Design of a Management System for Wireless Home Area Networking

Tapio Rantanen[1], Janne Sikiö[1], Marko Hännikäinen[1], Timo Vanhatupa[1]
Olavi Karasti[2], and Timo Hämäläinen[1]

[1] Tampere University of Technology Institute of Digital and Computer Systems
Korkeakoulunkatu 1, FIN-33720 Tampere, Finland
{tapio.a.rantanen, marko.hannikainen}@tut.fi
[2] Elisa Corporation, POB 81, FIN-33211 Tampere, FINLAND
olavi.karasti@elisa.fi

Abstract. A management system for home area networks has been developed. The main design targets have been to support heterogeneous network technologies, automate the network configuration and management, and to enable application based Quality of Service support. The resulting system architecture has a five-layer functional architecture and a centralised topology with a management server. Also, the support of new proprietary management functionality has been designed for wireless access points and client terminals. A wireless LAN and Java based prototype of the management system is being implemented and its architecture presented.

1 Introduction

Both the number and variety of home applications and projected network technologies for home environment are growing. While office type of data transfer is still required, interactive gaming and consumer electronics are placing new demands on network services [1]. Broadband wireless technologies can replace wired networks because of the comfort and mobility provided [2]. Wireless Local Area Networks (WLAN) and Wireless Personal Area Networks (WPAN) are the main wireless technology category for home area. Currently, the most important standard WLAN technology used in home networking is the IEEE 802.11 [3].

No single management protocol has been established for the management of various equipment of the home network environment. Therefore, flexible management systems are required with the support for multiple management protocols. The Simple Network Management Protocol (SNMP) standard has been most widely adopted by network device manufacturers [4]. It uses a Management Information Base (MIB) to define attributes managed in a network device.

Quality of Service (QoS) support for enabling the different applications to operate and coexists is seen as a key functional requirement. The application QoS distribution can be divided into two main implementation approaches: bandwidth reservation and differentiated traffic handling. Bandwidth reservation systems use control messages to

H. Kosch, L. Böszörményi, H. Hellwagner (Eds.): Euro-Par 2003, LNCS 2790, pp. 1141–1147, 2003.

allocate bandwidth for a flow before the actual data transfer. This approach is taken by the Internet Engineering Task Force (IETF) for Integrated Services (IntServ) [5].

Few new management specifications targeting at management of heterogeneous networks are emerging. IETF SNMPConf working group has been developing methods for using SNMP framework for policy management [6]. The term policy management means the practise of applying management operations globally on all managed elements with similar characteristics. The Distributed Management Task Force (DMTF) is developing the Web-Based Enterprise Management (WBEM) initiative with high level of interoperability support with existing management standards [7]. Sun Microsystems has extended the Java 2 platform with a Federated Management Architecture (FMA) standard. The FMA implementation is called Jiro, which enables interoperability of different management systems, and provides tools for easy management application programming. [8]

The home area network management is a new challenge. The management challenges in home environment have been identified and a high level architecture proposed in [9]. However, no technical architecture has been provided and the operation of the system is left open. Home network service and management architecture is provided in [10]. The architecture is flexible and takes advance of mobile code. However, it requires that the agents situated in home network appliances to be capable of running the mobile code. In heterogeneous network environment not all devices support running environment required for mobile code.

In this paper, an architecture and design for a QoS management system for home area wireless networks are presented. The system is targeted for managing of heterogeneous networks and to provide abstraction and automation to the home management tasks. Section 2 presents the architecture and functionality of the designed management system, while Section 3 gives an overview of the prototype implementation. Conclusions and future work is discussed in the final section.

2 Wireless Home Area Management System (WHAMS)

The conceptual layer architecture of the system is depicted in Fig. 1. First, physical *devices* represent the actual managed network devices, such as APs, LAN bridges, and terminals. The devices contain a set of managed attributes (e.g. variables, management procedures), which are organised into a MIB.

