DESIGN AND IMPLEMENTATION OF IEEE 802.16 MAC LAYER SIMULATOR

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ABSTRACT

The IEEE 802.16 Wireless MAN is a broadband wireless access network, which provides high-rate network connections to stationary sites, operates over greater distances, provides more bandwidth, takes advantage of a broader range of frequencies, and supports a greater variety of deployment architectures, including non-line-of-sight operation. The medium access control layer protocol includes an initialization procedure designed to eliminate the need for manual configuration. Upon installation, a Subscriber Station begins scanning its frequency list to find an operating channel. It may be programmed to register with a specified Base Station. Systems shall support the applicable procedures for entering and registering a new Subscriber Station or a new node to the network. This project concentrates upon the network initialization procedure to bring up the subscriber and base stations in the 802.16 network. It also provides the Dynamic Service Management procedure for transportation connections. Socket programming has been used to perform simulations.

KEYWORDS: *MAC, IEEE 802.16, SAP*

I. INTRODUCTION

The IEEE 802.16 medium access control layer (MAC) protocol is designed for point-to-multipoint broadband wireless access applications. It addresses the need for very high bit rates, both uplink (to the Base station) and downlink (from the Base station). The medium access control layer is capable of supporting multiple physical layer specifications optimized for the frequency bands of the application. This paper deals with various steps for initialization between BS and SS. The 802.16 specification accommodates MAC management messages that allow the base station to query the subscriber station. The objective of this paper is to design a IEEE 802.16 MAC layer for broadband wireless access. It is a complex and efficient protocol. Access and bandwidth allocation algorithms must accommodate hundreds of terminals per channel. Terminals may be shared by multiple end users. The services required by these end users are time-division multiplex (TDM) voice and data, Internet Protocol (IP) connectivity, and packetized voice over IP (VoIP). The 802.16 MAC accommodates both continuous and bursty traffic. Additionally, these services expect to be assigned quality of service in keeping with the traffic types. The IEEE 802.16 offers an alternative to cabled access networks, such as fiber optic links, coaxial systems using cable modems, and digital subscriber line (DSL) links. Wireless systems have the capacity to address broad geographic areas without the costly infrastructure development required in deploying cable links to individual sites, hence the technology

may prove less expensive and may lead to more ubiquitous broadband access. The IEEE 802.16 MAC gives both broadband access and good quality of service (QoS). With the technology expanding in this direction, it is likely that a standard will evolve to support nomadic and increasing mobile users.
The paper aims at analyzing the initialization procedure between Base station (BS) and Subscribe station (SS) and discusses the design for the steps involved in the initialization procedure.

II. RELATED RESEARCH WORK

The 802.16 medium access control (MAC) layer [1, 2] supports many different physical layer specifications, both licensed and unlicensed. Through the 802.16 MAC, every base station dynamically distributes uplink and downlink bandwidth to subscriber stations using time-division multiple access (TDMA). This is the basic difference from the earlier version of 802.11 MAC. 802.11 MAC operating through the use of carrier sensing mechanisms does not provide effective bandwidth control over the radio link. Figure 1depicts the reference model [1, 2] of IEEE 802.16 MAC. The MAC comprises three sub layers these are service specific convergence sub layer, medium access control common part sub layer (MAC CPS), and privacy sub layer. The service specific convergence sub layer (CS) provides transformation or mapping of external network data, received through the CS service access point (SAP), into MAC SDUs received by the MAC common part sub layer (MAC CPS) through the MAC SAP. This includes classifying external network service data units (SDUs) and associating them to the proper MAC service flow and connection identifier (CID). The MAC CPS provides the core MAC functionality of system access, bandwidth allocation, connection establishment, and connection maintenance. The MAC also contains a separate privacy sub layer providing authentication, secure key exchange, and encryption. Data, physical layer (PHY) control, and statistics are transferred between the MAC CPS and the PHY via the PHY SAP. The PHY may include multiple specifications, each appropriate to a particular frequency range and application.

