OPTIMIZING WLAN DESIGN FOR E-LEARNING ENVIRONMENT

Nayan V Jobanputra, Dr. Nikesh A Shah

ABSTRACT

This paper presents a WLAN model optimization rules and simulated results for E-Learning Environment like universities and other academic institutions. WLAN design with mathematical approach for coverage and access point placement estimation is discussed in the paper. WLAN throughput and workstation load estimation is calculated considering E-learning environment where voice and video data transmission is major role player.

Keywords: WLAN, HTTP, FTP,802.11 b/g/n ,Streaming services

1. INTRODUCTION

Designing a Wireless Local Area Network is demanding task for a Network designer. Many issues need to be considered viz. RF planning based on geography of location, number of users in that particular area, application type and priority of application , bandwidth requirement etc. Much of the WLAN design is currently done based on the designers experience and "rules of thumb". The ad-hoc nature of this approach limits the performance of the deployed network.

And just as high performance and availability are critical to customer satisfaction for global enterprises, so too are these qualities necessary to ensure the ongoing satisfaction of teachers, students and administrators in settings that depend on e-learning technologies. Educational institutions face challenges similar to those faced by corporations in ensuring the successful deployment and ongoing use of critical applications.

E-learning applications can place heavy demands on servers and networks for short periods, such as when many users establish connections almost simultaneously or when large files are transmitted to large numbers of users. It is critical for the application to be able to effectively handle spikes in usage in order to maintain a high level of user satisfaction[9].

Most important WLAN design considerations are (1) Determination of Physical coverage volume (2) Verification of Signal to Noise ratio and (3) Determination of Speed – Distance Relation.[4] These issues are covered in 2.0 briefly.

To optimize the WLAN from the design level before implementing the WLAN such areas must be taken care. We try to establish WLAN model which is ideal for E-Learning environment. A model which is based on the user location , Application bandwidth requirement , Availability of access and cost verses user satisfaction. In order to get optimum design mathematical and simulation of network is the best choice. In this paper best fit model is derived mathematically for placement of Access Points across the campus , through put of access point and user application requirements and available bandwidth are then tested in a simulator.

2. DESIGN TIME CONSIDERATIONS

2.1 "Hot Zones" – high density areas

Some areas will have high activity and usage. For example, in conference rooms may require higher amounts of wireless network capacity, or in university environments you may have Labs and auditoriums with hundreds of students connected to the wireless network at the same time. An RF planning should address this need by allowing you to identify "Hot Zones" and then planning for the higher capacity requirements specific to that area while simultaneously coordinating the RF coverage with the rest of the wireless network.

2.2 Throughput vs. Coverage

Considering the coverage and throughput requirements that are appropriate for the applications that will run on your network. Voice and location services demand a consistent and higher-density style of deployment, while traditional data services can work well by scaling the access point density solely according to the client density.

2.3 Indoor and Outdoor Coverage

When we consider indoor coverage placement of APs is complicated due to indoor propagation losses that are highly dependent on the type of the building and the composition of walls. One must consider geography of the location and path loss inside the building.

Outdoor coverage needs proper RF planning to reduce interference with other channels and devices that work in universal band. Many educational institution architecture is such that class rooms and laboratories are having ample of windows and faced to open area. Signal propagation from outside in provides

2.4 Environment Description

To design flexible and site-specific IEEE 802.11 networks, the designer needs to be able to describe the environment where the network will be deployed. The environment description should be at a minimum to allow designers to specify the required area easily. Such an environment can be described with walls. Using specified walls and floors, a skeleton of a building or environment can be constructed. The combination of these walls allows for the specification of rooms or corridors where people may be static or moving.

This environment description is used as an input to the propagation model to estimate signal levels.

2.5 User Demands

As part of the fitness evaluation of a generation, user demands in a E-Learning environment need to be defined before the optimisation can begin. Based on the suggested AP placement the satisfaction of these demands is evaluated. The User Demands required are the definition of target areas where the Wi-Fi network needs to cover, such as specific rooms or corridors, and a definition of the average throughput required by users. Besides definition of target areas it is also useful to specify restricted areas if they exist, where it is not necessary to cover or place APs.

2.6 Bandwidth Estimation

User needs in a E-learning environment is specific than other normal users, we expect interactive web surfing with audio and streaming video at least of moderate quality and size . Number of concurrent users in a similar application is expected 25 during simulation of design.

