Predict Optimal Transmission Power by Comparing Three Fading Channel (Rayleigh, Rician & Shadowing) using random strategy

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Abstract- In wireless sensor network, where nodes are power driven by batteries and it is important to prolong the network lifetime by minimize the energy consumption of each node. Thus the choice of optimal transmission power is one of the prime concerns in such network. Optimal transmission power is the minimum power required to sustain the network connectivity while maintain the predetermined maximum tolerable bit error rate (BER). In this paper, optimal transmission power is derived for a WSN deployed based on random topology. In this paper the effect of three fading channel (Rayleigh, rician & shadowing) on optimal transmission power; route BER and energy consumption for successful delivery of data in multihop is studied for such randomly deployment in wireless sensor network. In random network, an intermediate node in the route selects the nearest node with in a sector of angle (ϴ) towards the direction of the destination of the next hop. The effect of search angle (ϴ) on optimal transmission power, route BER performance & energy consumption in case of the here fading channel are also indicated**.**

Index Terms- Wireless sensor network; optimal transmission power; search angle; random topology.

I. INTRODUCTION

Recent developments in wireless communication technologies such as Bluetooth and Zigbee have led to great interest in wireless sensor network (WSN) sensor nodes are constructed only by using sensor devices with wireless communication facilities at physical layer. Energy conservation is one of the most important issues in WSN, where nodes are likely to rely on limited battery power. If transmission power is not sufficient high then may be single or multiple link failure. Further transmitting at high power reduces the battery life and introduces excessive internode interference. Most of the work on performance of WSN assumes idealized radio propagation model & regular topology without considering impact of fading & shadowing at physical layer. In [1] Arnab Nandi, Sumit Kundu derived optimal transmission power for a wireless sensor network where MRC space diversity is employed at destination nodes in presence of Rayleigh fading while maintain a certain predefined maximum tolerable route BER. In [2] optimal transmission power for a modified square grid architecture of WSN incorporating MRC based space diversity power is investigated in presence of lognormal shadowing. In [3] Sumit Kundu, Arnab Nandi evaluate energy level performance of three packets delivery scheme in a wireless sensor network in multipath rician fading channel. In [4] proposed an adaptive power scheme for WSN where transmit power is adapted as node density and level of shadowing become different so as to maintain the detection probability at a given level as demanded by sensing range. In [5] investigate the optimal common transmit power in a random WSN over Rayleigh fading channel. They also evaluate the energy consumption for successful delivery of a file via multihop route in such fading scenario considering an infinite ARQ scheme between a pair of nodes. In this paper, we investigate the optimal transmission power in a random WSN by comparing fading channels i.e. Rayleigh, rician & shadowing fading channel. We also evaluate energy consumption for successful delivery of a file via multihop route in such fading scenario Optimal transmission power & energy consumption is evaluated under several condition of network such as node density, data rate & search angle (ϴ).

The rest of the paper is organised as follows: in section II, we delineate the system model. Section III shows result and discussion .finally conclusions are drawn in section IV.

II. SYSYTEM MODEL

We consider a random topology of network as shown in fig 1. It assumed that N no. of nodes are distributed over a region of area 'A' obeying random topology. The node spatial density is defined as number of nodes per unit area i.e. $\rho^2 = \frac{N}{A}$ position of nodes in the network are independent & uniformly distributed. It is assumed that all sensor nodes are stationary in present study.

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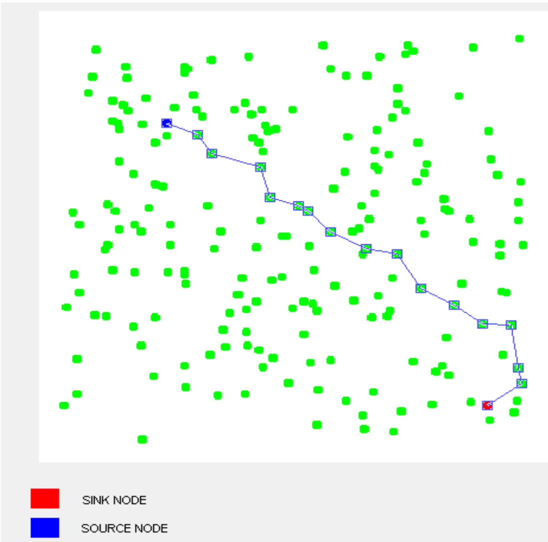

We consider a routing scheme where each intermediate node in a multihop route relays the packet to its nearest neighbours in the direction of the destination. In particular, we assume that an intermediate node in the route select the nearest node with in a sector of angle 'Ө' towards direction of the destination as next hop[5]

Here we consider a simple reservation based MAC protocol called Reserve – and-go (RESGO) following [7]. According to this protocol, a source node first reserve intermediate nodes on a route for relaying its packets to the sink. A transmission is activating only after a route is discovered and reserved. If destination node is busy, it waits for an exponential random back off time before or relay each packet. When the random back off time expires then the node starts dispatch a packet. Note that the random back off time helps to reduce interference among nodes in the same route and also among nodes in different routes right through this paper, we assume that the random back off time is exponential with mean 1/λ1, where λ1 is packet transmission rate.

