Requirements for a New Resource Reservation Model in Hybrid Access Wireless Network

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Abstract: - The wireless systems entered a phase characterized by the integration of the existing platforms into hybrid access wireless IP architectures. The requests of the real time applications ran in heterogeneous environments need the presence of a mechanism for resource negotiation and management. The paper suggests the design and implementation of an inter-domain QoS mechanism in a hybrid access wireless IP architecture using mobile agents. The hybrid access wireless IP architecture intends to integrate wireless spatial and terrestrial wide area networks, and wireless metropolitan and local area networks. The demands imposed to the inter-domain QoS mechanism recommend the use of mobile agents as an alternative to the classical method of resource reservation and QoS parameters transfer. In order to provide the quality of services, mobile agents act on behalf of the user. Inter-domain QoS support proposed by this mechanism needs the accomplishment of three phases: resource negotiation, resource allocation, and resource management. Each phase is associated to a corresponding specific profile. The purpose of the mobile agents is to determine the selection of a corresponding profile according to the negotiated set of QoS parameters.

Key-Words: - Resource Reservation, QoS Mechanisms, Hybrid Wireless Access

1 Introduction

There is a little consensus on QoS definition. Different people and communities perceive and interpret QoS in different ways.

There are two major visions:

(1) networking community
(2) application community

"*QoS is a set of service requirements to be met by the network in transporting a flow. QoS provides end-to-end service guarantees and policy-based control of an IP network's performance measures, such as resource allocation, switching, routing, packet scheduling, and packet drop mechanisms*."[1]

"*The ultimate judge of network quality is the user perception of quality, so it is essential to identify user's needs and then relate them to the technical standards of a network professional*."[2]

In context of a heterogeneous traffic vehicle in a network, there are a number of factors and components that affect the performances of multimedia application. Grouping all these elements, we consider that the QoS problem has two major perspectives:

(1) network perspective (objective analysis)
(2) application/user perspective (subjective analysis)

From the network perspective, QoS refers to the service quality or service level that the network offers to applications or users in terms of network QoS parameters, including: latency or delay of packets travelling across the network, reliability of packet transmission, and throughput.

From the application/user perspective QoS generally refers to the application quality as perceived by the user. That is, the presentation quality of the video, the responsiveness of interactive voice, and the sound quality of streaming audio. We group applications and users in the same category because of their common way they perceive quality.

Also we promote two QoS concepts:

(1) vertical QoS
(2) horizontal QoS

The vertical QoS concept includes intra-system QoS resource reservation mechanisms. These mechanisms are included in the system specifications or defined as extensions to the initial specifications. The vertical QoS concept separates the QoS aspects on each layer. We consider that protocols on each layer essentially contribute to the global QoS evaluation.

As we suggest, in the network there should be cooperation between the medium access techniques, the routing protocols, and the session setup protocols in order to establish a path that can handle the resource reservation request. This requires the cooperation of the QoS mechanism: admission control, packet classification, packet scheduling, and traffic policing.

In other words, the vertical QoS reservation mechanisms suppose resources negotiation, resources allocation, and resources management. The paper will present three vertical QoS support mechanisms for satellite (WWAN), IEEE 802.16 (WMAN), and IEEE 802.11 (WLAN) networks.

The horizontal QoS concept proposes an inter-system QoS resource reservation mechanism. The inter-system QoS reservation mechanism is an end-to-end QoS mechanism. There are many proposals for fulfilling the end-to-end requirements for resources negotiation, allocation, and management suggesting that the best way to guarantee QoS is to provide some sort of resource reservations in the network elements. The aim of the paper is to propose an inter-system QoS resource reservation support model for a hybrid wireless scenario including WWANs, WMANs, and WLANs, based on the use of intelligent mobile agents.

2 Intra-domain QoS Mechanisms

Multimedia support issues can be presented by using the Quality of Service (QoS) term, which is an overloaded term with various meanings and perspectives. In our vision QoS includes network capabilities in order to satisfy the user requirements (QoS definition).

