Volume: 01 Issue: 03 Pages: 181-187 (2009)

Dynamic channel allocation for user demanded packet optimality–Focus on network initialization Procedure

Dr. Pradeep. B.S
Asst. Professor, Department of CSE, RRCE, Bangalore, Karnataka-74
Email: pradeepbs78@yahoo.com

Soumya.S, Student, MTech (IT), KSOU, Mysore, Karnataka
Email: soumyaswarna@yahoo.co.in

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 MAC 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 research concentrates upon the network initialization procedure to bring up the subscriber and base stations in the 802.16 networks Socket programming has been used to perform simulations. This paper describes the simulation and experiment setup.

Keywords: MAC, Dynamic service creation, Dynamic service modification, Dynamic service deletion.

Date Of Submission: October 10, 2009 Accepted: November 11, 2009

1. Introduction

The IEEE 802.16 (WiMAX) 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 BS) and downlink (from the BS). The medium access control layer is capable of supporting multiple physical layer specifications optimized for the frequency bands of the application. This research deals with various steps for initialization between BS and SS. The 802.16 specifications accommodate MAC management messages that allow the base station to query the subscriber station.

1.1 Reference Model of IEEE 802.16 MAC Layer

Figure 1.1 depicts the reference model [1, 2] of IEEE 802.16 MAC. The MAC comprises three sublayers these are service specific convergence sublayer, MAC CPS, and privacy sublayer. The service specific convergence sublayer (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 sublayer (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, and connection establishment and connection maintenance. The MAC also contains a separate privacy sublayer providing authentication, secure key exchange and encryption. Data, PHY control and statistics are transferred between the MAC CPS and the PHY via the PHY SAP.

The MAC silent features are:

1. Bandwidth in both downstream and upstream directions is controlled by the modem to allow QoS support.
2. Upstream multiple access method allows both contention and reservation-based data transmission.
3. TDD mode of operation allows flexibility in the division of bandwidth between upstream and downstream.
4. MAC can be easily adapted to FDD mode of operation.
5. Support of variable-length packets and collision avoidance enhances MAC efficiency.
6. It can support IP, ATM and other kinds of traffic.
7. It can provide wired equivalent security.

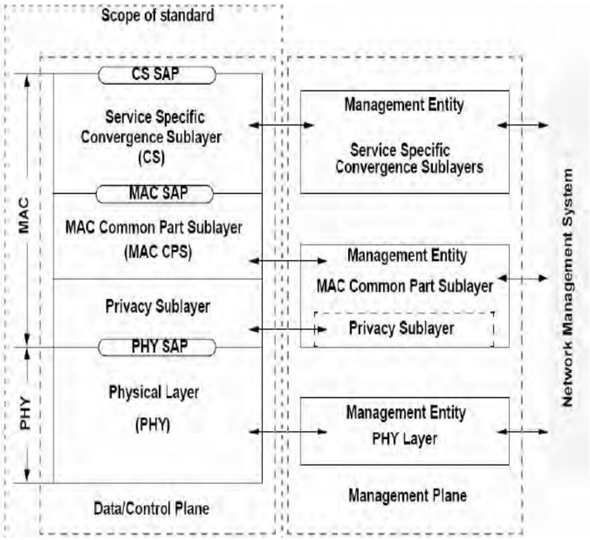

Figure 1.1 Reference model of IEEE 802.16 MAC

2. Design and Implementation

This session describes the design and implementation of network entry and initialization procedure. 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.

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

2.1 Overview of network entry and initialization

In order to communicate on the network an SS needs to successfully complete the network entry process with the desired BS. The network entry process is divided into DL channel synchronization, initial ranging, capabilities negotiation, authentication message exchange, registration, and IP connectivity stages. Figure 2.1 shows the network entry process.