III. DESIGN AND IMPLEMENTATION

As the MAC is clearly seen to cycle around some determined states, the complete MAC solution is divided into few state machines, namely network entry state machine and dynamic service flow transition state machine. This section provides different views of the system being designed, with many sequence diagrams to show how messages are passed between different entities during runtime. These are in accordance with the UML based design principles. The features considered for design and implementation are listed below.

i) Network entry and initialization entity
- a) Downlink synchronization
- b) Uplink parameter acquisition
- c) Initial ranging
- d) Capability negotiation
- e) Registration
- f) Establish IP connectivity
- g) Establish time of the day
- h) Transfer operational parameters

3.1 Down link channel synchronization

When an SS wishes to enter the network, it scans for a channel in the defined frequency list. Normally an SS is configured to use a specific BS with a given set of operational parameters, when operating in a licensed band. If the SS finds a down link channel and is able to synchronize at the physical layer (PHY) level (it detects the periodic frame preamble), then the MAC layer looks for DCD and UCD to get information on modulation and other DL and UL parameters. The BS sends downlink channel descriptor (DCD) and DLMAP messages periodically for the downlink synchronization with SS. Once SS synchronizes with BS the SS would wait for uplink channel descriptor (UCD) message for uplink channel characteristics for uplink transmission from BS. Once SS gets the UCD and it waits for uplink map (ULMAP) message for initial maintenance interval for initial ranging.

3.2 Initial ranging

When an SS has synchronized with the DL channel and received the downlink and UL MAP for a frame, it begins the initial ranging process by sending a ranging request MAC message on the initial ranging interval using the minimum transmission power. If it does not receive a response, the SS sends the ranging request again in a subsequent frame, using higher transmission power. Eventually the SS receives a ranging response. The response either indicates power and timing corrections that the SS must make or it indicates success. If the response indicates corrections, then the SS makes these corrections and sends another ranging request. If the response indicates success, the SS is ready to send data on the upper link.

3.3 Capabilities negotiation

After successful completion of initial ranging, the SS sends a capability request message to the BS describing its capabilities in terms of the supported modulation levels, coding schemes, rates, and duplexing methods. The BS accepts or denies the SS, based on its capabilities. The SS sends the SBCREQ message to negotiate SS basic capabilities and it waits for SBCRSP. Once BS receives SBCREQ message and processes the message, it determines enables SS capabilities and sends SBCRSP message to SS.

3.4 Authentication

After capability negotiation, the BS authenticates the SS and provides key material to enable the ciphering of data. The SS sends the X.509 certificate of the SS manufacturer and a description of the supported cryptographic algorithms to its BS. The BS validates the identity of the SS, determines the cipher algorithm and protocol that is used, and sends an authentication response to the SS. The response contains the key material to be used by the SS. The SS is required to periodically perform the authentication and key exchange procedures to refresh its key material.

3.5 Registration

After successful completion of authentication the SS registers with the network. The SS sends a registration request message to the BS, and the BS sends a registration response to the SS. The registration exchange includes IP version support, SS managed or non-managed support, classification option support, cyclic redundancy check (CRC) support, and flow control. Once BS authorizes SS, the SS sends registration request (REGREQ) message to BS for registration and waits for REGRSP message. The BS processes the REGREQ message which includes calculating hashed message authentication code (HMAC) over REGREQ message and sets the status of SS as ‘supported’ in REGRSP.

3.6 IP Connectivity

The SS attains an IP address via dynamic host configuration protocol(DHCP) and establishes the time of the day via the internet time protocol. The DHCP server also provides the address of the TFTP server from which the SS can request a configuration file. This file provides a standard interface for providing vendor-specific configuration information. At this point, the SS will invoke DHCP discover message in order to obtain an IP address and any other parameters needed to establish IP connectivity. If the SS has a configuration file, the DHCP response will contain the name of a file which gives further configuration parameters. Establishment of IP connectivity will be performed on the SS’s secondary management connection.

3.7 Establishing time of the day

The SS and BS need to have the current date and time. This is required for time stamping logged events for retrieval by the management system. After DHCP is successful the SS sends time of the day request to time server. The time server processes the request and sends the response with correct

time of the day offset to create local time. Establishment of time of the day will be performed on the SS's secondary management connection.

3.8 Transfer operational parameters

After DHCP is successful, the SS will download the SS configuration file using trivial file transfer protocol (TFTP) on the SS's secondary management connection. When the configuration file download has been completed successfully, the SS will notify the BS by transmitting a trivial file transfer protocol complete (TFTPCPLT) message on the SS's primary management connection. Transmissions will continue periodically until a TFTP response (TFTPRSP) message is received with "OK" response from the BS. Once the download of the configuration file from the TFTP server to SS is over, then the SS sends the TFTPCPLT message to the BS and waits for TFTP response.