Applications have different QoS requirements expressed in terms of the QoS parameters. Networks receive from the applications (implicitly or explicitly) their QoS requirements:

(1) quantitative (QoS parameters/ objective analysis): throughput, delay and delay jitter, loss
(2) qualitative (QoS requirements/ subjective analysis): interactivity level, delay tolerance, time-critical

Networks need to respond to applications QoS requirements by supplying QoS services using a number of QoS mechanisms. These QoS mechanisms enable QoS services and can be categorized into two groups based on how the application traffic is treated:

(1) traffic handling mechanisms or in-traffic mechanisms): classification, channel access, packet scheduling, traffic policing
(2) bandwidth management mechanisms or out-of-traffic mechanisms): resource reservation, admission control

Next, this chapter will provide a general symmetric framework for analyzing vertical QoS support mechanisms for satellite (WWAN), IEEE 802.16 (WMAN), and IEEE 802.11 (WLAN) networks.

2.1 Quality of Services Support for Satellite Networks

Satellite DVB-RCS communication systems provides an integrated QoS architecture model.

DVB-RCS systems offers bi-directional data transfer using two channels: the broadcast channel and the interaction channel. The interaction channel consists of a forward interaction channel (from the service provider to end-user) and return interaction channel.

The QoS mechanism categorizes traffic into four per-connection categories which enables per-flow QoS services:

(1) Continuous Rate Assignment (CRA): for real-time constant bit rate (CBR) applications
(2) Rate-Based Dynamic Capacity (RBDC): for variable bit rate (VBR) applications
(3) Volume-Based Dynamic Capacity (VBDC): for delay tolerant applications
(4) Free Capacity Assignment (FCA): for applications that do not have any QoS requirements

The DVB-RCS standard defines some basic QoS mechanisms such as classification, channel access, and capacity request signalling:

(1) classification: using Ch_ID application identification
(2) resource allocation requests: using capacity requests and signalling methods
(3) channel access: MF-TDMA access technique and TBTP table

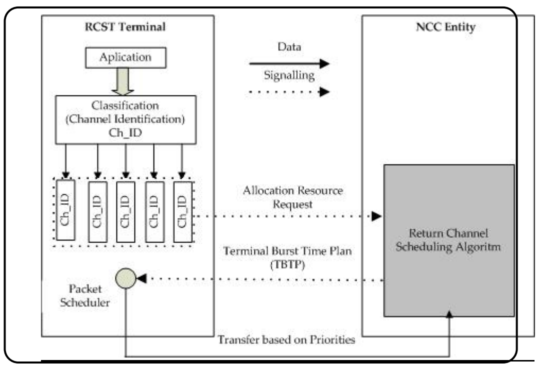

Fig.1 DVB-RCS System QoS Architecture

2.2 Quality of Services Support for IEEE 802.16 Networks

The principal mechanism of IEEE 802.16 standard for providing QoS support is to associate a packet with a service flow. A service flow is a unidirectional flow of packets that provides a particular QoS.

The standard defines four types of service flows that provide QoS support for a wide range of applications. The services include:

(1) Unsolicited Grant Service (UGS): for real-time constant bit rate (CBR) applications
(2) Real-Time Polling Service (rtPS): for variable bit rate (VBR) applications
(3) Non-Real-Time Polling Service (nrtPS): for non-real-time applications
(4) Best Effort (BE) Service: applications that do not have any QoS requirements

The standard details the mechanisms of how to allocate bandwidth and how to send the “BW Requests” in each service flow:

(1) classification: based on CID and SFID tags
(2) resource allocation requests: through the “BW Request” message
(3) channel access: TDM/TDMA access technique and UL-MAP/DL-MAP messages

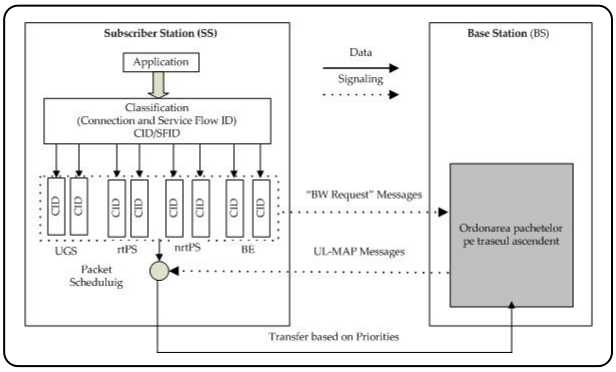

Fig.2 IEEE 80.16 System QoS Architecture

2.3 Quality of Services Support for IEEE 802.16 Networks

IEEE 802.11 MAC has two modes of operation: DCF and PCF. Each operation mode delivers different QoS support. We first examine the QoS mechanisms provided by IEEE 802.11 using DCF mode. The QoS mechanism includes:

(1) classification: there is no classification mechanism or service differentiation provided
(2) channel access: contention-based media access control mechanism
(3) packet scheduling: packet scheduler uses FIFO mechanism.

