Websites:
http://www.sciencepub.net
http://www.sciencepub.net/rural

Emails:
editor@sciencepub.net
sciencepub@gmail.com

World Rural Observations

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Mapping QoS Classes in Loose Coupling Heterogeneous Networks

Firas Ousta[1], Nidal Kamel[1], Mohd Zuki Yusoff[1], Sadek Ali[2]

[1.] Center of Intelligent Signal and Imaging Research, Department of Electrical and Electronic Engineering, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750Tronoh, Perak Darul Ridzuan, Malaysia
[2.] Department of Electrical and Electronic Engineering, Tishreen University, Lattakia, Syria
fousta@ieee.org

Abstract: One of the main objectives of Heterogeneous Wireless Access Networks (HWAN) is to integrate the different wireless access technologies, such as Universal Mobile Telecommunication System (UMTS), Worldwide Interoperability for Microwave Access (WiMAX) and Wireless Local Area Network (WLAN), with a common IP-based network in order to offer mobile users continuous and unified service in a transparent way. However, one of the major issues is to support End-to-End Quality of Service (QoS) across all these technologies at all stages of the service from set-up to handoff. We present, in this paper, a novel method of mapping QoS of UMTS and WiMAX over a loose coupling environment across Internet Protocol/Differentiated Service (IP/DiffServ) network.
[Ousta F, Kamel N, Yusoff M, Ali S. **Mapping QoS Classes in Loose Coupling Heterogeneous Networks**. World Rural Observ 2022;14(2):1-6]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 1. doi:10.7537/marswro140222.01.

Keywords: QoS; HWAN; 4G; NGWN; UMTS; WiMAX; IP; DiffServ

1. Introduction

Existing wireless networks (e.g. 2G/3G, LTE, WiFi, WiMAX, cdma, cdma2000, etc…), have been independently designed and deployed without cooperating with each other. In order to provide, at anytime and anywhere, the end-users with the best service at the lowest cost, incorporating between these networks, through Heterogeneous Wireless Access Network (HWAN) also known as Next Generation Wireless Network (NGWN) and referred to as the 4th Generation Network (4G), becoming a must, however it will introduce new challenges; such as Security, Billing, Handoff, Mobility management, End-to-End QoS (Sarraf and Ousta, 2008), due to the different radio access characteristics with varying bit rate, available and allocated bandwidth, fault tolerant levels and handoff methods and protocols.

This paper addresses the issues of supporting QoS in loose coupling approach of 4G wireless networks from End-to-End point of view and presents novel mapping mechanisms between UMTS CoSs, IP/DiffServ and WiMAX QoS categories in loose coupling approach, however it does not address the other issues and challenges neither mapping the QoS between the other wireless access networks nor in tight coupling.

The structure of this paper is as follows, section 2 tangles the open issues and challenges of Heterogeneous Wireless Access Network in general and describes the architecture of Heterogeneous wireless network with its two methods: loose coupling and tight coupling; Overview of QoS over different systems is described in section 3; while the mapping strategies between different CoSs is presented in section 4; while a novel methods for mapping CoSs of UMTS into WiMAX QoS categories with their associated parameters using IP/DiffServ as backbone network is presented in section 5; and finally section 6 concludes by summing up with emphasis on related future work.

2. 4G Network Architecture

Since the 4G wireless networks are composed of multiple heterogeneous radio access networks, as illustrated in (Figure 1), mobile users should seamlessly be connected and handed-off between those multimode radio access capabilities (Stratogiannis et al., 2010). However, even if the terminals can adapt to the different radio interfaces, maintaining the service continuity and the offered QoS through diverse environments is a complex issue that current methods do not support.

In order to achieve this interconnection between the various wireless access networks, two main approaches have been considered: Integrated and Interworking networks approaches.