Attribute adaptors have been defined for hiding the details of management access protocols and the physical device parameters from the higher layers of WHAMS. Thus, the adaptors are a uniform interface layer to the needed attributes of devices. Table 1 presents the designed attribute adaptors.

Functions use the attribute adaptors to perform automated management tasks. Functions can be adjusted to be in observation or automation states. In an automation state, a function observes, generates notifications, and automatically reacts to changes according to the operation and configuration of the function. The target is to improve the network operation and performance that is related with the function.

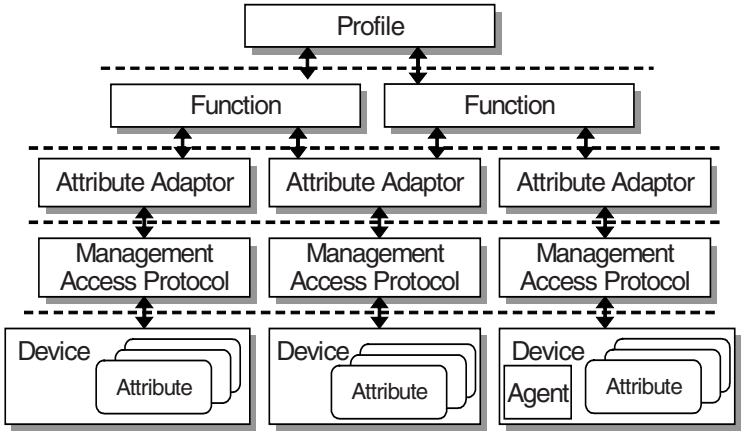

Fig. 1. WHAMS concept architecture with different layers

The following functions are defined: traffic function, frequency function, media function, security function, and auto configuration function. The traffic function observes traffic on all managed sub-networks, and balances the traffic loading of wireless networks by assigning client terminals to less loaded APs. The function provides a view of network traffic loading to a network manager.

The frequency function observes or automates frequency allocations using radio attribute adaptors. When automated this function tries to balance used frequencies so that interference from other networks is minimal.

The media function observes or automates bandwidth allocations of traffic flows. The function uses media connection attribute adaptors. When automated this function provides media connections with the requested bandwidth according to the connection priorities. This is established by limiting other traffic in the network when required. The security function manages the security policy of the whole network. When automated this function observes changes in the wireless networks (new devices), and ensures that the requested security level is achieved at all times.

The auto configuration function enables automatic configuration of devices in the network. The configuration requires that the client is running auto configuration software that performs the configuration of the wireless client.

A *profile* defines the network management configuration, defining the operation environment and its characteristics. Thus, a profile contains all parameters that are required by the functions for automated network management. A common policy is needed, as the operation of the different functions can be contradictory. A profile can emphasise the importance of certain applications and devices. In the current design, the profile rules are stated as priorities assigned for functions, terminals, and applications.

The resulting system architecture consists of a centralised management server, wireless APs and optional client terminals. The server will contain the management functionality. A client terminal can have added WHAMS specific functions for

Table 1. Attribute adaptors of the WHAMS system

Adaptor	Examples of attributes	Description
Status	Connection status, data transmission rate	Generic adaptor that can be used to any type of device
Radio	Radio type, used frequency, signal strength, radio usage	Abstracts the management of wireless media.
Security	Encryption, authentication, failed authentications	Abstracts the security issues of a device.
Media connection	Start address, end address, bandwidth control, delay, jitter	Abstracts the QoS management of an application flow.
Access point	Number of connected devices, loading	Abstracts the management of a access point.
Internet gateway	Loading, configuration, access type	Abstracts the management of Internet gateway.
Traffic control	Number of retries, number of errors, duplicate count	Abstracts traffic control management

enabling more efficient management. Each device is connected to the WHAMS management system via a management access protocol. As discussed, there are several different standard protocols available, while proprietary protocols can also be supported.