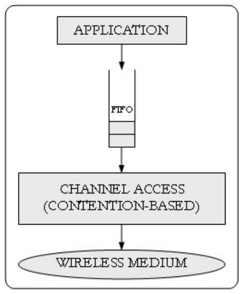

Fig.3 DCF QoS Architecture

DCF mode delivers best effort QoS service. Bandwidth is equally contented by stations. There is no service differentiation and no service guarantee in terms of bandwidth and delay. This operation mode is suitable for non-real time applications. PCF mode can deliver a certain level of guaranteed QoS service thanks to the centralized polling mechanism. The QoS mechanism includes:

(1) classification: there is no classification mechanism or service differentiation provided
(2) channel access: polling-based media access control mechanism using an AP
(3) packet scheduling: packet scheduler uses FIFO mechanism.

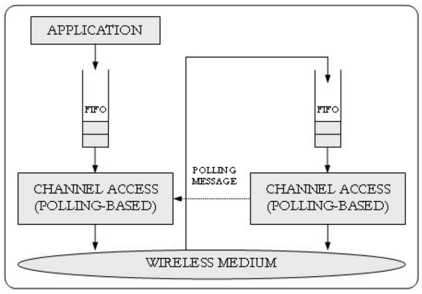

Fig.4 PCF QoS Architecture

The access point polls the stations and provides collision-free access to the channel for a given station. In the same station, all traffic is treated equally. PCF can deliver a certain level of guaranteed QoS service which is suitable for real-time applications.

IEEE 802.11e (QoS Extension) propose two new modes of operation (backward compatible with IEEE 802.11) in order to improve QoS in wireless networks: EDCF and HCF.

The EDCF provides per-class differentiated QoS services (prioritized QoS) for a maximum of eight distinct traffic classes. The QoS mechanism includes:

(1) classification: implements traffic category (TC) classification offering per-class QoS services
(2) channel access: contention-based media access control mechanism with the addition of priority

(3) packet scheduling: transmission opportunity (TXOP) grants to the highest priority traffic category

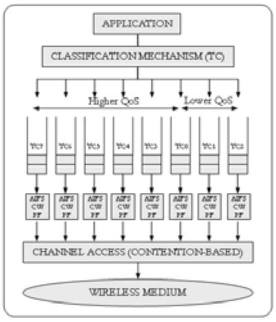

Fig.5 EDCF QoS Architecture

The major enhancement provided by EDCF vs. DCF is the introduction of eight distinct traffic classes. EDCF combines a collision based channel access and priority packet scheduling in order to deliver qualitative QoS services. HCF enables the delivery of per-flow guaranteed QoS services (parametric QoS) based on the applications' QoS requirements (TSPEC). HCF is an extension of the polling idea in PCF, using a centralized polling-based mechanism. The QoS mechanism includes:

(1) classification: implements traffic stream (TS) classification offering per-flow QoS services
(2) channel access: polling-based media access control mechanism using a HC
(3) packet scheduling: transmission opportunity (TXOP) is granted per-station

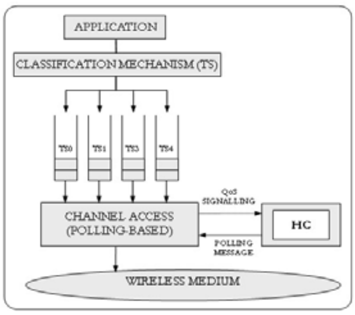

Fig.6 HCF QoS Architecture

HCF is analogous to PCF. Using a hybrid coordinator (HC), that has the highest access priority, HCF allocates bandwidth and contention-free transmission opportunities (TXOPs). HCF provides for much more efficient use of the medium when the medium is heavily loaded.

3 Resource Reservation Support based on Mobile Agents

QoS provisioning or resources reservation in computer networks requires at least three processes: resources negotiation, resources allocation, and resources management.

The alternative way of using classical QoS negotiation, setup and management is to use intelligent mobile agents, which work on behalf of the user or another entity to complete a certain task.