IV. EXPERIMENTAL RESULTS

The network entry process for SS is simulated using Linux Berkeley socket interfaces and designed using enterprise architect UML tool.

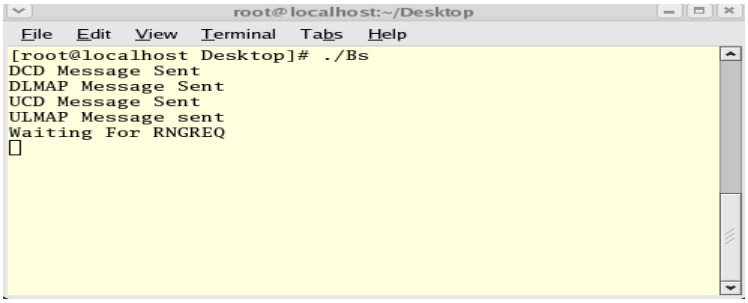

Figure 1: Downlink synchronization (BS)

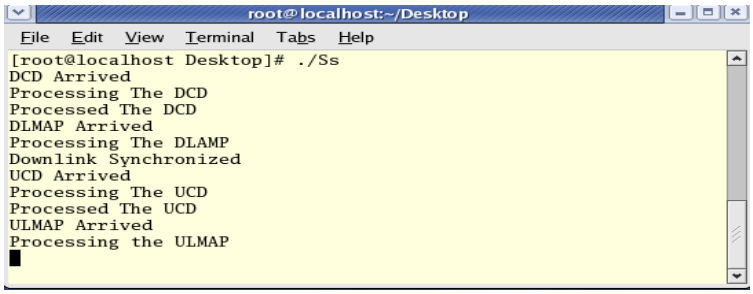

Figure 2: Downlink synchronization (SS)

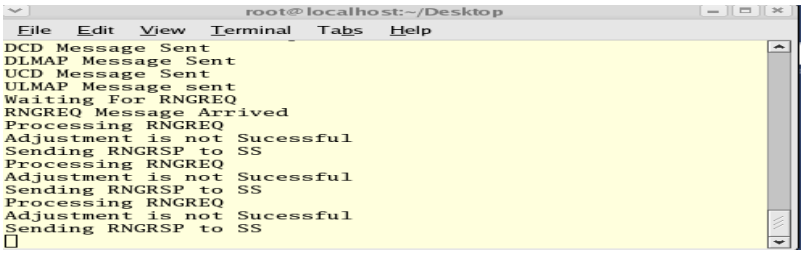

Figure 3: Initial ranging (BS)

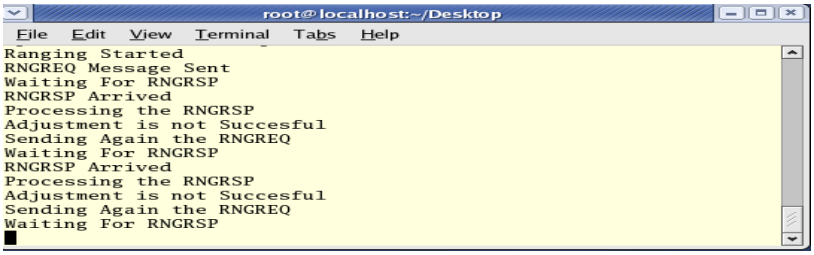

Figure 4: Initial ranging (SS)

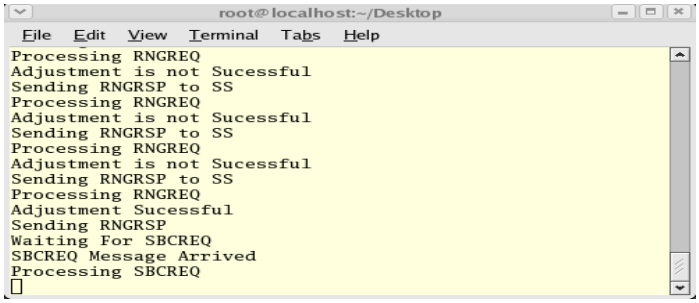

Figure 5: Capabilities negotiation (BS)

