

Statistical Analysis for Mean Communication Range under Nakagami Fading in Wireless Ad Hoc Networks

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Abstract— Over the last few decades mean communication range has attracted considerable attention in wireless networks. One of the main metric for deciding the performance of a wireless network is the mean communication. The analysis of fading effect on mean communication range is equally important for establishing a reliable and efficient communication system. In this research paper, the effect of Nakagami fading on mean communication range in case of wireless sensor networks has been discussed. Extensive investigations are conducted to analyse the effect of Nakagami-m fading to signify importance of it over the mean communication range. The results are governed and enhanced through the efficient use of simulation tools.

Keywords— Mean Communication Range; Nakagami- m fading; Attenuation Constant; Non randomness; Wireless ad hoc.

I. INTRODUCTION

Wireless ad hoc sensor network is a decentralized, multi-hop network. It contains wireless transmitting and receiving apparatus. With the absence of pre-existing infrastructure, every node participates in routing by forwarding data to neighboring nodes. It is a continuously self-configuring network in which every node can move independently in any random direction and thus making it to change the links with its neighboring nodes. Due to this nature of network, it is widely used for variety of applications in which the central node cannot be relied upon. The medical systems, civilian, robotic exploration and wireless offices are some of the wide areas where

ad hoc network is largely applied and used. One of the fields in science or communication having potential for wider research and attracting the researcher's interest is considered to be Wireless Sensor groups (WSNs) [1-3]. There will be few hundred to several thousands of actively participating nodes in this wireless sensor networks. Nodes are responsible for transmitting and receiving the messages or data in the form of packets. The rapid growth of communication technologies over the short span has ignited and contributed for research and development in the field of wireless ad hoc networks.

The performance of wireless sensor network is hindered due to failure of the nodes in maintaining the connection in several situations. This lead many researchers to focus on the metrics associated with the design for improving the connection between the nodes [4-6]. Multi-hop has become the dominant and optimized research area where the large scale wireless networks are focused and analyzed. The dominant problems which are considered by these groups are spread over wide areas like connectivity between the nodes, capacity of the nodes, delay in transmission and reception of the data packets and coverage area [7-8].

The results obtained for one-dimensional case can be applied to group in higher dimensions to obtain the bounds on the connectivity. These bounds are not tight hence restricting to focus on analyzing the limited ad hoc groups. With the qualitative take up of uniformitarian of the nodes and one-dimensional group, we established the correct formula for the probability analysis groups connected [9-10]. The connectivity scale and availability of a node in

a region are known to decrease in power law attenuation but in contrast to this they do not have a singularity at the origin and found to be bounded consistently in one dimensional group. These results are presented in [11].

The significant effect of mean communication between the nodes under the influence of Nakagami-m fading is discussed in this paper. We assumed that every wireless node is having same communication range. In order to find the exact coverage or exact communication distance for a wireless sensor networks it is described to determine mean communication distance. The average communication distance for all the wireless nodes available in the wireless sensor network is the basic idea and this has been discussed.

II. SYSTEM MODEL

The keyword “mean communication range”, is an immediate physical description in the instance of a non-randomness channel model, describes the capability of any node to allow a prevalent communication. In fading channels, the influence of the nondeterministic due to the Gaussian noise is generally neglectable compared to the angular distance in signal to noise ratio due to the fading process.

The probability that a signal is received correctly at a space amid two point differences d is given by [16]:

$$p(\gamma \geq \psi) = \int_{\psi}^{\infty} f_{\gamma}(a) da \quad (1)$$

Node of transmission for signify mean communication is given by

$$F_R(a) = p[R \leq a] = 1 - p(R > a) \quad (2)$$

Whereas signify mean communication is computed by

$$E[R] = \int_0^{\infty} [1 - F_R(a)] da \quad (3)$$

III. Study Signify in Mean Communication Range for Nakagami-m Fading

Here, we will evaluate the signify mean communication range under consideration of the Nakagami-m fading