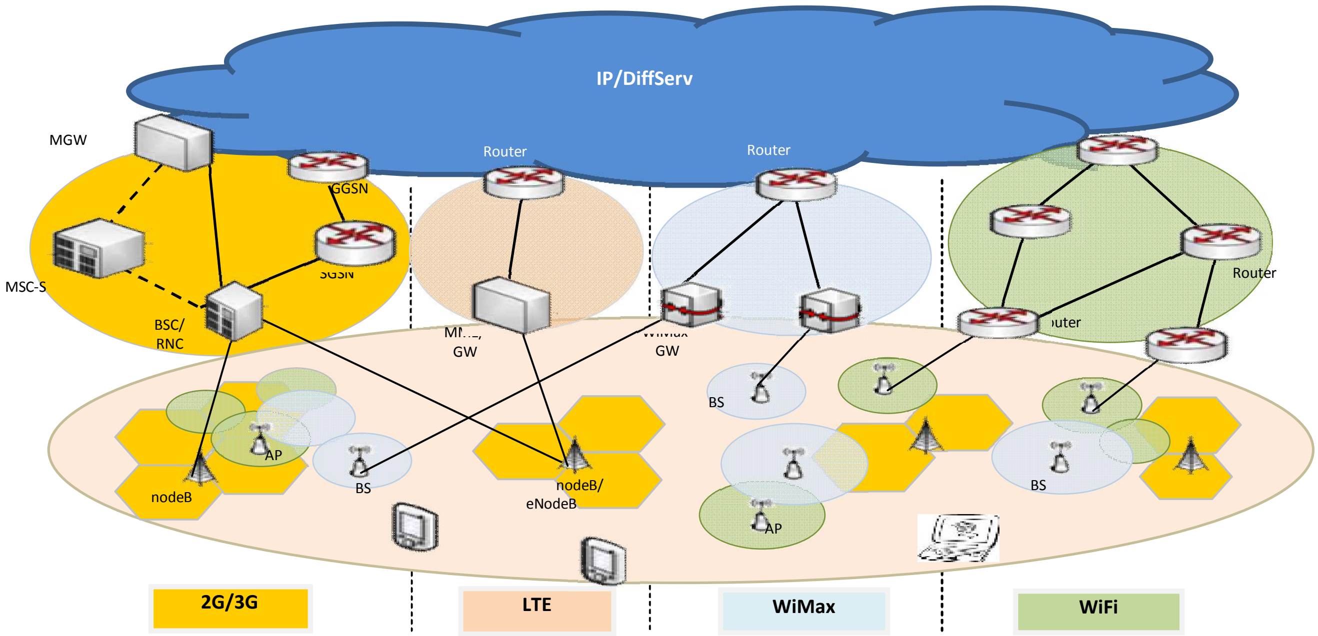

Figure 1. Heterogeneous Wireless Network (HWAN)

Table 1. UMTS QoS Classes

Traffic Class	ARP	THP	MBR	GBR
Conversational	Yes	No	Yes	Yes
Streaming	Yes	No	Yes	Yes
Interactive	Yes	Yes	Yes	No
Background	Yes	No	Yes	No

In integrated networks – Tight Coupling –, the air interfaces from different radio access technology are coupled at radio access network (RAN) or core network level (CN) (Wu H et al., 2001). Whereas, interworking networks – Loose Coupling – method is constructed by introducing edge gateways and linking between the latters to connect different wireless systems, and exchanging information as well as signaling through those gateways (Song W et al., 2005; Masip-Baruin X et al., 2007 ; ETSI, 2001).

In loosely coupled architecture, the different wireless access networks are independent of each other providing a flexible framework. However the main disadvantage is the mobility management where the signaling messages may traverse long path causing relatively high latency for handoff and QoS.

3. Quality of Services over Different Systems

3.1. Universal Mobile Telecommunication System

Four classes of services, Conversational, Streaming, Interactive and Background, have been defined in UMTS with different QOS parameters and attributes used for prioritization, scheduling and queuing. Some of the most important attributes are Maximum Bit Rate (MBR), Guaranteed Bit Rate (GBR), Traffic Handling Priority (THP) and Allocation/Retention Priority (ARP) that may be used, within the same class, for further differentiation as detailed in Table 1.

3.2. Worldwide Interoperability for Microwave Access System

Similarly five QoS categories, named service flows, have been defined in WiMAX; a service flow refers to unidirectional flow of packets that is associated with a particular QoS. These five services flows as defined in (IEEE Std 802.16e, 2005) are listed in Table 2.

It is worth noting that in WiMAX network, the Medium Access Control layer (MAC) is responsible of handling QoS according to a parameter set defined for each service flow.

3.3 IP/DiffServ System

The Internet Protocol is a connectionless best effort protocol; therefore it does not support QoS. Consequently, a Differentiated Service technique is used to support QoS over backbone network. DiffServ code point (DSCP) and per-hope behaviors (PHB) are the main components which are used to classify different classes of service in DiffServ domain. The DiffServ (DS) Domain consists of a contiguous set of nodes that guarantee service level agreement (SLA) requirements.