Typical bandwidth requirement per user in different applications can be classified as shown in the table 2.6.1.[8]

Table: 2.6.1 Performance Targets for Interactive Services[8]

Medium	Application	Degree of Symmetry	Typical Data Rate/Amount of Data	Key Performance Parameters and Target Values		
				One-Way Delay (Response Time)	Delay Variation	Information Loss
Audio	Voice messaging	Primarily one-way	413 kbps	< 1 sec for playback < 2 sec for record	< 1 msec	< 3 percent packet loss ratio
Data	Web browsingHTML	Primarily one-way	~ 10 kbps	< 4 sec/page		0
Data	Transaction serviceshigh-priority (for example, e-commerce and ATM)	Two-way	< 10 kbps	< 4 sec		0
Data	E-mail (server access)	Primarily one-way	< 10 kbps	< 4 sec		0

In determining bandwidth for streaming services, the amount of bulk data transfer/retrieval and synchronization information is approximately < 384 kbps. A movie clip or real-time video requires 20384 kbps. Video streaming over data networks has been on the rise recently, it is in fact a reality over wire line data networks today. It is data intensive and can be difficult to support on wireless networks. While many of the video streaming applications require high quality picture frames, with high resolution and clarity in the video data (as in the case of movie clips), many others do not.

Performance Targets for Streaming Services[8]						
Medium	Application	Degree of Symmetry	Data Rate/Amount of Data	Key Performance Parameters and Target Values		
				Start-Up Delay	Transport Delay Variation	Packet Loss at Session Layer
Audio	Speech, mixed speech and music, and medium and high-quality music	Primarily one-way	5128 kbps	< 10 sec	< 1 msec	< 1 percent packet loss ratio
Video	Movie clips, surveillance, and real-time video	Primarily one-way	20384 kbps	< 10 sec	< 1 msec	< 2 percent packet loss ratio
Data	Bulk data transfer/retrieval, layout and synchronization information	Primarily one-way	< 384 kbps	< 10 sec		0
Data	Still image	Primarily one-way		< 10 sec		0

2.7 Selection of Candidate Access Points

To speed up the optimization process the software automatically creates an irregular grid of Candidate Access Point positions thus forming a mesh that can be traversed during the optimization . The grid is formed based on a growing self-organizing grid algorithm. Each AP not only has a position but also an associated signal coverage map for the defined environment. The coverage map is evaluated only once before optimization begins. In the grid each AP has a list of its neighbors which when connected create the edges which can be traversed. By using the candidate access point mesh, the optimization search space is reduced.

Positioning and Optimization of Single AP: Coverage and path loss is site specific even though during simulation the following some of the following parameters are considered based on previous research[2].

Table 2.7.1[2]

PHY	DSSS/CCK				OFDM							
PHY rate [Mbps]	1	2	5.5	11	6	9	12	18	24	36	48	54
Rec. sens [dBm]	-93	-90	-87	-84	-82	-81	-79	-77	-74	-70	-66	-65
Cell radius [m]												
Free Space	1380	980	695	495	390	348	276	220	155	98	62	55
Lee (WLAN)	240	202	170	145	128	121	107	96	81	64	51	48
Open office	715	521	382	280	227	204	166	134	98	65	43	38
Semiopen office	85	65	53	45	38	36	31	26	21	16	12	11
Closed office	25	22	19	17	15	14	12	11	10	8	7	6

Decision of placement of APs can be modeled using based on quality of coverage at each access point , the parameter of Coverage Quality can be measured using the following way[1].

The path loss for each receiver should satisfy the following condition:

$$\min_{j=1,\ldots,N} pl(a_j, r_i) \leq pl_{max} \tag{1}$$

Constraint (1) states that path loss is evaluated against the maximum tolerable path loss plmax. This ensures that
the quality of coverage at each receiver location is above the given threshold. This given value, plmax can be calculated by subtracting receiver threshold (Rth) from transmitter power (Pt).

$$pl_{max} = P_t - R_{th}. \tag{2}$$

The above inequality (1) can be expressed in the equality form as:

$$\left(\min_{j=1,\ldots,N} pl(a_j, r_i) - pl_{max}\right)^+ = 0, \tag{3}$$

where

$$(\alpha)^+ = max(\alpha, 0).$$

Therefore, a solution (a1, ..., aN) is feasible if and only if:

$$\sum_{i=1}^{M} \left(\min_{j=1,\ldots,N} pl(a_j, r_i) - pl_{max}\right)^+ = 0 \tag{4}$$

Where :
aj , j=1, . . . ,N Access point (AP)
ri, i=1, . . . ,M Receiver/user

pl(aj , ri) Path loss from user ri to AP aj

plmax Maximum tolerable path loss

It should be noted that aj represents the unknown coordinates of APs. Their number N is not known either. The
coordinates of users ri are assumed to be known and these users can be distributed in design area according to the
design specifications. AP can be placed if the solution is true.