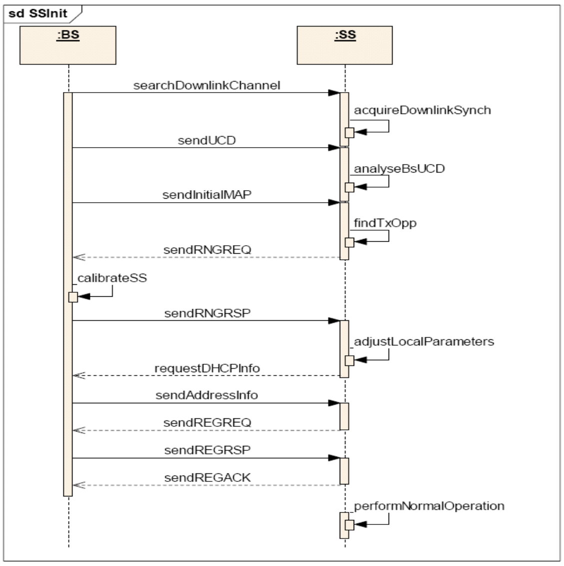

Figure 2. 1: SS initialization overview

2.2 Detail design for n/w entry and initialization

The following section describes the design details for network entry and system initialization. Figure 2. 2 give the state flow for each step of network entry and initialization process.

ScanForDownlinkChannel: This state is established during downlink. Synchronization of SS.

ObtainParameters: This state is established when it passes downlink synchronization.

StartInitialRanging: This state is established when it acquires uplink parameters from BS.

ExchangeCapabilities: This state is established when it passes the initial ranging.

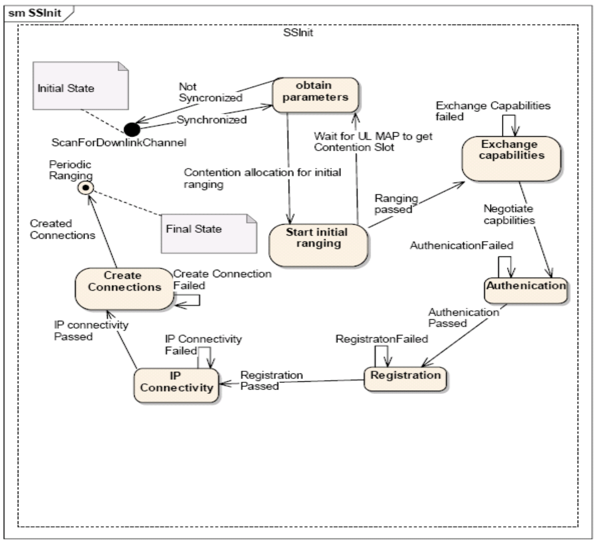

Figure 2. 2: State diagram for network entry

Authentication: This state is established when it passes the capability negotiation.

Volume: 01 Issue: 03 Pages: 181-187 (2009)

Registration: This state is established when it passes the authentication.
IPConnectivity: This state is established when it passes the registration.
CreateConnections: This state is established when it passes the IP connectivity.

2.2.1 Downlink 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 DL channel and is able to synchronize at the 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. Figure 2. 3 show the sequence diagram for downlink channel synchronization.

DownlinkChannelSynchronization ()
{
// Time the SS searches for preambles on a given Channel
a) Start Timer T20
b) Search for PHY frame on channel i
c) If PHY frame is not found go to next channel i+1 and go to step a
d) PHY frame detected
// Time the SS searches for DLMAP on a given channel
e) Start timer T21
f) If DLMAP is found
{
i) Start Lost DLMAP Timer
ii) Start Lost T1 // Wait for DCD Timeout
iii) If one of these timers timeout go to step a
iv) Start Timer T12 // Wait for UCD Descriptor
}
Else go to step a

g) Downlink Synchronized
h) Obtain uplink parameters

If UCD is found
{
i) Uplink parameters acquired
ii) Start Timer T2 // Wait for Broadcast ranging timeout
iii) Start lost ULMAP timer // Wait for ULMAP message
iv) If lost ULMAP goes timeout go to step a
}
Else go to step a
}

