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ANALYSIS OF THE MULTIHOP ROUTING ALGORITHM FOR WIRELESS SENSOR NETWORK BASED ON BAUD RATE AND PATH LOSS MODELS

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ABSTRACT

The Information gathered by the sensor node in Wireless Sensor Networks (WSNs), is sent to the sink either by multi hop transmission or by direct transmission. In multi hop transmission energy is saved as it sends the information to the nearest node and then the node hops to another node till it reaches the sink node. Selecting the optimal nearest node for sending the information is the greatest challenge in WSN. Therefore, in the proposed work, a routing protocol has been presented that selects the optimal nearest node utilizing Shannon Channel Capacity 'C' and a propagation model. Accurate modeling of propagation and path loss with respect to different terrains is another challenge in WSN system design and analysis. Among many metrics used to measure the performance of WSN, the proposed method uses the parameter, throughput and network lifetime. The experimental results present the type of propagation model and Shannon Channel Capacity 'C' that should be employed based on terrain for designing the algorithm for WSN.

Keywords: *Wireless Sensor Network, Path loss model, Shannon Channel Capacity, Routing algorithm, Multi hop, Two ray ground model, Okumura-hata model, Costa 231-hata model.*

1. INTRODUCTION

More than 50 years ago, the concept of WSNs was first conceived as a vision, mostly in response to military requirements. In actuality, cutting-edge WSN deployments were utilized throughout the Vietnam War [1]. In fact, Southeast Asian forests served as the actualization of the legendary air-dropped sensors scenario. However, the technology of the time was both costly and bulky, and it required over 40 years (from the start of the twenty-first century) for the empowering stages to become accessible, compact, versatile, and powerful enough to carry out fundamental sensing, communication, and computation functionalities. For more than a decade, academic and industrial research and development activities on WSNs have grown rapidly. The WSN vision is now evolving into a sophisticated technology with applications in seamless fields. Wireless Sensor Networks (WSNs) are made up of sensor nodes that operate in multi-hop and self-organizing modes. Field obstacles, terrains and node structure are readily influenced by wireless channels as signal transmits between transmitter and receiver ends in WSN [2]. Numerous researches have assessed the modeling benefits [3, 4] and channel propagation properties of WSNs [5].

Shannon used probabilistic models for information sources and communication channels to describe the fundamental issue of accurate information transmission in statistical terms [6]. He modified a logarithmic metric for the information content of a source based on a statistical formulation. Additionally, he has shown how the channel capacity may be used to combine the effects of additive noise, transmitter power constraints, and bandwidth restrictions into a single metric. An ideal band-limited channel with bandwidth BW has a capacity determined by additive white Gaussian noise interference.

The main contribution of this article is the Development of a Novel Routing Algorithm for WSN using Shannon Channel Capacity 'C' & different propagation models. Analysis of Two ray ground model, Okumura-hata model and Costa 231-hata model have been carried out for different frequencies for suburban and large cities. As indicated below:

1. Two ray ground model, Okumura-hata model and Costa 231-hata model.
2. Okumura-Hata model for large cities for the frequencies 150 MHz&1500MHz and

for medium cities only for the frequency 150 MHz.

3. Okumura-Hata model for Suburban for the frequencies 150MHz and for rural area for the frequencies 1500MHz.
4. Costa Model for Large cities for the frequencies 1500 MHz&2000MHz and for medium cities for the frequency 1500 MHz only.

2 LITERATURE SURVEY

Authors [7] have made a precise literature survey to recognize propagation models broadly utilized in WSN deployment in farming or normally vegetated conditions and their viability in measuring signal losses. The outcomes present, in the majority of the application cases, especially in vegetative models gave high error values while measuring attenuation.

The authors [8] have estimated Received Signal Strength Indication (RSSI) values of near-ground WSN under four various terrains and obtained the statistical path loss models. By extensive analysis of the impact of various antenna levels and terrain factors, they presented the constraints of existing models and proposed a path loss model technique for WSNs.

Large scale propagation models like free-space model, the two-ray model, log-distance model, and the shadowing model used for outdoor WSN application is briefly explained in [9]. In this article the authors demonstrated that WSN deployment is impractical without utilizing proper path loss models for target scenarios.

A hybrid path loss model based on Polynomial equation (PE) and Particle Swarm Optimization (PSO) was proposed in [10] to find the distance between two nodes. The performance metrics like distance estimation errors and correlation co-efficient are considered and simulation was done using MATLAB. The results present that proposed hybrid model was improved by 85% in terms of distance estimation errors compared to Log Normal Shadowing model. The value of th correlation coefficient of their proposed model was 0.98 and the value for Log Normal Shadowing model was 0.87.

The analysis of radio wave propagation on the wireless network under various kinds of environmental conditions is presented in [11].The experiment was conducted to obtain signal propagation losses for the frequencies 2GHz and 5GHz. The result showed that the values of signal propagation loss obtained from the experiment were better than the theoretical signal propagation loss values.

The path loss models were presented for various conditions of weather like humidity and temperature by the authors [12]. In this article DigiXBee S2 modules were used for the measurements and values of RSSI were obtained in various conditions of weather. The experimental results show that log- normal model performs better than two-ray ground propagation model.

The Propagation model was developed for landslide management system [13] by utilizing log-normal model and ray tracing model. The developed propagation model was applied to measure the performance of WSN. Simulations were conducted by placing sensor nodes randomly using Castalia. The results of simulation presents that short-range WSN can be applied for landslide management system.

The authors [14] proposed hybrid path loss model, a combination of log normal model and two ray ground reflection model. The impact of antenna height on path loss exponent was shown by different estimations taken in such environment. In this article empirical data was compared with different models and it had positive outcomes for the proposed model.