The major perturbation in wireless transmission are large scale fading and small scale fading[6].The fading represent the average signal power attenuation or path loss due to motion over large area is large scale fading. This observation is affected by jutting out terrain contains mounds (hills), forest, large outdoor boards, clumps of building, etc. between the source & sink. In case of small scale fading it display rapid changes in signal amplitude & phase as a result of small changes in the spatial separation between a sink & source. The rate of change of these proliferate condition accounts for fading rapidly. Rayleigh fading is also called small scale fading because if the multiple reflective paths are large in number and there is no line of sight signal constituents, the envelop of the received signal is statically described by Rayleigh PDF given below [5]

$$p(r) = r/6^2 \exp[-r^2/26^2] \quad \text{For } r \geq o$$
$$= \text{null} \quad \text{else} \qquad (1)$$

If there is a dominant non-fading signal constituent, the small scale fading shroud is described by a rician PDF given below [7]

$$p(r) = r/6^2 \exp\left[-\frac{r^2+s^2}{26^2}\right] I\left(\frac{rs}{6^2}\right), \quad \text{For } r \geq o$$
$$= \text{null} \quad \text{else} \qquad (2)$$

Here r is the envelope amplitude of the received signal and 26^2 is the pre detection Mean power of the multipath signal.

Large scale propagation model (or shadowing) re used to predict the mean signal strength decay as a function of the transmitter-receiver (T-R) separation distance raised to some power. In the presence of shadowing with a T-R partition of d, the path loss PL(d) at a fastidious location is random & distributed log normally about the mean distance dependent value of $PL(d)$. The received signal can be expressed as below [2]

$$P_{sw}(d)\big|_{dBm} = G_t\big|_{dB} + G_r\big|_{dB} + P_{Tx}\big|_{dBm} - \left(\overline{PL}(d)\big|_{dB} + X_{\sigma}\right) \qquad (3)$$

III. Simulation Model

We now present our simulation model developed in MATLAB to evaluate the performance WSN based on a random topology in Rayleigh, rician & shadowing fading channel:

- Digital data 1 and 0 with equal probability is generated at base band. Our transmitted signal is+1 or -1 corresponding to data 1 and 0.
- Fading channel coefficients are generated following Rayleigh distribution ,rician distribution as in equation (1) & (2)
- Next, a number of interfering nodes with in the circle of radius 2W centred at the receiver are generated according to a two dimension passion distribution with mean $a6^2$
- Operative (active) interfering nodes are identified using binomial distribution random variable for node activity.
- Interference from such operative interfering nodes is generated assuming interference undergoes similar kind of fading as the desired signal.
- The desired message signal is affected by multipath fading, thermal noise and interference from other nodes or another node. The s/g received by the receiving antenna in destination nodes is generated following equation.

$$Y_i = h_i S_{rcv} + \sum_{j=1}^{N-2} S_j + n_{thermal} \qquad (4)$$

- The received signal Y as given in equation (4) is then detected considering the threshold level at 0. If the received signal is greater than the threshold level 0 then it is detected as 1 otherwise it is detected as 0.
- Each received bit is then compared with the transmitted bits. If there is mismatch an error counter is incremented now dividing the error count by the total number of transmitted bits, link BER is obtained in case of three fading channel.

- Transmit power is increased gradually in step starting from a very low power till desired BER_{th} is satisfied. The transmit power satisfying desired BER_{th} is optimal common transmit power. Thus optimal transmit power for various bit rate and node spatial density is obtained in case of three Rayleigh ,rician & shadowing fading channel.
- The energy consumption in random network in case of Rayleigh, rician and shadowing fading channel is evaluated using equation

$$E_{total} = \sum_{i=1}^{n_{rndm}} E_{hopi} \qquad (5)$$

IV. RESULTS AND DISCUSSION

Table shows the important network parameter used in simulation study.

TABLE 1:
Network parameter used in simulation

Parameter	values
Path loss exponent(ɤ)	2
No of nodes in network	1000
Node spatial density(ρ_{sq})	$1 * 10^{-3} - 9 * 10^{-3}$
Carrier frequency(fc)	2.4Ghz
Packet arrival rate at each node(λ)	1 pck/s
Noise figure(F)	6dB
Room temperature(T0)	300k
Search angle	π/2 ,π/4
Transmission power(P_t)	1mW

Fig 3 shows route BER as function of node spatial density. It is observed that BER performance improves with increases the node spatial density. However it is seen that beyond a certain node density the BER does not change with further increase in node spatial density and a floor in BER route, as denoted as BER_{floor} appear. It is seen that BER_{route} performance improves as bit rate decreases. This is due to the increases in vulnerable interval with decreases in bit rate.as a result transmission probability of the interfering node increases. Further BER_{route} performance improves with increase in search angle ( ).This is due to fact that for high value of search angle ( ) the hop length is likely to be short.