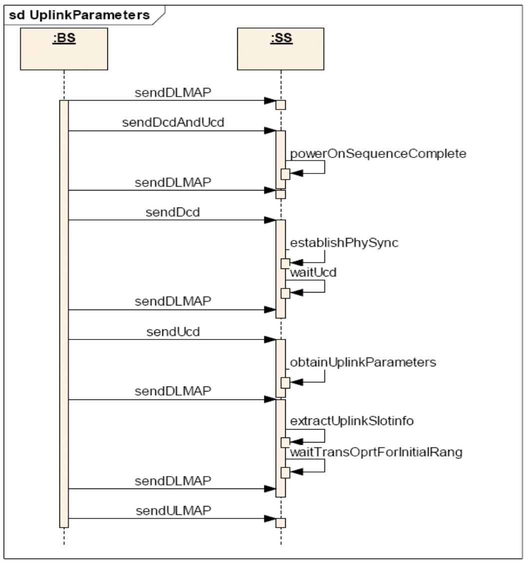

Figure 2.3: Downlink synchronization and uplink parameters acquisition

2.2.2 Initial ranging

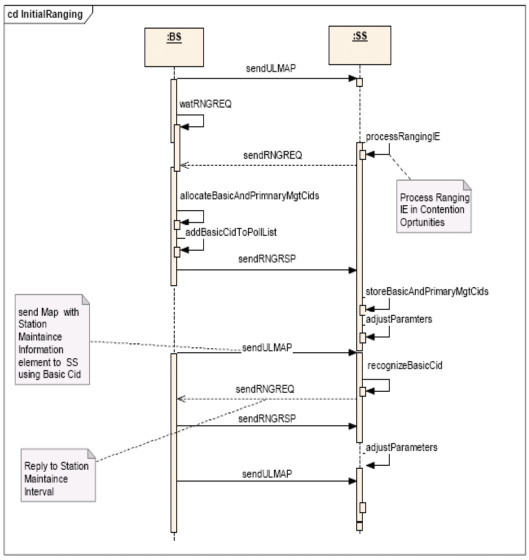

Figure 2.4: Initial ranging

SSInitialRanging ()
{
a) Wait for initial ranging interval
b) If timeout T2 occurs go to scan for downlink channel
c) Receive ULMAP with ranging opportunity
d) Send RNGREQ to BS
e) Start timer T3
f) Wait for RNGRSP from BS.
g) If timer T3 timeouts then
i) Send again RNGREQ with increment to next power level in next ranging interval until ranging retries limit if it exceeds go to scan for downlink channel.
h) RNGRSP from BS

Volume: 01 Issue: 03 Pages: 181-187 (2009)

i) If RNGRSP is continue then
i) Adjust ranging parameters from BS and send again RNGREQ in next ranging interval.
j) If RNGRSP is success then
i) Ranging is successful and SS is ready for communication with BS.
}

BSInitialRanging ()
{
a) Wait for RNGREQ in Initial ranging contention slot
b) RNGREQ from SS
c) If CIDs are not assigned then
i) Assign Basic and Primary Management CIDs to SS and add SS to poll list.
d) If signal is good enough then
i) Send RNGRSP with success to SS.
Else Send RNGRSP with continue to SS
}

2.2.3 Capabilities negotiation

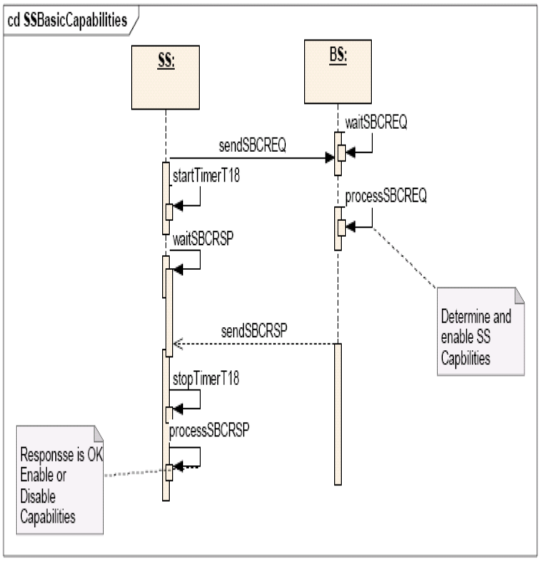

Figure 2. 5: Capabilities negotiation

SSCapabilitiesNegotiation ()
{
a) Send SBCREQ to BS
b) Start Timer T18 // Wait for SBCRSP timeout
c) Wait for SBCRSP
d) If timer T18 timeouts then reinitialize MAC
e) SBCRSP from BS
f) If Response is OK then
Disable or Enable basic capabilities
Else Reinitialize MAC
}
BSCapabilitiesNegotiation ()
{
a) Wait for SBCREQ
b) SBCREQ from SS
c) Determine and enable SS Basic Capabilities
d) Send SBCRSP to SS
e) Negotiation is done
}

2.2.4 Registration

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. Later registration process takes place as follows.