The authors have worked on assigning priorities to the sensor nodes in WSN for effective data communication based on the trust value [15]. They have improved the throughput.

Sowmyashree and C S Mala [16] have proposed shortest and secured route for communication in WSN using cost-centric-cuckoo search algorithm.

In the literature survey it is observed that only few articles have used Shannon Channel Capacity 'C' and propagation model to device routing algorithm for WSN. Therefore this article focuses on multi hop transmission for WSNs that uses Shannon Channel Capacity ‘C’ along with different propagation model to choose the best nearest node for delivering the information.

2.1. Problem statement

Propagation models play a crucial role in Wireless Sensor Network (WSN) system design and analysis. These models abstract the complex electromagnetic wave propagation characteristics in a simplified manner, using a small number of parameters. Accurate modeling of propagation and path loss is essential for various performance metrics in WSNs, such as energy dissipation, route optimization, reliability, and connectivity. Using accurate propagation models in routing algorithm for WSN and analysis is vital for several reasons such as network lifetime, route optimization and

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throughput. To improve the routing algorithm for WSN, it is essential to promote the utilization of valid path-loss models that are specific to WSNs. By addressing these challenges and adopting accurate propagation models, the WSN community can enhance the reliability and performance of WSN systems and pave the way for more effective wireless communication in various applications. Further maintaining a connected network topology is critical for the proper functioning of Wireless Sensor Networks (WSNs). The choice of propagation model and its accuracy directly impact the estimation of path loss between sensor nodes, which, in turn, affects the overall network connectivity and the number of sensor nodes required for deployment.

2.1. Research question

We develop the following research questions in accordance with this problem statement:

- How propagation models in routing algorithm for WSN impacts on performance of the network?
- What are the important parameters considered to evaluate the performance of routing algorithm with propagation model for WSN?

3. THE PROPOSED MODEL

The Shannon Channel Capacity, 'C', and the path loss model to the next node will be utilized as the two parameters for selecting the next hop in the proposed method, since CH utilizes many hops to reach the BS. The highest rate at which data may be carried through a transmission channel with a certain bandwidth when there is noise is known as the Shannon Channel Capacity. Based on the theories of Nyquist and Hartely, Clude Shannon created the concept of channel capacity in the 1940s [15].

The primary goals of propagation models are to calculate the average strength of signal loss at various transmitter-receiver separations and the strength of signal variability immediately surrounding a given transmitter-receiver separation [16]. Variations in the propagation route between the receiver and the transmitter are due to variations in signal intensity. Signal intensity changes as a result of relative motions of the transmitter and/or receiver. Additionally, even if the transmitter and receiver are stationary, the propagation environment's moving scatters or shadowed objects may cause the signal intensity to fluctuate.

The proposed algorithm creates clusters and chooses CH using the same techniques as the LEACH protocol [17]. The proposed algorithm will also feature a number of rounds, each of which will entail choosing a CH and cluster members, similar to the LEACH protocol. The CH must be picked at the start of each round, and its selection is entirely stochastic. A node that is a Cluster Head in the present round is not allowed to change roles in subsequent rounds; instead it should hold on until all nodes in the clusters have taken on the CH role. After selecting the CH and cluster members, for each member CH allots a time slot for data transmission using channel access technique,the Time Division Multiple Access (TDMA).Only during its designated time slot, the nodes are permitted to transfer data.

The best neighbour CH for transmitting the information is chosen in the second stage of each round. For this, Eq. (1) is used to determine the Shannon Channel Capacity "C" for each closest CH. Due to a less path loss and a higher bit rate 'C', as illustrated in Figure 1, the CH node 'i' chooses its neighbour CH node 'j'.

$$C = BW log_2\left(1 + \frac{R_p}{N_p * BW}\right) \quad (1)$$

where, Np is Noise Power (k*T, where k is Boltzmann Constant,1.3806503 X 10-23 m^2 kg $s^{-2}K^{-1}$and T is temperature in degree Kelvin), Rp is Power Received in watts and BW is Channel bandwidth in Hz. In order to find Rp in Eq. (1), Eq. (2) will be used;

$$Rp\ (d)[dB] = Tp\ [dB] - Pl(d)[dB] \quad (2)$$

where , Pl(d)[dB] is path loss in dB at a distance 'd' from transmitter, Tp[dB] is Transmitted power in dB and Rp(d)[dB] is Received power in dB at a distance 'd' from transmitter.

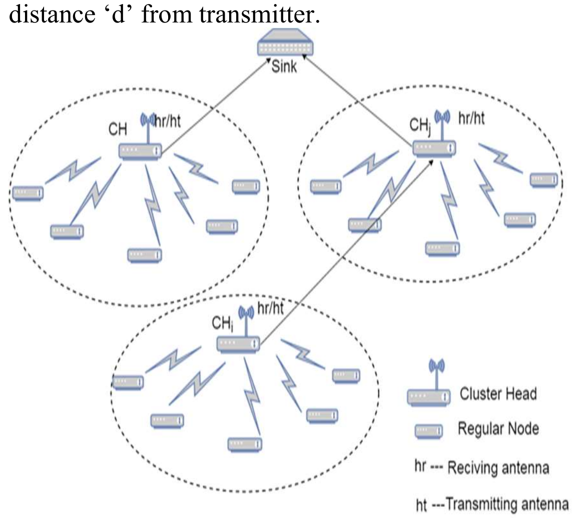

Figure 1: Multihop communication from source CH_i to Sink

3.1 Two-ray ground path loss mode lover smooth terrain.

$$Pl(d) = 40logd - 10(logT_g + logR_g + 2logh_r + 2log_t) \quad (3)$$

Where 'd' is distance between receiver and transmitter, Rg and Tg are receiving and transmitting antenna gain and hr and ht are receiving and transmitting antenna height respectively. Substituting Eq. (2) in Eq. (1), we get

$$C = BWlog_2\left(1 + \frac{T_p[dB] - Pl(d)[dB]}{k*T*BW}\right) \quad (4)$$

To get bit rate 'C', substitute Eq. (3) in Eq. (4)

$$C_{two-ray} = BWlog_2(1 + (T_p[dB] - 40log\,d + 10logT_g + 10logR_g + 20logh_r + 20logh_t)/(k*T*BW)) \quad (5)$$