In the negotiation phase, agents are provided with the necessary information that enables them to act intelligently and accomplish their job without the intervention of users.

In the allocation phase, agents guarantee a path between source and destination that meets the requirements negotiated during previous phases.

In the management phase, agents monitor the network in order to maintain the allocated resources in the previous phase. All this phases require a dedicated domain agency based on the use of intelligent mobile agents and specific scenarios based on which they act.

We implemented a resource reservation scheme which emphasizes the following characteristics of the agents: independent functioning, reaction to the environment in which they are used, ability to communicate with other agents, and personalization. We used Visual Basic.NET for development. The idea of the application is shown in the following figure: a number of users are connected to a web server, and they are trying to retrieve different kinds of resource reservation configuration files.

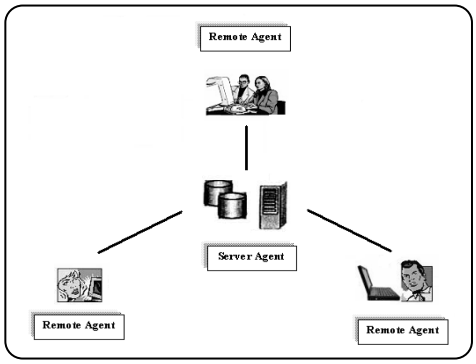

Fig.7 The structure of the proposed mobile agent domain agency

The solution uses multiple agents working together in order to accomplish this task. It consist of a Windows service located on a remote users' computer, a Windows service located on a central Web server, and a Web service that is used by the remote agent to retrieve data from the central server.

Next are given a few details of implementation of the agents that we used.

The remote agent runs on the local hosts, and is responsible for pulling files and database updates from the central server. It operates independently since it will execute continuously as a Windows service. It can be configured to start automatically, so the user is not involved in its functioning. If an error occurs it is recorded in the Windows Event Log, before continuing the processing.

This agent periodically checks to see if the wireless node is connected to the network. If so, it determines that specific files the user wants to be updated or added.

These files contain the QoS parameters (the reserved resources). Since these files can be different for different users, it results from here that the agent must be configured in different ways on two different wireless nodes (this is the personalization property of the agent). Finally, a network transfer is performed.

The agent is customized for each user with the help of an XML-based file that contains information about which QoS parameters the user is interested in, correlated to the QoS implemented mechanism. These are identified based on certain predetermined file attributes, such as extension, author, and keywords. All the documents are stored on the local hard-disk in a directory selected by the user. The server agent runs on the central web server. It creates an XML file which contains all the files and directories that have recently changed on the server.

This file is copied periodically by the remote agent to determine whether a change has taken place since the last time it checked. Depending on this evaluation, a network transfer may be started for the negotiated parameters.

This is an example of how multiple agents can work together to achieve a common goal, to keep the user up to the resource reservation process. Breaking up the tasks into manageable items allows each agent to specialize in a specific task. It also distributes the processing among multiple sources, thereby giving the entire system more power. In today's distributed work environments, these types of solutions will become increasingly more important.

4 Proposed QoS Support Model using Intelligent Mobile Agents

The proposed QoS support model suppose three phases associated to the corresponding profiles:

(1) Resources Negotiation - Available Profile

The classical resource reservation request can be rejected because of insufficient resources availability. The source request a specific amount of resources and the network cannot offer. In this case the end user has no information regarding the maximum available resources. On the use of intelligent mobile agents, an agent negotiates and proposes a different level of services by indicating the maximum available resources.

(2) Resources Allocation - Negotiated Profile

The classical resource reservation mechanism proposes a specific QoS support that enables QoS services for individual environments and technologies. In this case, an end-to-end resource reservation procedure between different autonomous systems is a challenging task. On the use of intelligent mobile agents, an agent made compatible and translate the resource reservation request for each network segment.

(3) Resources Management - Adopted Profile

After a certain time, the network resources will be consumed and the service provider does not have a network upgrading strategy. On the use of intelligent mobile agents, an agent carries out periodic analyses that aim to inform the operator about the overall state of available resources on each link within its domain.