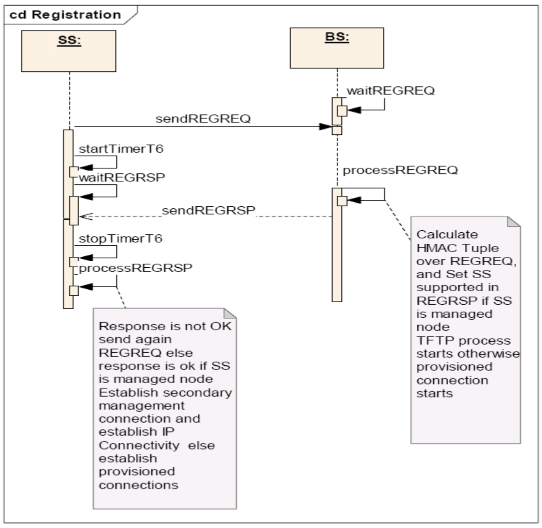

Figure 2.6: Registration

SSRegistration ()
{
a) Send REGREQ to BS
b) Start timer T16 // Wait for registration response
c) Wait for REGRSP
d) If T6 timeouts then
i) Send REGREQ again until retries limit else reinitialize MAC
e) REGRSP from BS
f) Process REGRSP
g) If SS is managed node then
i) Establish secondary management connections and IP connectivity
Else Establish provisioned connections
}

BSRegistration ()
{
a) Wait for REGRSP
b) Receive REGRSP from SS.

Volume: 01 Issue: 03 Pages: 181-187 (2009)

c) Calculate HMAC over REGREQ
d) Set SS capabilities in REGRSP
e) If SS is managed then
    i) Start TFTP Process
Else Start Provisioned Connections
}

2.2.5 IP connectivity

The SS attains an IP address via 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 that gives further configuration parameters. Establishment of IP connectivity will be performed on the SS's secondary management connection.

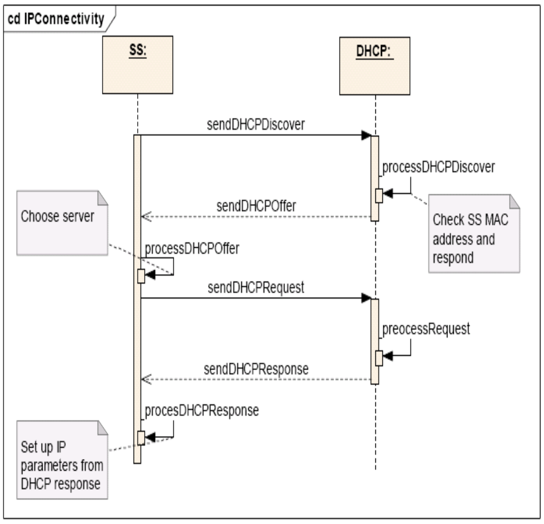

Figure 2.7: Establishing IP connectivity

2.2.6 Transfer operational parameters

SSTransferOperationalParameters ()
{
a) Send TFTPCPLT to BS
b) Wait for TFTPRSP
c) Receive TFTPRSP from BS
d) SS is ready for establishing provisioned connections using dynamic service messages
}
BSTransferOperationalParameters ()
{
a) Wait for TFTPPCFLT
b) Receive TFTPCPLT from SS