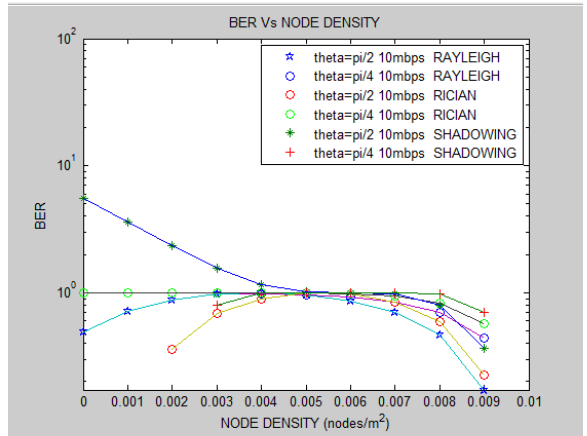

Fig 3: Route BER vs node spatial density;P_t =1mW

As shown in fig, there is a comparison of three fading channel i.e. Rayleigh fading channel, rician fading channel & shadowing fading channel. When the search angle is π/2 BER_{route} performance is degrade as when search angle is π/4 BER route performance is improve. Fig. shows that in case of rician fading channel. Bit error rate is less as compared to Rayleigh & rician fading channel with search angle π/4. In case of shadowing it has a more bit error rate with search angle π/4.

In fig 2,we compare the optimal common transmit power in a random work a function of bit rate in Rayleigh fading channel, rician fading channel & shadowing fading channel. Optimal transmit power is the minimum transmit power sufficiently to preserve network connectivity while satisfy a predetermined BER value at end of multiple route. It is seen that optimal transmit power increases as data rate increases. It is mainly because of high thermal noise introduced due to high bit rate.

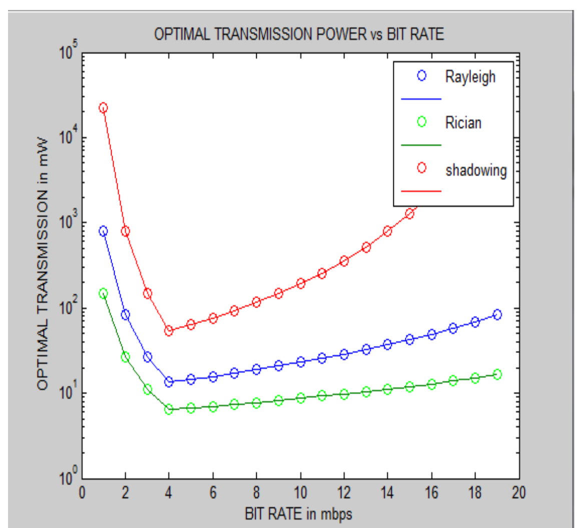

Fig 4: Optimal transmit power as function of bit rate

The critical bit rate occurs at the point when the BER_{floor} for particular data rate become high than desired BER. Further it is seen that critical bit rate increases in presence of fading.in this fig critical bit rate is 1Mbps in presence of fading. Critical bit rate decreases with increases in search angle (π/2).rician fading channel in case of this perform better than Rayleigh fading &

shadowing fading. Shadowing fading channel has more optimal transmit power than Rayleigh fading channel.

In fig 5, the graph is drawn between the energy and bit rate. In this graph show that energy requires to successful deliver a file, it is seen that energy requirement increases in presence of fading.

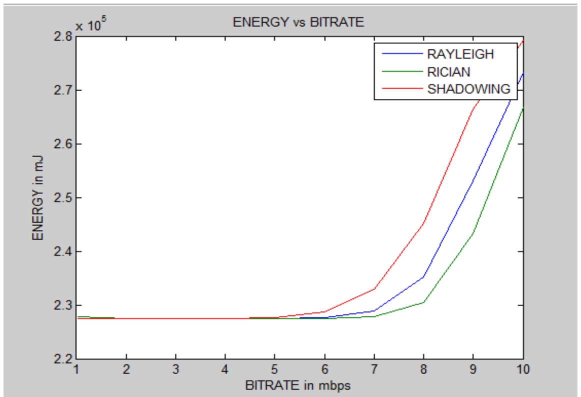

Fig 5: Energy consumption vs. bit rate to transfer a file

Further energy spent in successful delivery of file increases with increases in search angle (ϴ). In case of shadow fading channel, depend on characteristics, it take more energy for successful delivery of files as compare to Rayleigh fading channel & rician fading channel.

V. Conclusion

In present work optimal common transmit power in presence of Rayleigh fading channel, rician fading channel & shadowing fading channel for a WSN following a random topology is evaluated. Energy consumption for successful delivery of file is also evaluated in such scenario. It is observed that optimal transmit power required to maintain network connectivity satisfy a given maximum acceptable BER threshold value in shadow fading channel is more as compared to rician & Rayleigh fading channel. Further it is seen that optimal transmission power increases with increase data rate .critical bit rate increases in presence of fading. It is seen that the route BER in case of rician fading channel is less as compared to Rayleigh fading channel & shadowing fading channel. Further shadowing fading channel required more energy for successful delivery of file. The study helps in designing energy efficient randomly deployed WSN.

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