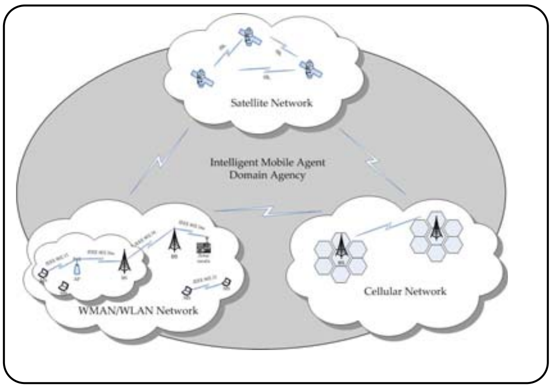

Fig.8 The structure of the proposed network architecture model

As we already mention, the QoS reservation mechanism is based on a file transfer containing the parameters that indicates the corresponding profile.

System specific QoS architecture suggests at least four application types: real-time constant bit rate applications, variable bit rate applications, delay tolerant applications, and applications that do not have any QoS requirements.

Actually, the intelligent mobile agents will negotiate the application needs (according to the application type), obtaining a specific profile. The specific application type is decided in a so called RADP (Resource Allocation Decision Point).

Hence, the reservation process consists on two major parts:

(1) intra-system system specific QoS reservation mechanism
(2) inter-system application QoS resource allocation based on the use of intelligent mobile agents

4 Measurements and evaluations for an inter-domain QoS mechanism in a hybrid access wireless IP architecture

We developed two QoS approaches which assume the integration of some basic elements in the area of quality of services, like: (1) vertical QoS, and (2) horizontal QoS.

The vertical QoS approach includes the intra-domain QoS resource reservation mechanisms. The intra-domain QoS mechanisms are either already included in the last wireless standard architectures (i.e. IEEE 802.16, DVB-S, UMTS) or defined as extensions of the existing standard architectures (i.e. IEEE 802.11e). An intra-domain resources reservation process is a simple one if the resources are managed by a single entity or by a set of entities supporting a common negotiation protocol. The vertical QoS approach suggests the separation of QoS aspects on each layer. Since each layer contributes to the offered quality of service, the vertical QoS approach supposes the extraction of the specific QoS parameters on each network layer. The QoS parameters' analysis is done from the network's perspective, of the support that the network guarantees to the applications.

The horizontal QoS concept is assuming the presence of an inter-domain QoS resource reservation mechanism in a hybrid access wireless IP network. The inter-domain reservation mechanism is an end-to-end QoS mechanism and represents the proposed solution of this paper. These basic approaches had been developed in previous chapter.

The proposed inter-domain QoS reservation mechanism suggests keeping the intra-domain QoS reservation mechanisms implemented in the wireless systems that intend to be interconnected. The alternative to the classical resource reservation method and QoS parameters transfer is the use of mobile agents. The mobile agents shall act on behalf of the user in order to realize the QoS support.

Two major conclusions could be highlighted at the end of this analysis: (1) from the network's perspective, each layer contributes to the QoS parameters evaluation, and (2) from the application's perspective, there should be a request for a QoS parameters set in order to guarantee the negotiated quality of service.

4.1 Inter-domain QoS mechanism in a hybrid access wireless IP architecture using mobile agents

A first inter-domain IP architecture, having similar characteristics with the one promoted by this paper, is presented in [5]. The paper demonstrates the efficiency of a resource reservation scheme using mobile agents by increased allocated bandwidth, decreased dropping rate, and decreased blocking probability as compared to non agent-based resource management scheme. The paper proposed a scalable QoS mechanism which integrates satellite networks and wireless metropolitan area networks.

The usage of mobile agents for resource provisioning in telecommunications networks is suggested also in [6]. The article focuses on the possibility of the usage mobile agents for resource management. Mobile agents, in described system, are responsible both for splitting and for merging informational streams that are created between the source and the destination. This QoS mechanism is an in-traffic one, being closer to the intra-system QoS approach, but the suggested QoS mechanism is out off-traffic.

The paper [7] proposes a QoS mechanism in order to manage and allocate resources at a middleware layer, transparent to the system users. In context of a hybrid terrestrial-satellite system, the paper promotes a resource control mechanism based on a client/server paradigm. It suggests a multi-agent system composed by three basic typologies of agents. Each agent topology has allocated a specific task, dedicated for application control, user location, and system resources management. The paper suggests that a mobile agent platform is the solution for end-to-end QoS requirements of the future 4G broadband heterogeneous scenarios.