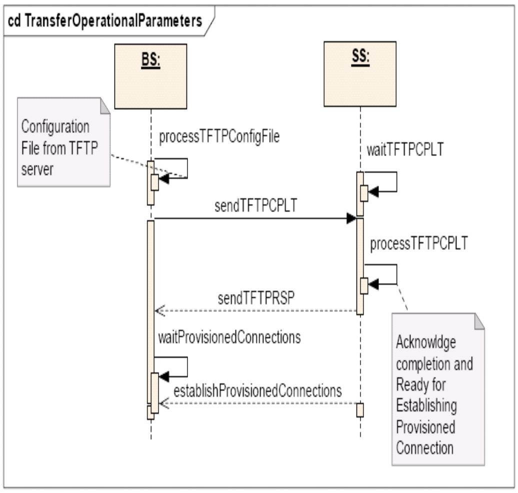

Figure 2.8: Transfer of operational parameters

c) Process TFTPCPLT for ready for establishing provisioned connections
d) Send TFTPRSP to BS
}

3. Results

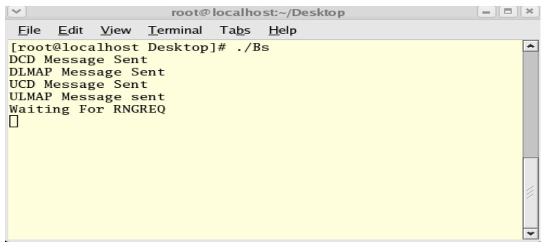

Figure 3.1: Downlink synchronization (BS)

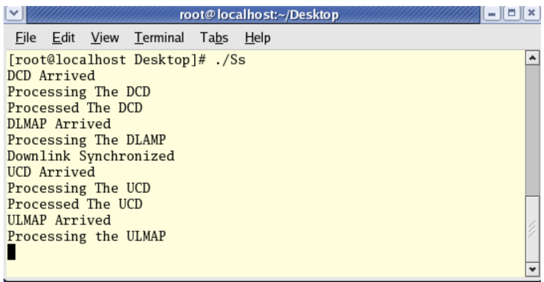

Figure 3.2: Downlink synchronization (SS)

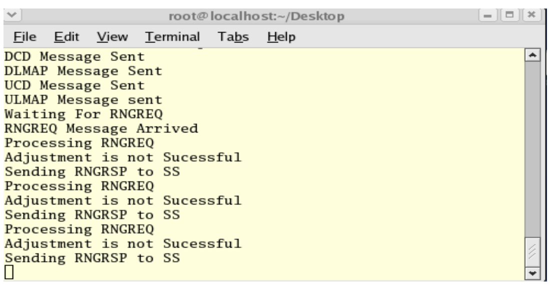

Figure 3.3: Initial ranging (BS)

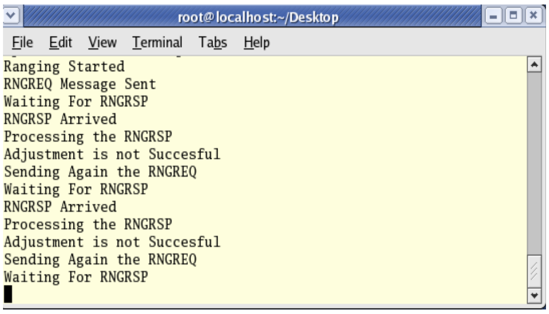

Figure 3.4: Initial ranging (SS)

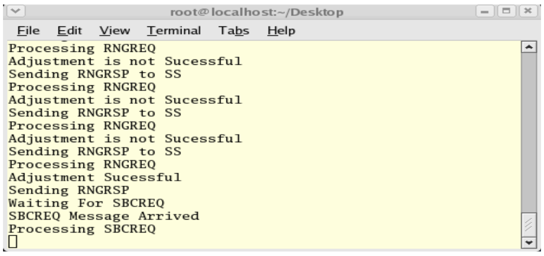

Figure 3.5: Capabilities negotiation (BS)

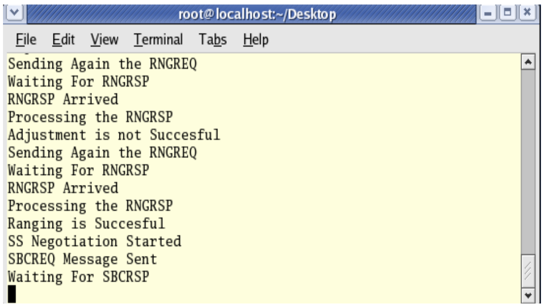

Figure 3.6: Capabilities negotiation (SS)

