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

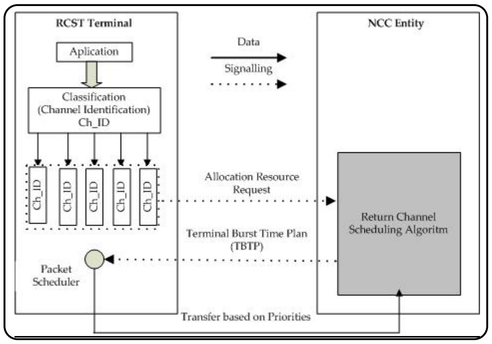

Fig.1 DVB-RCS System QoS Architecture

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

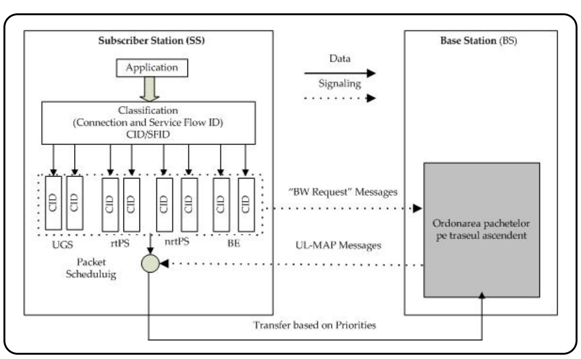

Fig.2 IEEE 80.16 System QoS Architecture

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.

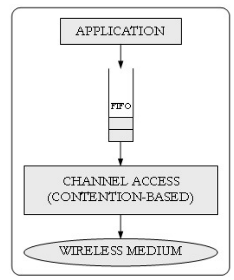

Fig.3 DCF QoS Architecture

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.

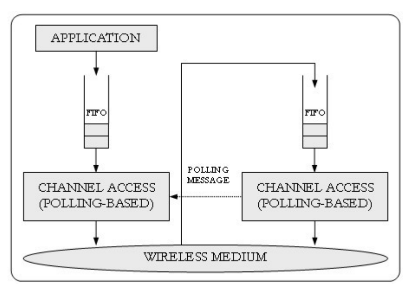

Fig.4 PCF QoS Architecture

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

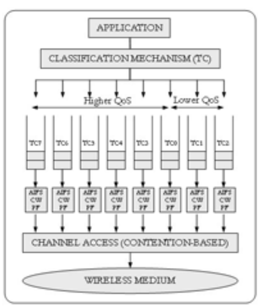

Fig.5 EDCF QoS Architecture

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

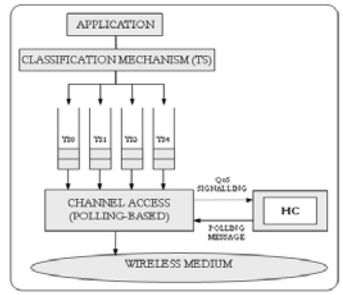

Fig.6 HCF QoS Architecture

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.

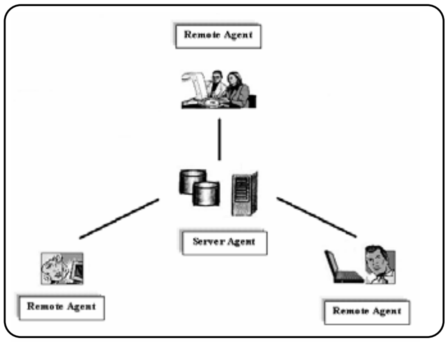

Fig.7 The structure of the proposed mobile agent domain agency

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.

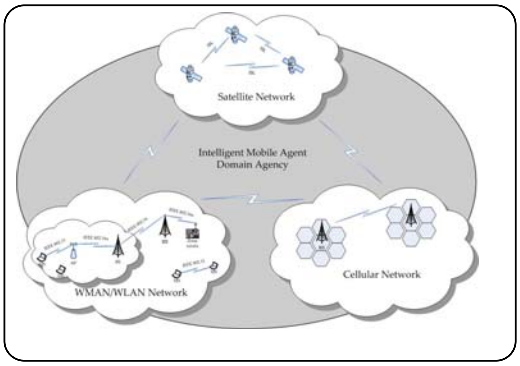

Fig.8 The structure of the proposed network architecture model

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 Conclusion

The paper proposes a resource reservation scheme for a hybrid wireless scenario based on the use of intelligent mobile agents. We used Visual Basic.NET for development of the mobile domain agency. In order to meet the user requirements we propose a QoS model support with three phases and also three types of negotiated profiles.

These messages are according with the inter-system QoS mechanism implemented in each network type. The server agent will guarantee a common inter-system end-to-end resource reservation profile based on RADP (Resource Allocation Decision Point).

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