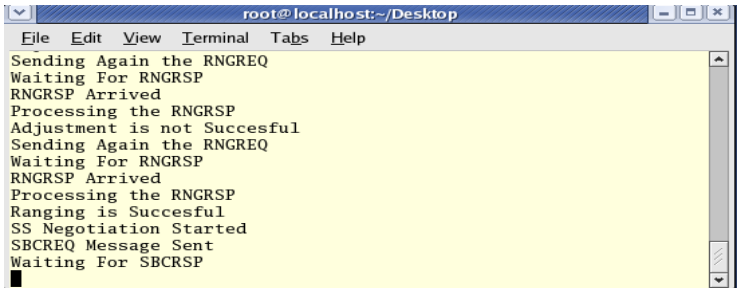

Figure 6: Capabilities negotiation (SS)

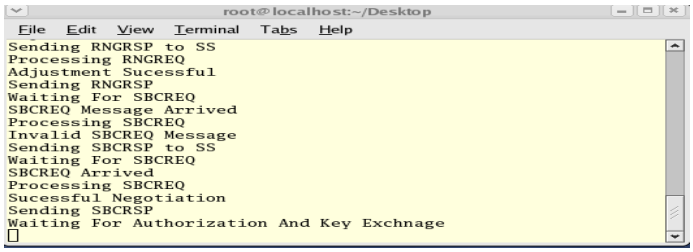

Figure 7: Authentication (BS)

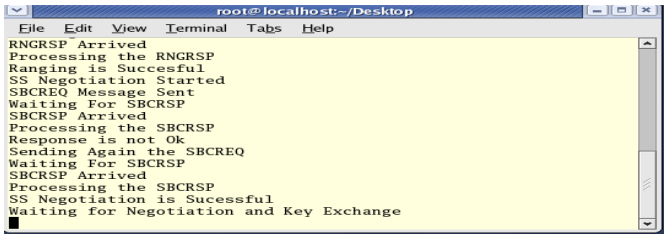

Figure 8: Authentication (SS)

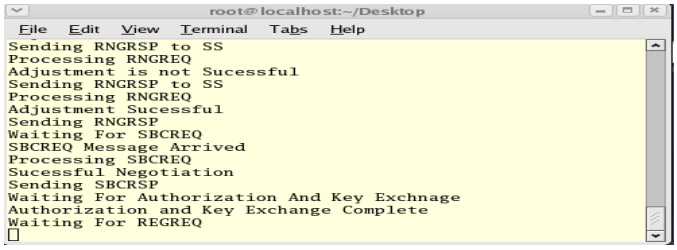

Figure 9: Registration (BS)

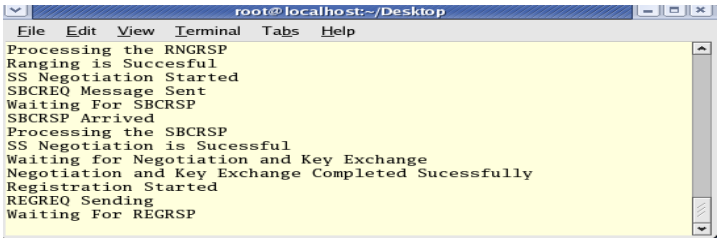

Figure 10: Registration (SS)

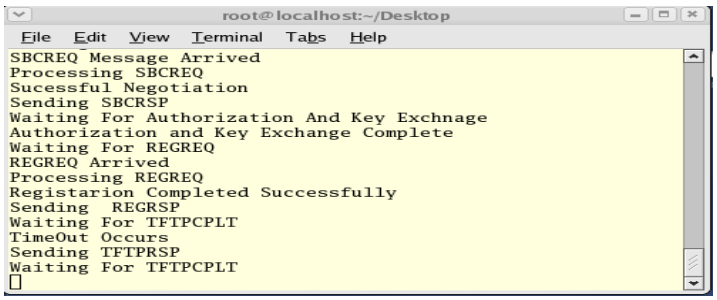

Figure 11: IP connectivity (BS)

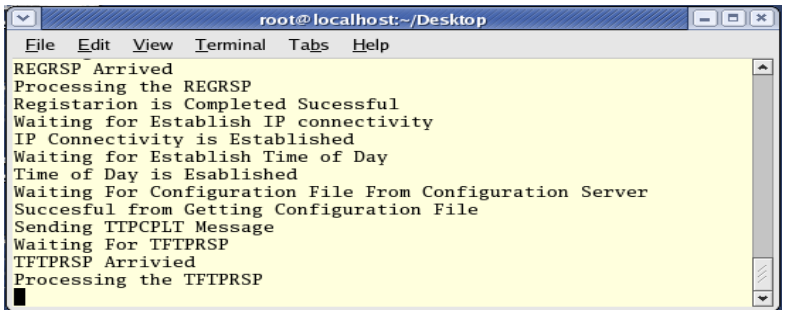

Figure 12: IP connectivity (SS)