Proposed broadband hybrid access wireless architecture intends to integrate the wireless spatial and terrestrial wide area networks, and the wireless metropolitan and local area networks.

4.2 Simulation environment

QoS parameters evaluation was done using ns-2 simulation environment. We upgrade a mobile agent's extension to ns-2.28. Initial extension was designed for -2.1b9a. We need this upgrade in order to run an all-in-one [8] hybrid access wireless architecture under ns-2.28. This patch [9] allows us to use modules for several wireless and wired technologies, like EEE 802.3 (Ethernet), IEEE 802.11b (WLAN), IEEE 802.15.1 (Bluetooth), and UMTS.

4.3 Measurements and parameters evaluation for the inter-domain QoS mechanism in a hybrid access wireless architecture using mobile agents

The work consists in an implementation of a resource management mechanism by using mobile agents used to calculate the propagation delay in a hybrid access UMTS-WLAN network architecture.

The implementation of the resource management system was divided in two steps: (1) the evaluation of the application's global delay over UMTS links, in order to determinate the parameters, and (2) the calculation of the propagation delay in the hybrid access UMTS-WLAN network architecture, by using mobile agents, in order to select the best route.

In order to realize a first step for the inter-domain QoS resource management architecture, we extract, as QoS parameter, the propagation delay by using the mobile agents.

The propagation delay, as QoS parameter, was evaluated as the combined effect of Uu and Iub network interface parameters over the propagation delay in a hybrid access UMTS-WLAN network architecture.

Scenario 1

The first scenario simulates the communication between a MN connected to WLAN network and a UE attached to UMTS network.

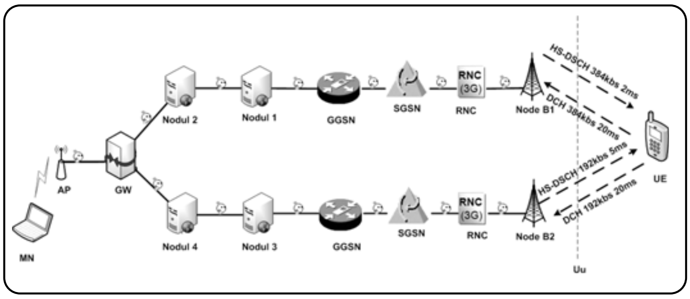

Fig. 9 The effect of Uu network interface parameters over the propagation delay in a hybrid access UMTS-WLAN network architecture

Before starting the application, the mobile agents are launched in order to test all possible links between source and destination points in order to select the best route, based on the minimum propagation delay.

The parameter set for UMTS fix part of the network is shown in the table:

TABLE I
UMTS NETWORK PARAMETERS FOR SCENARIO 1

	Node 1	Node 2	GGSN	SGSN	RNC	NodeB
throughput	10Mbps	10Mbps	622Mbps	622Mbps		622Mbps
delay	35 [ms]	15 [ms]	10 [ms]	0.4 [ms]		15 [ms]

For the Uu network interface we set up two links, having the following parameters:

TABLE II
UU INTERFACE PARAMETERS FOR SCENARIO 1

CHANEL	HS-DCH (uplink)		DCH (downlink)	
	throughput	delay	throughput	delay
LINK 1	384 [kbps]	2 [ms]	384 [kbps]	20 [ms]
LINK 2	192 [kbps]	5 [ms]	192 [kbps]	20 [ms]

After launching the application, we generate a file in which we have saved the average end-to-end delays calculated by the mobile agents for each particular segment of the network, and also the global average end-to-end delay in the network.

TABLE III
AVERAGE END-TO-END DELAY CALCULATED BY MOBILE AGENTS FOR DIFFERENT SEGMENTS OF THE NETWORK FOR SCENARIO 1

LINK	WLAN network	UMTS network	END-TO-END DELAY
1	269.963 [ms]	1874.38 [ms]	2144.351 [ms]
2	269.963 [ms]	4484.38 [ms]	4754.343 [ms]

Mobile agent selects the best route in terms of minimum average end-to-end delay. In our case, the best route is link 1, characterized by an average end-to-end delay of 2144.351 ms.

Scenario 2

The second scenario simulates also the communication between a MN connected to WLAN network and a UE attached to UMTS network.

