
</tr>
<tr>
<td>Background class</td>
<td>AF1</td>
</tr>
</tbody>
</table>

IV. SIMULATION AND RESULTS

In this paper, we use the NS-2.26[11] for simulation. However, there are no IEEE802.11e EDCA module and UMTS module in this simulator. So we adapt the EDCA module from TKN and the EURANE module from the SEACON to this simulator for performance evaluation. Figure 5 shows the simulation architecture between WLAN and UMTS using proposed QoS mapping mechanism.

![Figure 5](image)

Fig. 5. Simulation Architecture between UMTS and WLAN

Figure 6 shows the simulation topology, which consists of four WLAN nodes and four UMTS nodes, respectively. Each wireless access network is connected to the IP core network, the AR is the edge router on WLAN and the GGSN is the edge router on UMTS. The QoS mapping operation is occurred on both AR and GGSN.

![Figure 6](image)

Fig. 6. Simulation topology in NS-2

Table III shows the configuration of links between nodes on simulation topology.

TABLE III
THE LINK CONFIGURATION FOR SIMULATION

<table>
<thead>
<tr>
<th>Link Position</th>
<th>Mode</th>
<th>Capacity</th>
<th>Delay</th>
<th>Queue</th>
</tr>
</thead>
<tbody>
<tr>
<td>WLAN Links</td>
<td>802.11</td>
<td>2 Mb</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>AR → CR</td>
<td>Simplex</td>
<td>10 Mb</td>
<td>5 ms</td>
<td>dsRED/edge</td>
</tr>
<tr>
<td>CR → GGSN</td>
<td>Simplex</td>
<td>1 Mb</td>
<td>5 ms</td>
<td>dsRED/core</td>
</tr>
<tr>
<td>GGSN → CR</td>
<td>Simplex</td>
<td>1 Mb</td>
<td>5 ms</td>
<td>dsRED/edge</td>
</tr>
<tr>
<td>CR → AR</td>
<td>Simplex</td>
<td>10 Mb</td>
<td>5 ms</td>
<td>dsRED/core</td>
</tr>
<tr>
<td>GGSN ↔ SGS</td>
<td>Duplex</td>
<td>100 Mb</td>
<td>10 ms</td>
<td>DropTail</td>
</tr>
<tr>
<td>SGSN ↔ RNC</td>
<td>Duplex</td>
<td>100 Mb</td>
<td>10 ms</td>
<td>DropTail</td>
</tr>
<tr>
<td>RNC ↔ NodeB</td>
<td>Duplex</td>
<td>622Mb</td>
<td>15 ms</td>
<td>DropTail</td>
</tr>
</tbody>
</table>

Table IV shows the generated traffic types and related traffic characteristics on WLAN nodes.
In this paper, we evaluate the three types of simulation scenarios. The first one is that MNs on the WLAN communicate with the UEs on the UMTS without any QoS mechanism. In this scenario, the IP core network is the bottleneck and the UMTS UEs use the common channel for communication. The second scenario is that MNs with EDCA mechanism on the WLAN communicate with the UEs on the UMTS in this case the UMTS and WLAN only use its internal QoS mechanism, but there is no QoS management functions in IP core network. In this scenario, the bottleneck condition is same as the first scenario, but the UMTS UEs use the dedicated channels. The last one is that the proposed QoS mapping mechanism is adapted on wireless access network and IP Core network for end-to-end QoS provision.

The simulation result shows the as follows. Figure 7 shows the throughput over simulation scenario 1. In this result, we can see that all the throughput of the MNs is similar to the 16kbps, because of the use of common channel on UMTS. In this scenario, the AC_VO class with high priority can’t be guaranteed the required QoS due absence of the QoS provision mechanism on both access networks.

![Fig. 7. Comparison of throughput without QoS management mechanism](image)

Figure 8 shows the throughput over simulation scenario 2. In this result, we know that WLAN and UMTS support the QoS for AC_VO class internally, but AC_VO class does not obtain the required throughput because of the bottleneck and no QoS guarantee mechanism on the IP core network.

![Fig. 8. Comparison of throughput with only access network specific QoS mechanism](image)

Figure 9 shows the throughput over simulation scenario 3. In this result, we know that the WLAN and the UMTS support QoS for AC_VO class sufficiently, and the IP core network classifies the sessions based on the QoS requirements. Therefore, MN with AC_VO service has obtained the desirable throughput compared with scenario 1 and scenario 2.

![Fig. 9. Comparison of throughput with the proposed QoS mechanism](image)

V. CONCLUSIONS

In this paper, we discuss the issues associated with provisioning QoS in mobile wireless networks and present the QoS architecture and the QoS mapping mechanism. For this propose, the IAQM and the AQM are proposed for the QoS management in heterogeneous wireless environment, these functional entities are deployed at the common operator network and each specific wireless access network, respectively. The IAQM is responsible for the negotiating and the transferring the contexts related to the QoS in case of inter-system handover. The AQM manages the functional entities related to the specific wireless network according to the characteristics of the sessions. The interaction between IAQM and AQM occurs when session setup and session transfer for end-to-end QoS provision. We propose the DiffServ mechanism as the QoS mapping mechanism between each wireless access network and the IP core network. Based on the proposed the mapping mechanism, we evaluate the performance about three different scenarios. The simulation result shows that the proposed mapping mechanism guarantees the QoS requirements effectively and enhances the overall throughput roughly.

REFERENCES