We have considered IEEE 802.11n technology based on user demand in such environment, which uses multiplexing (SDM) technique to increase the data rate[9] . In SDM, data rate is increased as the number of spatial stream (NSS) is increased. We consider that to handle more than one NSS number of transmit and receive antennas is also increased according to the number of NSS. We consider each stream is identical and independent. As a result, in ideal case for the data rate is just doubled in compare to. Data rate associated with NSS is shown in Table 2.7.2 . The purpose of this consideration is to treat certain aspects in general way, while modeling other aspects in more great details. The data rate using different modulation and coding (MCS) for NSS = 1 and NSS = 2 at 20 MHz channel for 800 ns guard interval and minimum receiver sensitivity for non space time block coding (STBC) mode is shown in Table 2.7.2 . Utilizing these information we will first derive the throughput-distance model for single stream case. Upon getting the throughput-distance model for case throughput-distance relationship for case can be derive by just doubling data rate of and use the same coverage range which has been achieved for case. The calculation of throughput-distance model is given below. Distance-based pass-loss model for antenna case can be expressed as (6) where is the path loss exponent. and are the total path-loss and path-loss at a distance of one meter respectively. is the distance between transmitter and receiver and expressed in meter. In terms of powers, and can be expressed as and [W] [W] where , and are the transmit power, receive power, and power at reference distance (1 meter), respectively. Assuming transmitter and receive antenna gain 1 and using receiver sensitivity from Table 2.7.2 the distance associated for maximum achievable data rate can be calculated . Finally the related computed distance and maximum achievable data rate for specified receive power is achieved. However, it should be noted that the data rate which has been specified in Table 2.7.2 is the physical data rate hence to achieve user level data rate we exclude overheads from the physical data rate. It is known that as the data rate increases the the percentage of overheads also increases. In this respect, we can classify the available data rate into three groups: higher data rate (65 Mbps, 58.50 Mbps, 52.0 Mbps), middle data rate (39 Mbps, 26 Mbps) and lower data rate (19.50 Mbps, 13.0 Mbps, 6.5 Mbps). The derived throughput-distance relationship model for and antenna case is shown in Table 2.7.2 [3][8]:

Table 2.7.2 : Physical modes and corresponding throughput, NSS, receiver sensitivity[8].

Modulation	NSS = 1, Datarate[Mbps]	NSS = 2, Datarate[Mbps]	Receiver Sensitivity[dBm]
BPSK (1/2)	6.5	13.0	-82
QPSK (1/2)	13.0	26.0	-79
QPSK (3/4)	19.5	39.0	-77
16QAM (1/2)	26.0	52.0	-74
16QAM (3/4)	39.0	78.0	-70
64QAM (2/3)	52.0	104.0	-66
64QAM (3/4)	58.5	117.0	-65
64QAM (5/6)	65.0	130.0	-64

3. SIMULATION AND RESULTS

It is very difficult to create a real test environment in such a large scale and freeze the parameters for test. Best option is to simulate the test environment using testing tools and test the model. We simulated our design in two different phases 1. Simulation of Outdoor coverage for maximizing the coverage area. 2. Simulation of Indoor area coverage for best throughput.

3.1 Simulation of Outdoor Coverage

We used Airmagnets survey tool for Outdoor coverage. Prior to feed the details to the simulator we collected GPS data for each location , AutoCad design of Entire Campus and Buildings, Line of Site details for RF propagation etc.

Created a primary design based on Autocad and APs coverage area in the autocad itself and creates Cell structure of entire campus. (Figure 3.1.1). We planned maximization of coverage for roaming users using voice application with minimum Number of Access points requirement. We feed the actual collected GPS Data and other details and derived a detailed campus outdoor plan with RF management using Air magnets survey tool (Figure 3.1.2.) ploted over google map . We refined placement of access point based on density of usage and location details such as Number , type and structure of buildings. For the simulation purpose we used Motorola AP7181 Series access points providing 802.11n with data rate up to 300mbps and large coverage area. Maximization of coverage achieved placing the antennas at different level of heights. Path loss predicated was 8 to 10 dB at 2.4 GHz By placing just 21 Access points we could cover nearly 400 acres of land with more than 40 large to mid size building from outside.