Table 2. WiMAX QoS Classes

QoS Category	Applications	QoS Specifications
UGS Unsolicited Grant Service	VoIP, T1/E1, ATM CBR	Maximum Sustained Rate Maximum Latency Tolerance Jitter Tolerance
rtPS Real-Time Polling Service	Streaming Audio or Video	Minimum Reserved Rate Maximum Sustained Rate Maximum Latency Tolerance Traffic Priority
nrtPS Non-Real-Time Polling Service	File Transfer Protocol (FTP)	Minimum Reserved Rate Maximum Sustained Rate Traffic Priority
BE Best-Effort Service	Data Transfer, Web Browsing	Maximum Sustained Rate Traffic Priority
ErtPS Extended Real Time Polling Service	Voice with Activity Detection (VoIP	Minimum Reserved Rate Maximum Sustained Rate Maximum Latency Tolerance Jitter Tolerance Traffic Priority

On ingress to DiffServ domain, the traffics are classified using implicit classification methods into a limited number of traffic classes. The classification process depends on the content of the packet header by a differentiated service code point (DSCP).

Per-Hop-Behavior (PHB), which in turn defines the scheduling treatment of the packet and the drop probability for the packet. Three types of PHBs are identified, Default PHB, 2-Expedited Forwarding (EF) PHB and 3-Assured Forwarding PHB (AF1x, AF2x, AF3x, AF4x), supporting different types of traffics and applications (Nicolas K et al., 1998; Davie B et al., 2002; Exist E et al., 1999).

4. Mapping Strategies

Achieving an End-to-End QoS between 3G/UMTS and WiMAX in a loose architecture heterogeneous wireless network would consist of first mapping the QoS of one wireless network into IP/DiffServ and second mapping the QoS between IP/DiffServ and the other wireless network.

4.1 WiMAX-IP/DiffServ Mapping

UGS class of WiMAX supports services with minimum delay and jitter requirements with higher priority than other types of traffics; it is possible to map this class to the EF class of DiffServ network. On the other hand, the rtPS class of WiMAX supports real time applications with loss tolerant and can have traffic priorities, so the mapping process between this class and AF3 class of DiffServ network is recommended (ITU-T Y.1541, 2011).

In the case of nrtPS class, which supports non real time applications with higher delay tolerance, the better class that is matched nrtPS in DiffServ domain is AF2 or AF1. As extended rtPS class is a combination of UGS and rtPS class, the ertPS traffic is mapped to higher AF class like AF4 and the best-effort class is mapped to default DiffServ class or lower AF class with high drop precedence, as described in Table 3.

Table 3. WiMAX-IP/DiffServ QoS Mapping

WiMAX QoS Classes	DiffServ Class
UGS	EF
rtPS	AF3
nrtPS	AF2x & AF11,AF12
BE	AF13, Default
ertPS	AF4

4.2 UMTS-IP/DiffServ Mapping

The Conversational Class, in UMTS, mainly handles real-time applications with loose delay and jitter with guaranteed bit rate, therefore it is logical to map this class to EF and AF41 of DiffServ depending on required values of the delay, jitter and bit rate.

Similarly, Streaming Class of UMTS can be mapped to AF3 of DiffServ and Interactive Class that mainly has 2 types of applications – Web Browsing and File Transfer – may be mapped into AF2 and AF1 of DiffServ. Finally, the Background Class of UMTS is mapped to DF of DiffServ. Table 4 summarizes the mapping between UMTS classes of service and DiffServ.

Table 4. UMTS-IP/DiffServ QoS Mapping

UMTS QoS Classes	DiffServ Class
Conversational Class	EF & AF4
Streaming Class	AF3
Interactive Class	AF2 & AF1
Background Class	DF

5. End-To-End QoS Mapping between UMTS and WiMAX in Loose Coupling Architecture

We propose, in loose coupling HWAN over an IP/DiffServ backbone network, a novel strategy for mapping End-to-End between the CoSs of UMTS and WiMAX networks. The proposed framework is illustrated in Table 5.

This proposal is based on two mapping processes; the first performs a mapping between the four classes of services in UMTS, with their parameters into IP/DiffServ classes with DS Assignation and the second consists of mapping the corresponding IP/DiffServ classes into WiMAX QoS categories and parameters.

Since each class or category supports multiple applications with different QoS performance values, differentiation, at the QoS level, is achieved through assigning specific QoS parameters/attributes, therefore, we proposed, per class, further mapping. For example, the Conversational Class of UMTS may have three different ARP values supporting different PDPs; therefore, we proposed a mapping into 2 classes of DiffServ (EF & AF41) with two different DCSP values.

6. Conclusion and Future Works

6.1 Conclusion

Supporting the different applications with their required QoS, End-to-End over Heterogeneous Wireless Access Network, is a very challenging task. It requires appropriate mapping of related QoS categories, protocols, messages, attributes and parameters

In order to provide an End-to-End QoS, novel mapping mechanisms between the CoS of UMTS to WiMAX QoS categories, across IP/DiffServ backbone, has been proposed. The proposed mechanism recommends a mapping of the CoSs of UMTS associated with their attributes to WiMAX QoS categories with their corresponding attributes.