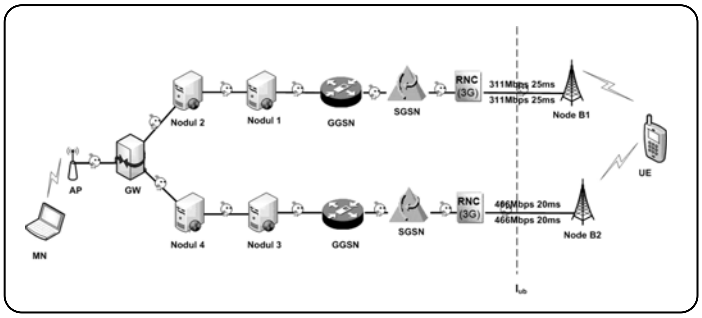

Fig. 10 The effect of Iub network interface parameters over the propagation delay in a hybrid access UMTS-WLAN network architecture

If in the first scenario we have tested the effect of Uu interface parameters, the aim of this scenario is to test the effect of the Iub network interface parameters (located between RNC and Node-B) over the propagation delay.

TABLE IV
UMTS NETWORK PARAMETERS FOR SCENARIO 2 – LINK 1

	Node 1	Node 2	GGSN	SGSN	RNC	NodeB
throughput	10Mbps	10Mbps	622Mbps	622Mbps		311Mbps
delay	35 [ms]	15 [ms]	10 [ms]	0.4 [ms]		25 [ms]

TABLE V
UMTS NETWORK PARAMETERS FOR SCENARIO 2 – LINK 2

	Node 1	Node 2	GGSN	SGSN	RNC	NodeB
throughput	10Mbps	10Mbps	622Mbps	622Mbps	466Mbps	
delay	35 [ms]	15 [ms]	10 [ms]	0.4 [ms]	20 [ms]	

TABLE VI
UU INTERFACE PARAMETERS

HS-DCH (uplink)		DCH (downlink)	
throughput	delay	throughput	delay
384 [kbps]	2 [ms]	384 [kbps]	10 [ms]

The parameter set for UMTS fix part of the network is shown in the table.

As in the first scenario, the role of the mobile agents is to calculate the average end-to-end delay for each particularly.link and to select the best route.

TABLE VII
AVERAGE END-TO-END DELAY CALCULATED BY MOBILE AGENTS FOR DIFFERENT SEGMENTS OF THE NETWORK FOR SCENARIO 2

LINK	WLAN network	UMTS network	END-TO-END DELAY
1	272.83 [ms]	2042.687 [ms]	2315.517 [ms]
2	272.83 [ms]	1910.387 [ms]	2183.223 [ms]

Mobile agent selects the best route in terms of minimum average end-to-end delay. In our case, the best route is link 2, characterized by an average end-to-end delay of 2183.217 ms.

5 Conclusion

The hybrid access wireless IP architecture intends to integrate wireless spatial and terrestrial wide area networks, and wireless metropolitan and local area networks.

The hybrid wireless system resources are diversified, distributed, managed and negotiated by different entities, and the quality of services problem must adapt both the user requests and the network context. The demands imposed to the inter-domain QoS mechanism recommend the use of mobile agents as an alternative to the classical method of resource reservation and QoS parameters transfer. In order to provide the quality of services, mobile agents act on behalf of the user.

The paper proposes a QoS resource reservation scheme for a UMTS-WLAN hybrid wireless scenario based on the use of mobile agents.

The propagation average end-to-end delay, as QoS parameter, was evaluated in three different scenarios: (1) the effect of Uu network interface parameters over the propagation delay in a hybrid access UMTS-WLAN network architecture, and (2) the effect of Iub network interfaces parameters (located between RNC and Node-B) over the propagation delay in a hybrid access UMTS-WLAN network architecture.

From the simulated scenarios, we can extract the following aspects related to a hybrid access UMTS-WLAN network architecture: (1) the major delay in the scenarios appears on the fix UMTS network segment compared to the WLAN segment, hence UMTS network interfaces essentially contribute to the global propagation delay, and (2) the air Uu network interface compared to the Iub network interface introduces a large propagation delay in the architecture.

This study demonstrates the possibility and importance of using mobile agents in the resource management for an inter-domain mechanism of a hybrid access UMTS-WLAN network architecture in order to select the best route based on the average end-to-end delay estimation, as a QoS evaluated parameter.

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