As a general rule, any surface is typically unpleasant which causes that the Two-ray model is at this point not sensible since a harsh surface presents numerous facets to the incident wave and it is independent of frequency.

3.2 OKUMURA HATA path loss model over different terrains.

The OKUMURA-HATA Model is created in view of path loss information gathered from OKUMURA model and It is an empirical formulation of the graphical path loss information given by OKUMURA, and is valid from 150MHz to 1500MHz [18].This path loss model can be reached out to various terrains along with correction factors. This model can be employed to macro cellular climate and it takes advantage of the same in lower frequencies. Path loss for urban areas can be written as,

$$Pl_{hata}(urban) = 69.55 + 26.16\log(f_c) - 13.82\log(h_t) - a(h_r) + [44.9 - 6.55\log(h_t)]\log(d) \quad (6)$$

Where, f_c -- operating frequency between 150 MHz to 1500MHz.

h_t--Transmitting antenna height of the range 30 meters to200 meters.

d--distance between the receiver and transmitter in km.

$a(h_r)$--height correction factor of the mobile antenna.

Substituting Eq. (6) in Eq. (4) bit rate 'C' is Obtained.

$$C_{hata}(urban) = BWlog_2\left(1 + \left(T_p[dB] - \frac{Pl_{hat}\ (urban)}{k*T*BW}\right)\right) \quad (7)$$

For small to medium sized cities a(hr) is presented by,

$$a(h_r) = (1.1\log(f_c) - 0.7)h_r - (1.56\log(f_c) - 0.8) \quad (7.a)$$

For large cities, a(hr) is presented by,

$$a(h_r) = 8.29(\log(1.54h_r))^2 - 1.1, for\ f_c <= 300MHz \quad (7.b)$$

$$a(h_r) = 3.2(\log(11.75h_r))^2 - 4.97, for\ f_c >= 300MHz \quad (7.c)$$

Path loss for suburban and residential areas;

$$Pl_{hata}(suburban) = Pl_{hata}(urban) - 4.78(\log(f_c))^2 + 18.33\log(f_c) - 40.9 \quad (8)$$

To get bit rate 'C', substitute Eq. (8) in Eq. (4)

$$C_{hata}(suburban) = BWlog_2(1 + (T_p[dB] - (Pl_{hata}(urban) - 4.78(\log(f_c))^2 + 18.33log(f_c) - 40.9))/(k*T*BW) \quad (9)$$

Path loss for Open/Rural areas

$$Pl_{hata}(rural) = Pl_{hata}(urban) - 2(\log\left(\frac{f_c}{28}\right))^2 - 5.4 \quad (10)$$

Substituting Eq. (10) in Eq. (4) bit rate 'C' is Obtained as

$$C_{hata}(rural) = BWlog_2\left(1 + \frac{T_p[dB] - (Pl_{hata}(urban) - 2\left(log\left(\frac{fc}{28}\right)\right)^2 - 5.4)}{k*T*BW}\right) \quad (11)$$

The OKUMURA HATA model may also be used for terrain with irregular features since parametric correction factors have been added,

3.3 COSTA 231 HATA path loss model over different terrains for higher frequencies.

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COST231 (or) COSTHATA (or) COST231HATA (or) HATA Model PCS extension is a radio propagation model developed by the European Union. This model was initially proposed for dense urban areas like Tokyo city, but was later extended to Suburban and Rural/Open areas. This model was developed based on European standards and addressing the frequency limitation of OKUMURA HATA model. The operating frequency range f_c is between 1500 MHz to 2000 MHz for COST 231 HATA model. The effective Transmitter antenna height/Base station value ranges between 30 meters to 200 meters. The mobile station/CPE/receiver antenna height varies between1 to 10 meters. The distance, d between the transmitter and the receiver is in the range of 1 km to 20 kms.

Path loss for urban area is presented by,

$$Pl_{costa}(urban) = 46.3 + 33.9\log(f_c) - 13.82\log(h_t) - a(h_r) + [44.9 - 6.5\log(h_t)]\log(d) + C \quad (12)$$

Where, fc --operating frequency expressed in MHz, ht--antenna height of effective base station expressed in meters, hr--antenna height of effective mobile station in meters, a(hr)--correction factor of antenna height for mobile station, d--distance between receiver and transmitter,

The environmental factor C = 0dB, for suburban, residential and vegetation environment, and C = 3dB, for urban and metropolitan center.

For small to medium sized cities, a (hr) is presented by,

$$a(h_r) = (1.1\log(f_c) - 0.7)h_r - (1.56\log(f_c) - 0.8)$$

For large cities, a(hr) is given by,

$$a(h_r) = 8.29(\log(1.54h_r))^2 - 1.1, f_c <= 300MHz$$

$$a(h_r) = 3.2(\log(11.75h_r))^2 - 4.97, f_c >= 300MHz$$

We get bit rate 'C' by substituting Eq. (12) in Eq. (4)

$$C_{costa}(urban) = BW log_2\left(1 + \left(T_p[dB] - \frac{Pl_{costa}(urban)}{k * T * BW}\right)\right) \quad (13)$$

COST 231 HATA model is mainly used in mobile telephony with a criterion that the base station is above the adjacent roof tops. The bit rate 'C' is calculated depending on the path loss model for each neighbor CH. The information obtained from the non-Cluster Head nodes is first accumulated at the Cluster Head and then sent to the nearest CH.