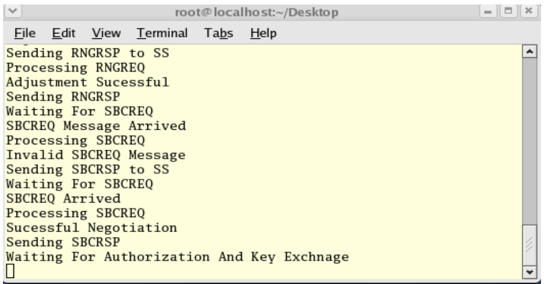

Figure 3.7: Authentication (BS)

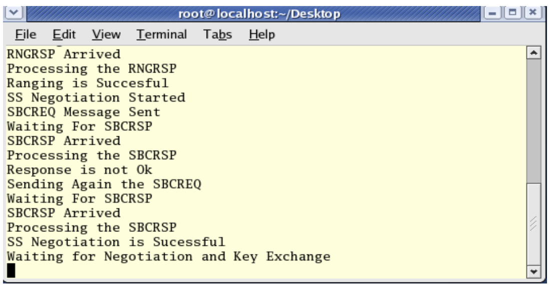

Figure 3.8: Authentication (SS)

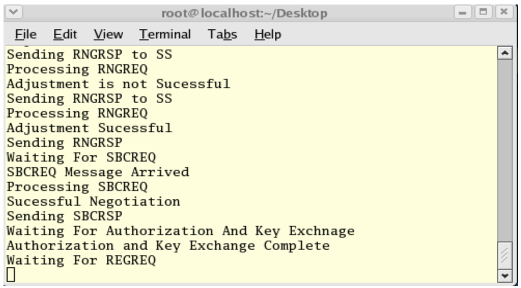

Figure 3.9: Registration (BS)

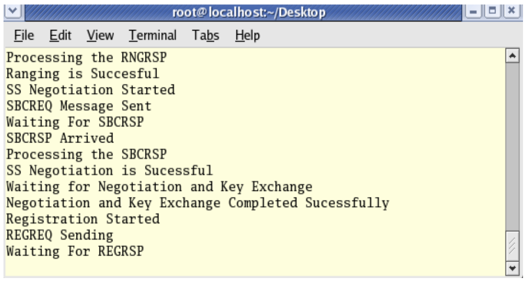

Figure 3.10: Registration (SS)

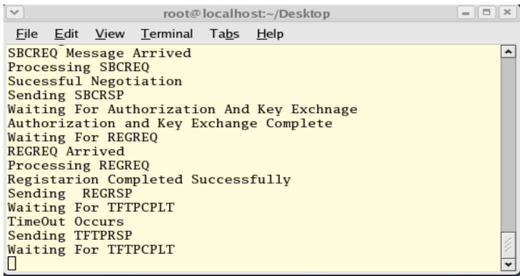

Figure 3.11: IP connectivity (BS)

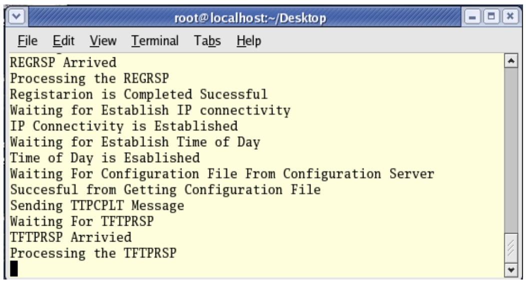

Figure 3.12: IP connectivity (SS)

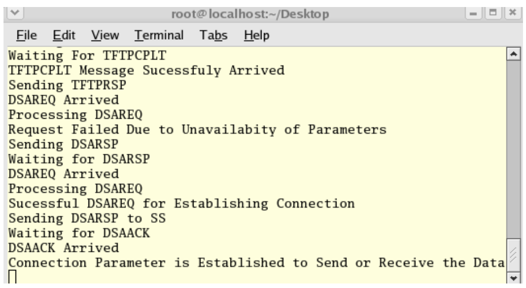

Figure 3.13: Connection setup using DSA (BS)