The efficient and full scale implementation of advanced management functions defined by WHAMS, such as application based QoS management, requires means to measure and analyse application traffic in network nodes. Adding of special measurement *agents* (WHAMS APs) can fulfil these functional requirements [11].

Still, the implantation of application QoS can be partly supported at the endpoints of a flow, where WHAMS specific functionality is easier to add. WHAMS is not platform specific but it can adapt to provide functionality that is possible with current technology.

3 WHAMS Prototype Implementation

A prototype of the WHAMS is being implemented for verifying the functionality. The prototype is presented in Fig. 2. The server software contains implementations of layer architecture components: management protocols, attribute adaptors, functions, and profiles. The WHAMS server is implemented as Java. The server also contains a WWW-server for loading the user interface implemented as Java applet. The server platform is PC computer with Windows 2000 operating system.

The WHAMS AP is capable of measuring flows and flow attributes such as throughput, delay, and delay variance. It provides bandwidth control in form of bandwidth reservation by queuing and access control for defined application traffic flows.

The WHAMS AP software can be divided into four modules: bandwidth control, measurements, packet analyser, and management access. The management access module contains sniffer functionality. The packet analyser examines packet headers

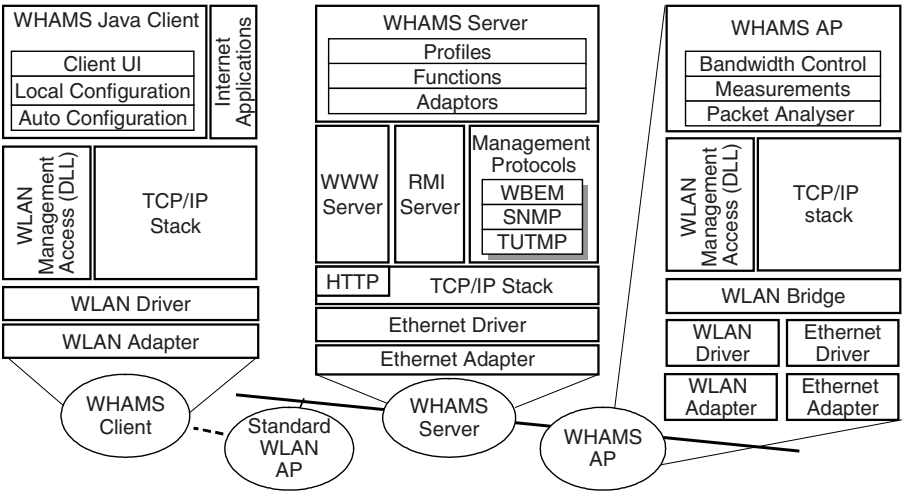

Fig. 2. WHAMS prototype topology and node architectures

for identifying flows. The measurements function performs actual flow measurements and stores the acquired data. The bandwidth control performs bandwidth reservations and control. It follows that the current reservations are fulfilled, and monitors the amount of unreserved bandwidth.