3.4 An algorithm for sending data from sensor node to the Base Station

A systematic algorithm for sending data from sensor nodes to the Base Station has been developed. It consists of three broad stages. They are Data gathering stage, Path selection stage and Data relay stage. An overview of these stages is presented below:

3.4.1Data gathering stage:

1. *If the sensor node is a non Cluster Head then*
2. *Gather the information*
3. *Non Cluster Head node has to wait until it gets a chance for data transfer*
4. *When non Cluster Head gets a chance , send the information to Cluster Head*
5. *end if*

3.4.2Path Selection stage:

1. *if the sensor node is a Cluster Head then*
2. *Information gathered from non-Cluster Head is aggregated*
3. *Calculate the 'C ' depending on path loss model for each neighbor Cluster Head*
4. *Select the maximum 'C' of nearest Cluster Head and send the gathered information*
5. *end if*

3.4.3Data relay stage:

1. *if the sensor node is the Base Station*
2. *Process the information received from Cluster Head*
3. *end if*

4. RESULT ANALYSIS

The algorithm developed is tested using MATLAB and analyzed for

i) Two-ray ground, Okumura-Hata and Costa 231 Hata Propagation model.
ii) Okumura-Hata model for large cities for the frequencies 150 MHz & 1500MHz and for medium cities for the frequency 150 MHz only.
iii) Okumura-Hata model for Suburban for the frequency 150MHz and Rural area for the frequency 1500 MHz
iv) Costa Model for Large cities for the frequencies 1500 MHz & 2000MHz and for medium cities for the frequency 1500 MHz only.

For analysis the different performance metrics such as, *number of data packets reaching the Base*

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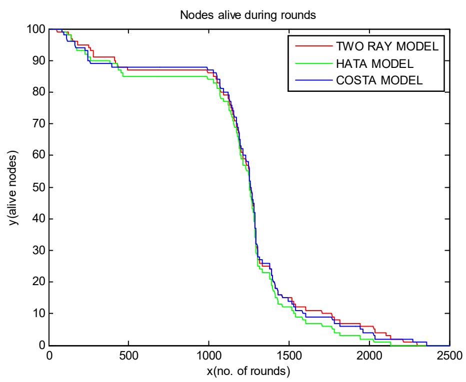
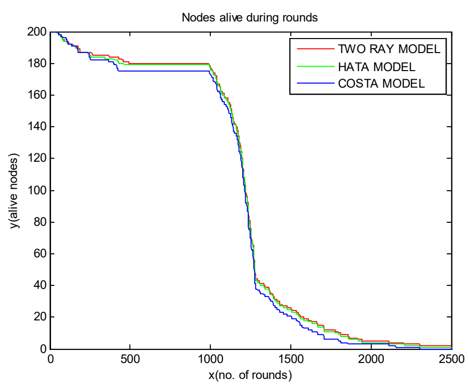
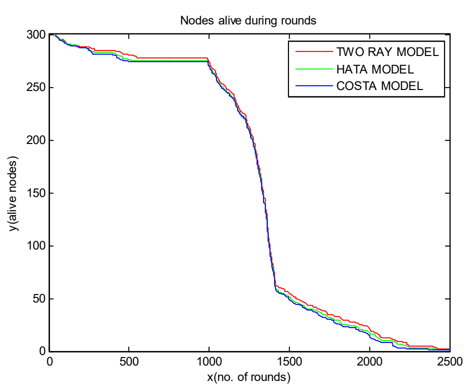
Station and the number of nodes alive are considered. The presented algorithm is examined for 100, 200, and 300 nodes deployed randomly in the 200m x 200m area.



2(a)



2(b)



2(c)

Figure2: Alive Node densities for Two-ray model, Okumura-Hata model and Costa 231 hata model.

The initial energy (Eo) for the sensor node was set at 0.5J.The value of Energy transmitted (Et) was set at 50J. Space model (εfs) and multipath fading (εmp) were set at 10pJ/bit/m2 and 0.0013pJ/bit/m4 respectively. Temperature was set to 100 ^{0} K, BW was set at 900 MHz and Transmitted power (Tp) was set at 50db.

Table 1: Two-ray model, Okumura-Hata model and Costa 231 hata model with reference to FND, HND and LND

No. of Nodes	Two-Ray model(In rounds)			Okumura-Hata model (In rounds)			Costa 231 hata model		
Nodes	FND	HND	LND	FND	HND	LND	FND	HND	LND
100	73	1246	2501	53	1237	2501	49	1234	2501
200	51	1295	2501	30	1290	2501	27	1286	2501
300	29	1310	2501	25	1300	2501	20	1288	2501

The Parameters like First Node Dead (FND), Half Node Dead (HND) and Last Node Dead (LND) determine the time during which the first node, half of the nodes and the last node of the network are dead respectively. Figure 2(a), (b) and (c) presents active nodes over simulation rounds for Two-Ray, Okumura-Hata and Costa 231 hata model for 100, 200 and 300 nodes respectively. Table 1 shows the statistical information of FND, HND and FND of Two-ray model, Okumura-Hata model and Costa 231 hata model.