Figure 3.1.1

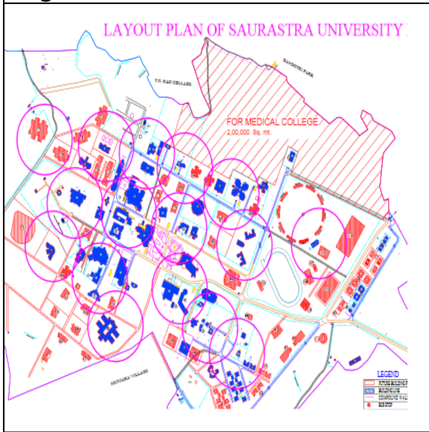


Figure 3.1.2

Figure 3.2.1

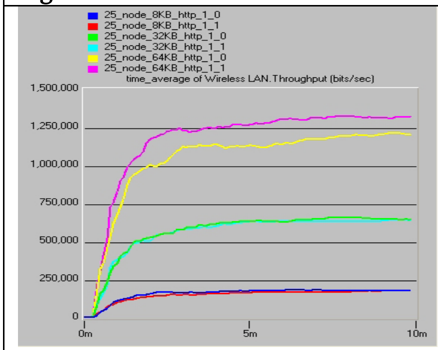


Figure 3.2.2

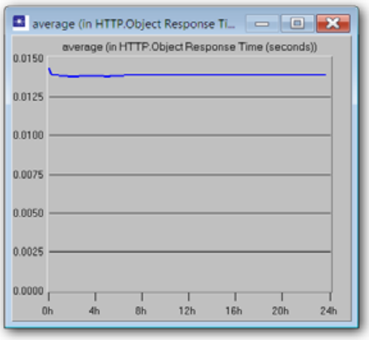


Figure 3.2.3

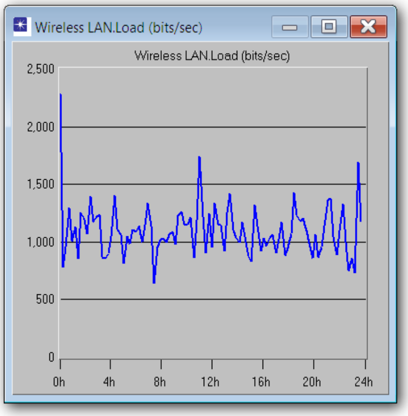
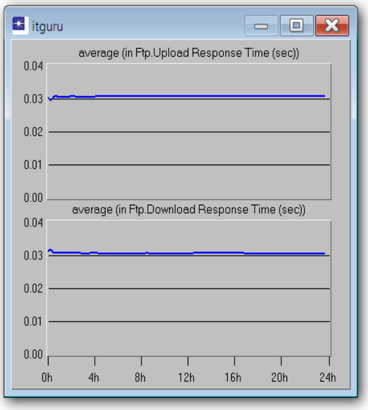


Figure 3.2.4



4. CONCLUSION

This paper presented optimization of WLAN design for and E-Learning Environment for academic institutions. The simulation results show that an IEEE 802.11 based WLAN can be designed using various combination of 802.11 b/g/n Class wireless technology in outdoor as well as indoor classroom / Laboratory use. Our study shows that simulation of outdoor WLAN design reduces number of access points to be deployed and better planning of RF management that in turn improves coverage and throughput. As design is more mathematical and simulation base may be difficult to implement. A design software based on this parameters can be developed to assist network designers. Although the design is not tested on a physical environment where some results may vary due to change in geographical environments.

REFERENCES:

1. S. Kouhbor, J. Ugon, M. Mammadov, A. Rubinov, A. Kruger,"Coverage in WLAN: Optimization Model and Algorithm"
2. Eduard Garcia Villegas , Josep Paradells Aspas "Self-Optimization of Radio Resources on IEEE 802.11 Networks"
3. IEEE Std 802.11n-2009, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 5," pp. c1 –502, 29 2009.
4. Lizzie Narváez, Jesús Pérez, Carlos García and Victor Chi," Designing 802.11 WLANs for VoIP and Data",2007
5. Helal Chowdhury, Janne Lehtomki, Juha-Pekka Makela , and Sastri Kota, " Data Downloading on the Sparse Coverage-Based Wireless Networks" ,2010
6. Lewis C, Pickavence S,Morrow M ,"Selecting MPLS VPN Services Application/Bandwidth Requirements"
7. Ramana Isukapalli, Efficient Real Time Content Delivery on Wireless Networks
8. Air Magnet , White Paper , "802.11n Primer",August-2008
9. Citrix Systems , White Paper ,"Maximize E-Learning Value and Optimize application Delivery" , 2006

Nayan V Jobanputra, M.Sc.(I.T. & CA), is i/c Director at Computer Centre ,Saurashtra University, Rajkot. He is having more than 25 years of experience in Computing and Academics. He has presented several research papers at International/National Conferences. His research areas include Computer Networks, E-Learning and Mobile Computing. He can be contacted at naya_job@yahoo.com.

Dr. Nikesh A. Shah, M.Sc.(Physics), PhD, is an Associate Professor of Electronics at Department of Electronics, Saurashtra University, Rajkot. He has published several research paper in referred journal. He has authored 3 books and several articles in repute electronics magazines. He has completed 2 minor research project and 1 major research project sponsored by National Research Agencies.