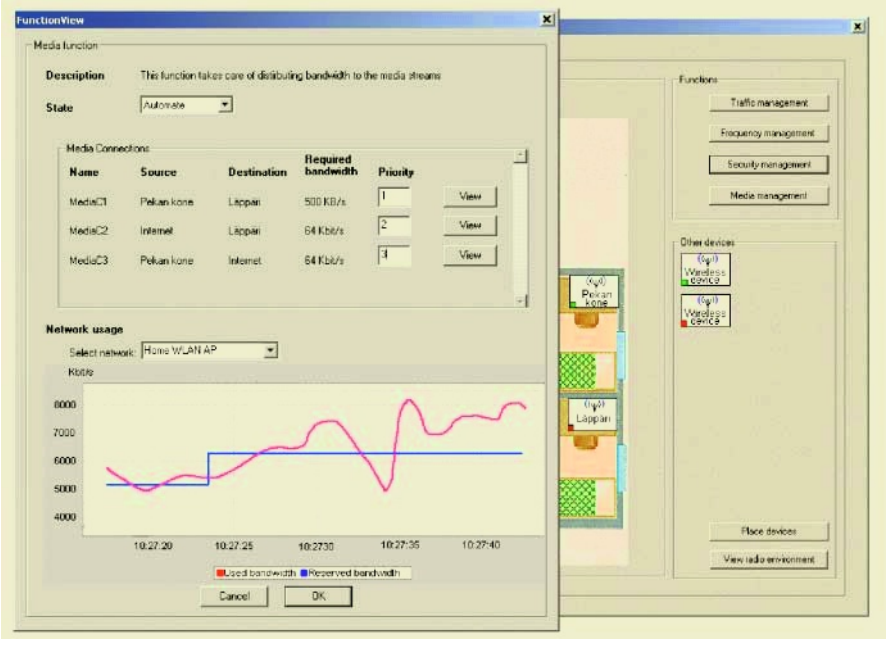

Fig. 3. Main view with floor plan (right) and the media function view (left) of the prototype

The user interface applet loads automatically to an Internet browser and establishes a communication to the WHAMS Remote Method Invocation (RMI) server. The manager UI consists of system views, function views, and adaptor views. Each function and adaptor has its own view displaying specific attributes and measurement results in graphics.

The main window of the manager client shows the floor plan and all known devices and gives an access to managing devices, radio environment, function views, and placing new devices on the floor plan. The device window shows device properties and available adaptor views. The main windows and the media function views are presented in Fig. 3.

In prototype implementation, the basic functions and adaptors use SNMP queries to several different standard and commercial MIBs. The media connection and adaptor implementations use a custom protocol to connect to a WHAMS AP and to obtain/adjust application QoS measurements and settings. The auto configuration function in WHAMS client listens to a selected TCP port and adjusts the client networks settings according to the configuration received from WHAMS server.

4 Conclusions and Future Work

The WHAMS is being developed for the management of heterogeneous wireless and wired networks in home environments. The design targets have been to facilitate the co-existence of wireless networks, support QoS for application flows, and enable more automatic management. The resulting architecture has been a centralised management server, and add-on functionality for client terminals and APs. The hierarchical functional architecture enables flexibility. A prototype system based on Java implementation is currently under construction, and will be used to evaluate and verify the performance of the developed management system.

References

1. EURESCOM: LUPA: Local provision of 3G and 3G+ services, available at http://www.eurescom.de/ (May 2003)
2. M. Hännikäinen et al.: Trends in personal wireless data communications, Computer Communications 25 (2002) 84 – 99
3. IEEE Sdt 802.11: Wireless Medium Access Control (MAC) and Physical layer (PHY) specifications (1999)
4. J.D. Case, et al.: Simple Network Management Protocol (SNMP), IETF RFC 1157 (1990)
5. P. P. White: RSVP and Integrated Services in the Internet: A Tutorial, IEEE Communications, (1997) 100-106
6. S. Waldbusser et al.,: Policy Based Management MIB, IETF SNMPConf working group, Internet-draft (2002)
7. Homepage of DMTF WBEM: http://www.dmtf.org/standards/standard_wbem.php (May 2002)
8. Sun Microsystems Inc.: Federated Management Architecture (FMA) specification version 1.0 revision 0.4, available at http://jcp.org/en/home/index (May 2003)

9. S. Moyer, et al.: Home Network Configuration Management & Service Assurance, IEEE 4th International Workshop on Networked Appliances, Gaithersburg, USA (2002) 77–86
10. C. Tsai, et al.: MASSIHN: a Multi-Agent Architecture for Intelligent Home Network Service, IEEE Transactions on Consumer Electronics 48, issue3 (2002) 509–514
11. T Rantanen et. al.: Design of a Quality of Service Management System for Wireless Local Access Networks, The International Conference on Telecommunications (ICT'2001), Bucharest, Romania (2001) Vol.3 107–114