As Two-Ray model is independent of frequency and applied over smooth terrain. First Node Dead was after 73 rounds, 51 rounds and 29 rounds for 100, 200 & 300 nodes respectively. HND was after 1246 rounds, 1295 rounds and 1310 rounds for 100, 200 & 300 nodes respectively. LND for 100, 200 and 300 nodes renained at 2501 rounds only. Okumura-Hata model and Costa 231 hata model are frequency dependent and applied over irregular terrain. Okumura-Hata model is designed for 150MHz. and Costa 231 hata model is designed for 2000MHz.In Okumura-Hata model FND was after 53 rounds for 100 nodes, 30 rounds for 200 nodes and 25 rounds for 300 nodes HND was after 1237 rounds for 100 nodes, 1290 rounds for 200 nodes and 1300 rounds for 300 nodes. LND after 2501 rounds for 100, 200 and 300 nodes. In Costa 231 model FND after 49 rounds for 100 nodes, 27 rounds for 200 nodes and 20 rounds for 300 nodes. HND was after 1237 rounds for 100 nodes, 1286 rounds for 200 nodes and 1288 rounds

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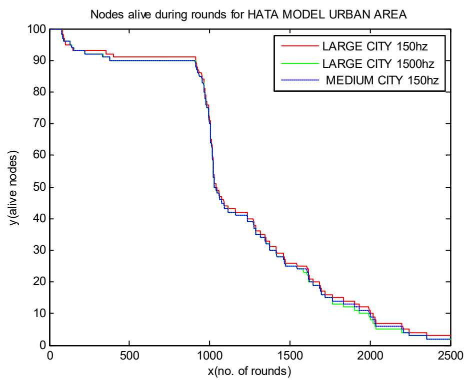
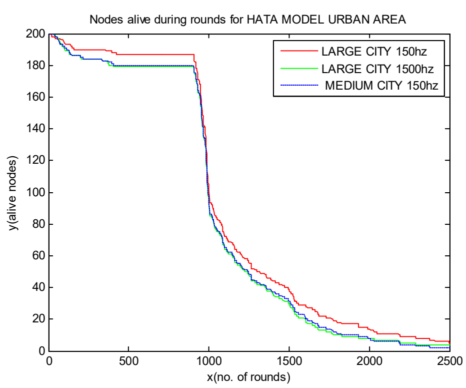
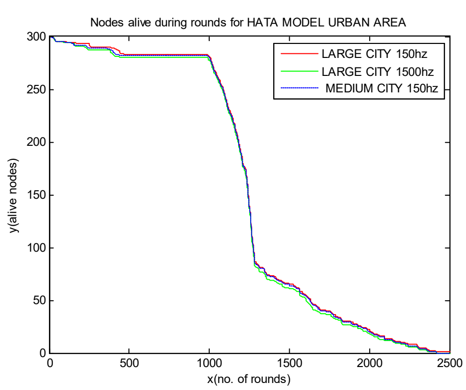
for 300 nodes. LND was after 2501 rounds for 100, 200 and 300 nodes.



3(a)



3(b)



3(c)

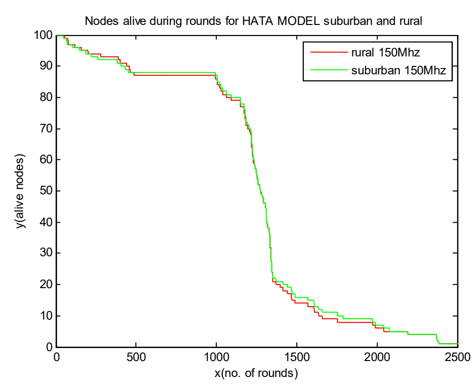
Figure 3: Alive Nodes for Okumura-Hata for Large cities (150MHz, 1500MHz) and Medium cities (150MH)z

Figure 3(a), (b) and (c) depicts the active nodes during simulation for 100,200 and 300 nodes for Okumura-Hata model for Large cities with frequency 150MHz and 1500Mhz and for medium cities with 150MHz frequency.

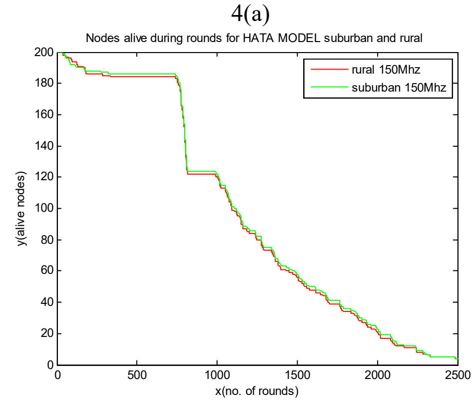
Table 2 shows the statistical information of FND, HND and LND of Okumura-Hata model for large cities with frequency 150MHz and 1500 MHz and for medium cities with 150MHz frequency. Figure 4 (a), (b) and(c) presents the active nodes during simulation for 100,200 and 300 nodes for Okumura-Hata model for Suburban area with frequency 150MHz and for rural area with 150MHz frequency.