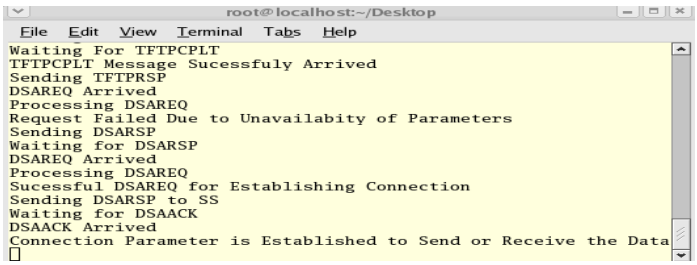

Figure 13: Connection setup using DSA (BS)

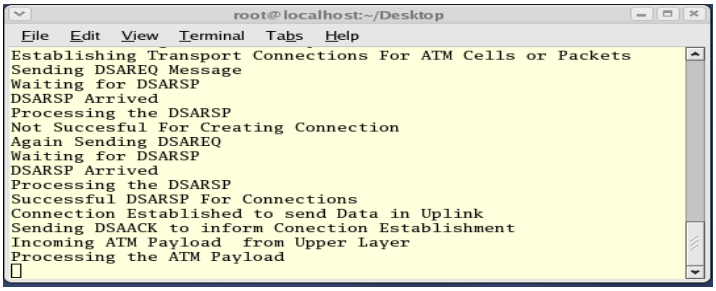

Figure 14: Connection setup using DSA (SS)

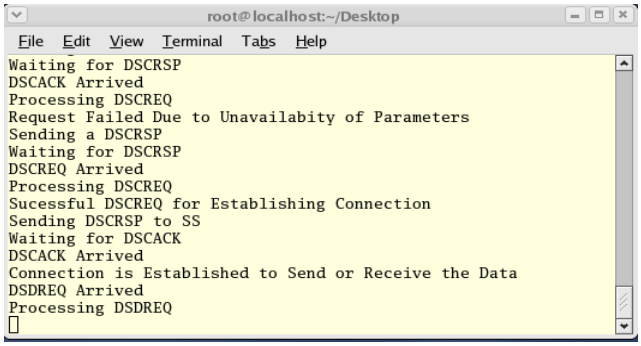

Figure 15: Connection modification and termination (BS)

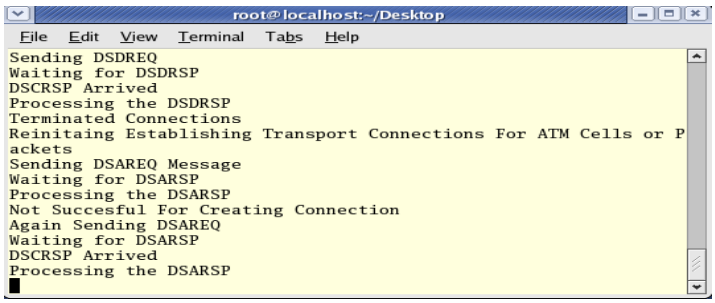

Figure 16: Connection modification and termination (SS)

V. CONCLUSION

The paper aims at providing a design for the IEEE 802.16 protocol in an efficient manner using object oriented design principles. The IEEE 802.16 is a very complicated standard, featuring high adaptiveness to maximize air link usage therefore, it requires sophisticated algorithms. At the same time, its implementation must be easy for users and provide adequate quality of service. The message post mechanism and the packet queuing mechanisms prove to be valuable addition to the way data is passed between upper and lower layer in the stack. This also helps the stack to handle inter module interactions in a clear manner. The simulation studies show that the proposed solution provides quality of service support in terms of bandwidth and delay bounds for all types of traffic classes as defined by the standard. We are currently working on connection admission control and classifier modules which are part of convergence layer of the standard and contribute greatly to quality of service provisioning. The key contribution of this research paper is in the development of a network entry and dynamic service management.

The above discussion makes it easy to see why so much anticipation surrounds IEEE's 802.16 standard. Service providers will be free from the substantial upfront costs and risks associated with network build out, allowing them to provide cheaper broadband access to more consumers. Finally, the interoperability and variety of services supported by Wireless MAN ensures rapid adoption and deployment, justifying the praise of 802.16 as the next wireless revolution.

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