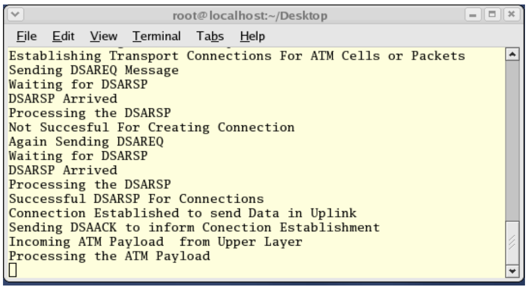

Figure 3.14: Connection setup using DSA (SS)

4. Conclusion

The research 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 airlink usage therefore, it requires sophisticated algorithms. At the same time, its implementation must be easy for users and provide adequate QoS. 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 QoS 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 QoS provisioning. The key contribution of this research 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 buildout, 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.

References

[1] Alan Cox "Beginning Linux Programming" 3rd Edition Wrox Publications For Sockets and IPC Mechanisms.

[2] C. Eklund, R. Marks, K. Starwood, and S. Wang, "IEEE Standard 802.16: A technical Overview of the Wireless MAN Air Interface for Broadband wireless Access", IEEE Communication Magazine, Volume: 40, Issue: 6, June 2002, Page(s): 98 -107.

[3] "C" Programming by Denis Ritchie.

[4] Enterprise Architect User Manuals For UML Tools.

[5] G. Nair, J. Chou, T. Madejski, K. Perycz, D. Putzolu and J. Sydir, "IEEE 802.16 medium access control and service Provisioning", Intel Technology Journal, vol. 8, no. 3, pp. 213-28, Aug. 2004.

[6] Grady Booch , James Rumbaugh , and Ivar Jockobsons, The Unified Modeling Language User Guide , Addison Wisley Pub Co , 1st edition

[7] G. Chu , D.Wang, S. Mei, "A QoS architecture for the MAC protocol of IEEE 802.16 BWA system" IEEE International Conference on Communications, Circuits and Systems and West Sino Expositions, vol.1,pp. 435-39, July 2002.

[8] IEEE 802.16-2001, "IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems," Apr. 8, 2002

[9] IEEE™ P802.16-REVd/D5-2004: "Air Interface for Fixed Broadband Wireless Access Systems", available on www.ieee802.org/16

[10] IEEE, 802.16 MAC LAYER Specifications on WiMAX Forum.

[11] J. Chou, Russ Reynolds, Vladimir Yanover, Shlomi Eini and Radu Selea "MAC and PHY MIB for Wireless MAN BS and SS", available on www.ieee802.org/16

[12] J. Chou, R. Reynold, V. Yanover, S. Eini, R. Selea, B. Moldoveanu, "MAC and PHY MIB for WirelessMAN and WirelessHUMAN BS and SS," http://grouper.ieee.org/groups/802/16/mgt/contrib/C80216mgt-04_04.pdf*

[13] Roger Marks "IEEE Standard 802.16: A Technical Overview of the Wireless MAN™ Air Interface for Broadband Wireless Access" available on http://www.comsoc.org/ci1/Public/2002/Jun/index.html

[14] Stanley Wang, Ken Stanwood, Yair Bourlas, Robert Johnson "IEEE 802.16.1 Convergence Sublayer for ATM"

[15] Tenenbaum, Data Structures Using C and C++ (2nd Edition), Prentice Hall of India.

Authors Biography

Dr.Pradeep.BS.B.E(CSE).,MTech (Networking).,Ph.D (CSE). He is working as assistant Professor in CSE dept. of RRCE, Bangalore, Karnataka. 8 years experienced in teaching. His areas of interest are networking, mobile computing, Computer organization, system software.

Mrs. Soumya.S. She is pursuing her II sem MTech in Information Technology at KSOU, Mysore, Karnataka. 3+ years experienced in teaching. Her areas of interest are networking, Computer graphics.