Table 2: Okumura-Hata for Large cities(150MHz,1500MHz) and Medium cities(150MHz) with reference to FND,HND and LND

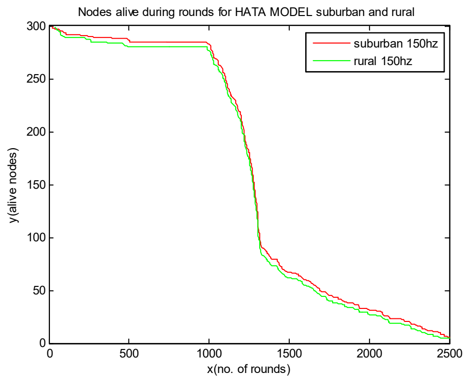
No. of nodes	Okumura-Hata model for large cities For 150Mhz (In rounds)			Okumura-Hata Model for Large cities for 1500MHz (In rounds)			Okumura-Hata model for medium cities for 150MHz (In rounds)		
Nodes	FND	HND	LND	FND	HND	LND	FND	HND	LND
100	82	1054	2501	77	1044	2501	80	1048	2501
200	43	1003	2501	35	996	2501	41	958	2501
300	34	1125	2501	26	1120	2501	31	998	2501



4(a)



4(b)



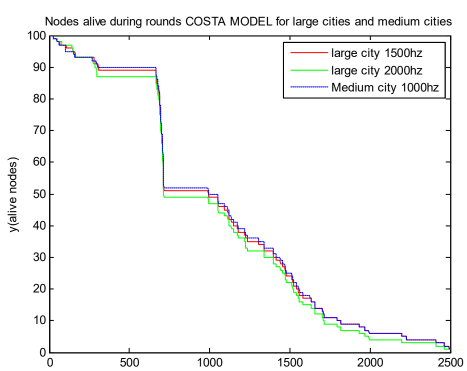
4(c)

Figure4: Alive Nodes for Okumura-Hata for suburban (150MHz) and rural (150MHz)

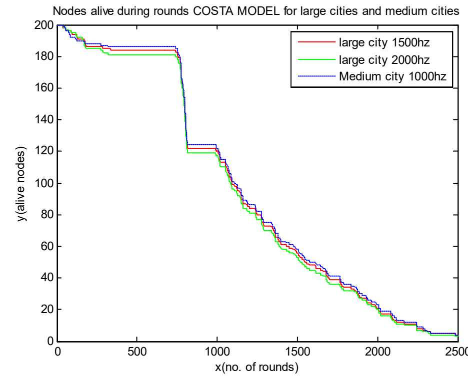
Table 3: Okumura-Hata for Suburban area(150MHz) and Rural area(150MHz) with reference to FND,HND and LND

No. of nodes	Okumura-Hata model for Suburban area for 150Mhz(In rounds)			Okumura-Hata model for Rural area for 150MHz(In rounds)		
No des	FND	HND	LND	FND	HND	LND
100	38	956	2501	29	910	2501
200	42	1051	2501	39	990	2501
300	28	1102	2501	21	1010	2501

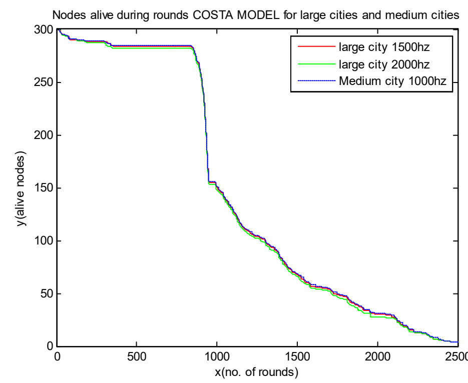
Table 3 shows the statistical information of FND, HND and LND of Okumura-Hata model for Suburban area with frequency 150MHz and for rural area with 150MHz frequency. Figure 5 (a), (b) and (c) presents active nodes during simulation for 100,200 and 300 nodes for Costa231Hata model for large cities with frequency 1500MHz and 2000 MHz and for medium cities with 1500MHz frequency.



5(a)



5(b)



5(c)

Figure 5: Alive nodes for Costa 231Hata model for large cities with frequency 1500MHz and 2000Mhz and for medium cities with 1000MHz frequency

Table 4 shows the statistical information of FND, HND and LND of Costa 231 Hata model for large cities with frequency 1500MHz and 2000 MHz and for medium cities with 1500MHz frequency.

Table 4 : Costa 231Hata for Large cities(1500MHz,2000MHz) and Medium cities(1500MHz) with reference to FND,HND and LND

No. of nodes	Costa 231 Hata model for large cities For 1500Mhz (In rounds)			Costa 231 Hata Model for Large cities for 2000MHz (In rounds)			Okumura-Hata model for medium cities for 1500MHz (In rounds)		
Nodes	FND	HND	LND	FND	HND	LND	FND	HND	LND
100	27	1050	2501	18	715	2501	25	992	2501
200	38	1122	2501	28	1087	2501	32	1090	2501
300	23	980	2501	18	910	2501	21	956	2501

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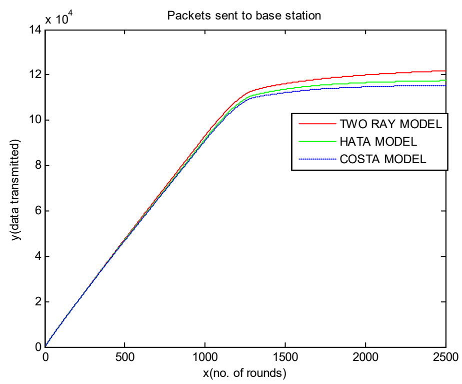
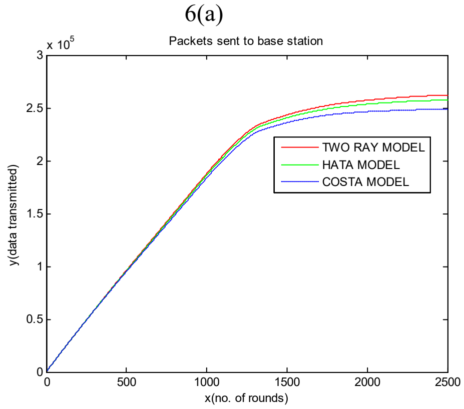
The plot of the number of packets transmitted to the base station for the Two-Ray, Okumura-Hata, and Costa 231 hata path loss models is shown in Figure 6(a),(b), and (c), and the total number of packets delivered is shown in Table 5.