6.2 Future Works

These mapping mechanisms must be evaluated and optimized in order to verify that End-to-End QoS parameters and values can be provided without affecting the services that are offered to the end users. Furthermore, the negotiated QoS messages during a session setup process must be mapped.

We are currently working on simulating these mechanisms using QualNet V 6.1 Network and Protocol Simulator.

Table 5. Mapping QoS Classes between UMTS and WiMAX systems over IP/DiffServ Backbone Network

UMTS Traffic Classes	UMTS QoS Parameters		DiffServ Network Classes & DS Assignation		DiffServ Network Classes & DS Assignation		WiMAX QoS Parameters	WiMAX QoS Classes
	THP	ARP	PHB	DSCP	DSCP	PHB		
Conversational Class	-	ARP1	EF	101111	101111 101110	EF	Maximum Sustained Rate, Maximum Latency Tolerance, Jitter Tolerance	UGS
	-	ARP2	EF	101110				
	-	ARP3	AF41	100010	100010	AF41	Minimum Reserved Rate, Maximum Sustained Rate, Maximum Latency, Tolerance Jitter, Tolerance Traffic Priority	ertPS
Streaming Class	-	ARP1	AF31	011010	011010 011100 011110	AF3x	Minimum Reserved Rate, Maximum Sustained Rate, Maximum Latency Tolerance, Traffic Priority	rtPS
	-	ARP2	AF32	011100				
	-	ARP3	AF33	011110				
Interactive Class	THP1	ARP1	AF21	010010	010010 010100 010110 001010 001100 001110	AF2 & AF1	Minimums Reserved Rate, Maximum Sustained Rate, Traffic Priority.	nrtPS & BE
	THP1	ARP2	AF22	010100				
	THP1	ARP3	AF23	010110				
	THP2	ARP1	AF11	001010				
	THP2	ARP2	AF12	001100				
	THP2	ARP3	AF13	001110				
Background Class	-	APR1	DF	000000	000000 001000 010000	Default	Maximum Sustained Rate, Traffic Priority	BE
		APR2	DF	001000				
		APR3	DF	010000				

Acknowledgements

The authors gratefully acknowledge the financial support provided by Center of Intelligent Signal and Imaging Research, and the cooperation and research support from the Department of Electrical and Electronic Engineering, Universiti Teknologi PETRONAS.

Corresponding Author:
Firas Ousta
Center of Intelligent Signal and Imaging Research
Electrical and Electronic Engineering Department
Universiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750Tronoh, Perak Darul Ridzuan, Malaysia
E-mail: fousta@ieee.org

References

[1]. Sarraf C, Ousta F. (2008). End-to-End Quality of Services Issues in 4G Mobile Networks. 12th WSEAS International Conference on Communications.

[2]. D. Stratogiannis D, Tsiropoulos G, Kanellopoulos J, Cottis P. (2010). 4G Wireless Networks: Architectures, QoS Support and Dynamic Resource Management. In: Wireless Network Traffic and Quality of Service Support: Trends and Standards. Angelidis P, Lagkas T, Georgiads L, ed. IGI Global Publisher. 2010.

[3]. Wu H, Qiao C, De S, Tonguz O. IEEE Journal on Selected Areas in Communications 2001;19(10):2105-2015.

[4]. Song W, Jiang H, Zhuang W, Shen X. Network IEEE 2005; 19(5):12-18.

[5]. Masip X, Yannuzzi M, Gracia R, Pascual J, Gabeiras J, Callejo M, Diaz M, Racaru F, Stea Giovanni, Mingozzi E, Beben A, Burakowski W, Monteiro E, Cordeiro L IEEE Communications Magazin 2007; 45(2): 96-103.
[6]. E.T.S. Institute. 2001. Requirements and Architectures for Interworking between HIPERLAN/2 and 3rd Generation Cellular Systems. TR 101 9572001.
[7]. IEEE Std 802.16e. 2005. Air Interface for Fixed and Mobile Broadband Wireless Access Systems. Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1.
[8]. Nicolas K, Blake S, Baker F, Black D. 1998. Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers.
[9]. Davie B, Charny A, Bennett J, Benson K, Boudec J, Courtney W, Davari S, Firoiu V, Stiliadis D. 2002. An Expedited Forwarding PHB, Per-Hop Behavior.
[10]. Exist E, Heinanen J, Baker F, Weiss W, Wroclawski J. 1999. Assured Forwarding PHB Group.
[11]. ITU-T Recommendation Y.1541. 2011. Network Performance Objectives for IP-based Services.

3/22/2022