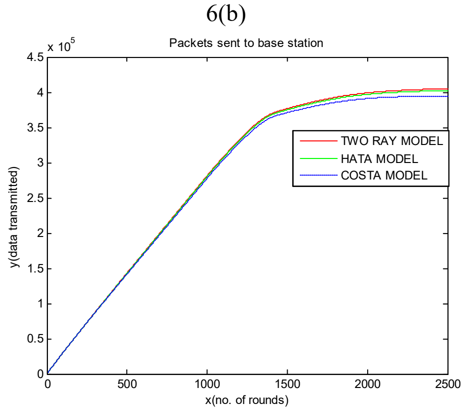
The Two-Ray model is intended for smooth terrain and had lower path loss, and it is frequency independent. Therefore, the bit rate "C" is higher. Hence additional packets are transmitted to the BS.



6(a)

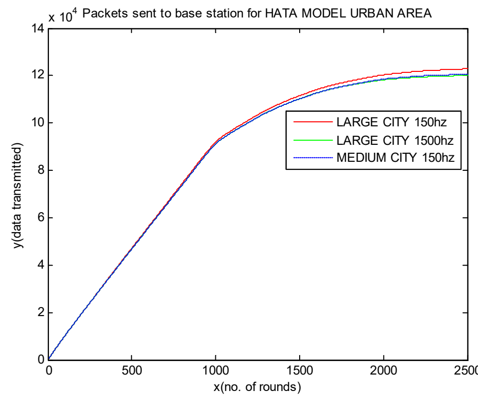


6(b)

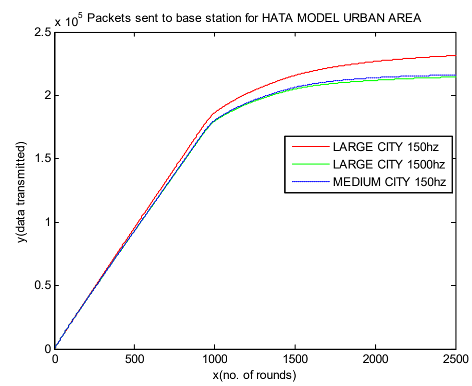


6(c)

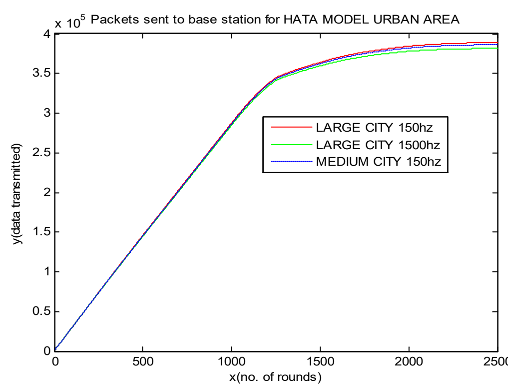
Figure 6: Packets sent to BS for Two-ray model, Okumura-Hata model and Costa 231 hata model



7(a)



7(b)



7(c)

Figure7: Packets sent to BS for Okumura-Hata for Large cities (150MHz, 1500MHz) and Medium cities 150 MHz

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Table 5: Two-ray model,Okumura-Hata model and Costa 231 hata model with reference to Packets sent to BS

No. Of nodes	Packets sent to Base Station		
Nodes	Two-Ray model	Okumura-Hata model	Costa 231 Hata model
100	119331	116268	102098
200	25450	234520	230100
300	39004	388675	37898

Okumura-Hata and Costa 231 hata models are frequency dependent and are designed for irregular terrains, where the path loss is more .Hence bit rate ‘C’ is less therefore relatively less number of packets are sent to BS.

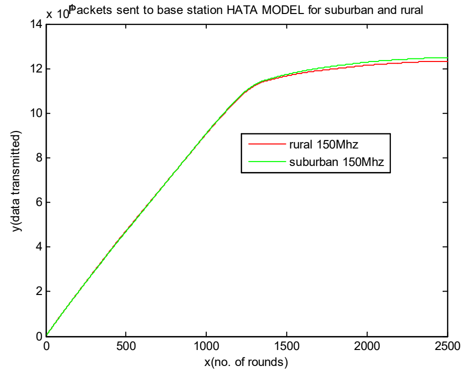
Figure 7 (a), (b) &(c) indicates the plot of packets sent to Base Station and Table 6 shows the number of packets sent to BS for Okumura-Hata model for urban area large cities with 150MHz and1500MHz medium cities with 150MHz .From the Eq.7(c) and 7(b) the path loss is less for large cities with 150MHz and path loss is more with 1500MHz.So the bit rate ‘C’ is more with 150Mhz and less with 1500Mhz.

Table 6: Okumura-Hata for Large cities (150MHz, 1500MHz) and Medium cities (150MHz) with reference to Packets sent to BS

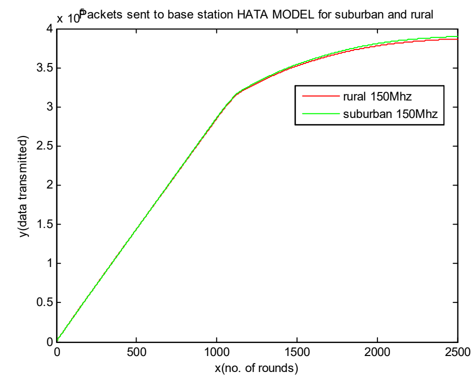
No. Of nodes	Packets sent to Base Station		
Nodes	Okumura -Hata model for large cities For 150Mhz	Okumura-Hata Model for Large cities for 1500MHz	Okumura-Hata model for medium cities for 150MHz
100	112888	110565	110978
200	231307	214520	216003
300	386675	381344	386019

From the Eq.7 (a) the path loss of medium cities with 150MHz is relatively less than the path loss of large cities with 1500MHz and has relatively more path loss than the large cities with 150MHz.Hence the bit rate is moderate.

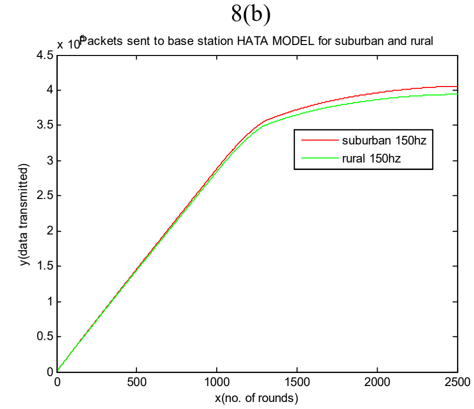
Figure 8 (a),(b) &(c) indicates the plot of packets sent to BS and Table 7 shows the number of packets sent to Base Station for Okumura-Hata model for suburban and rural area for 100,200 and 300 nodes. From Eq.(9) and Eq.(10) bit rate ‘C’ is more for suburban area as path loss is less when compared to bit rate ‘C’ of rural area. Hence packet sent to base station is more in suburban area than in rural area



8(a)



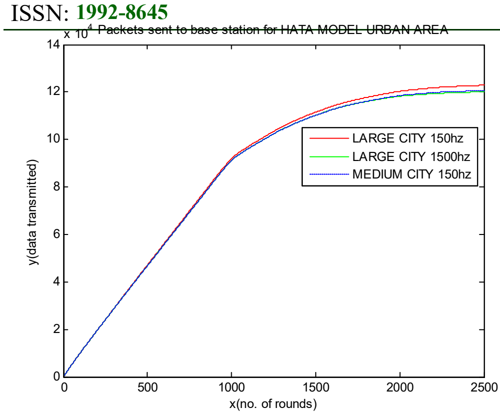
8(b)



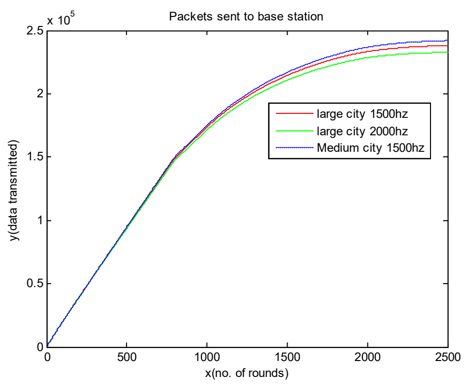
8(c)

Figure 8: Packets sent to BS for Okumura-Hata for suburban (150MHz) and rural (150MHz)

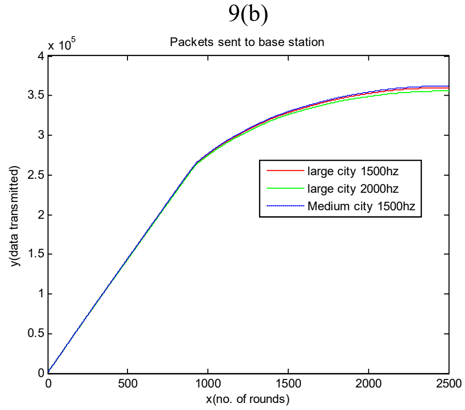
Figure 9 (a), (b)& (c) depicts the plot of packets sent to Base Station and Table 8 gives the number of packets sent to BS for Costa 231Hata model for Large cities with frequency 1500MHz and 2000Mhz and for medium cities with 1500MHz frequency.



9(a)



9(b)



9(c)

Figure 9: Packets sent to Base Station for Costa 231Hata model for large cities with frequency 1500MHz and 2000 MHz and for medium cities with 1500MHz frequency

Table 7: Okumura-Hata for Suburban area (150MHz) and Rural area(150MHz) with reference to Packets sent to BS

Nodes	Packets sent to BS	
	Okumura-Hata model for Suburban area for 150Mhz(In rounds)	Okumura-Hata model for Rural area for 150Mhz(In rounds)
100	123304	124825
200	235683	232002
300	389857	386899

Table 8: Costa 231Hata for Large cities (1500MHz, 2000MHz) and Medium cities(1500MHz) with reference to Packets sent to BS

No. Of nodes	Packets sent to Base Station		
Nodes	Costa 231 Hata model for large cities For 1500Mhz	Costa 231 Hata Model for Large cities for 2000MHz	Costa 231 model for medium cities for 1500MHz
100	106471	102239	107711
200	236542	232815	238161
300	360137	356023	362373

5. CONCLUSION

In our work, we have presented a multi-hop routing algorithm for WSN, by considering Shannon Channel Capacity ‘C’ and different path loss models. Two ray ground wave propagation model is used for smooth terrain, Okumura-Hata model is used for irregular terrain with correction factors and Costa 231-hata model is employed in mobile telephony, where base station is above the adjacent roof tops. We have carried out analysis using different propagation model with Shannon Channel Capacity ‘C’ for measuring the performance of WSN in terms of the Network life time and the Throughput. The experimental results illustrates Two ray ground Propagation model with Shannon Channel Capacity ‘C’ should be employed for smooth terrain, Okumura-Hata model should be used for irregular terrain and Costa 231-hata model is employed in mobile telephony for designing the algorithm for WSN. So far analysis of the routing algorithms was carried out for **outdoor propagation models only**. In the future work analysis of the routing algorithms can be carried out **for indoor propagation models.**

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