A. Study of mean communication range for nakagami-m fading channel

The statistical analysis expression for nakagami-m fading as well as Probability density function (PDF) of nakagami-m fading for (SNR) signal to noise ratio is given by:

$$P_{S(\bar{\gamma})} = \left(\frac{m}{\bar{\gamma}}\right)^m \frac{\gamma^{m-1}}{\Gamma(m)} \exp\left(\frac{m\gamma}{\bar{\gamma}}\right) \quad (4)$$

Since success probability ($\gamma \geq \psi$) is given by

$$P_{S(\bar{\gamma})} = \frac{1}{\Gamma(m)} \int_{\frac{m\psi}{\bar{\gamma}}}^{\infty} t^{m-1} e^{-t} dt \quad (5)$$

$$P_{S(\bar{\gamma})} = \frac{1}{\Gamma(m)} \cdot \Gamma\left(m, \frac{m\psi}{\bar{\gamma}}\right) \quad (6)$$

Where,

$$\Gamma\left(m, \frac{m\psi}{\bar{\gamma}}\right) = (m-1)! \exp\left(\frac{m\psi}{\bar{\gamma}}\right) \sum_{l=0}^{m-1} \frac{\left(\frac{m\psi}{\bar{\gamma}}\right)^l}{l!} \quad (7)$$

There four $P_{S(\bar{\gamma})}$ is given by

$$P_{S(\bar{\gamma})} = \exp\left(\frac{m\gamma}{\bar{\gamma}}\right) \sum_{l=0}^{m-1} \frac{\left(\frac{m\psi}{\bar{\gamma}}\right)^l}{l!} \quad (8)$$

$$\bar{\gamma} = \frac{P_r}{P_{noise}}, \bar{\gamma} = \frac{P_t d^{-\alpha}}{P_{noise}} \quad (9)$$

By simplifying equation (8) and (9) we have

$$P_{S(\bar{\gamma})} = \exp\left(\frac{m\psi d^{\alpha} P_{noise}}{P_{tx}}\right) \sum_{l=0}^{m-1} \frac{\left(\frac{m\psi d^{\alpha} P_{noise}}{P_{tx}}\right)^l}{l!} \quad (10)$$

We can find $E[R]$ by solving equation (3) and (10)

$$E[R] = \int_0^{\infty} [1 - F_R(a)] da \quad (11)$$

There four

$$\begin{aligned} 1 - F_R(a) &= 1 - [1 - P_{S(\bar{\gamma})}] \\ 1 - F_R(a) &= P_{S(\bar{\gamma})}[d = a] \end{aligned} \quad (12)$$

We can get $E[R]$ by solving equation (11) and (12)

$$E[R] = \int_0^{\infty} \exp\left(\frac{m\psi d^{\alpha} P_{noise}}{P_{tx}}\right) \sum_{l=0}^{m-1} \frac{\left(\frac{m\psi d^{\alpha} P_{noise}}{P_{tx}}\right)^l}{l!} da \quad (13)$$

$$\int_0^{\infty} x^{v-1} \exp(-\mu x^p) dx = \frac{\mu^{\frac{v}{p}}}{|p|} \Gamma\left(\frac{v}{p}\right) \quad (14)$$

By solving equation (13) and (14) we get,

$$E[R] = \left(\frac{m\psi P_{noise}}{P_{tx}}\right)^{\frac{-1}{\alpha}} \frac{1}{\alpha} \sum_{l=0}^{m-1} \frac{\Gamma\left(\frac{1}{\alpha} + l\right)}{l!} \quad (15)$$

VI. Numerical And Simulation Results

The simulation framework as indicated in previous section a systematic model has been established using MATLAB. The simulation structure and numerical results are accomplished with arguments $K = 10\text{dB}$, $P_{tx} = 1\text{mW}$, $W = 0.01\text{mW}$, $\psi = 1\text{Watt}$. The constraints (m, λ, α , and σ) have been considered appropriately and the group has been arrayed on $100\text{m} \times 100\text{m}$ measurement.

Figure 1: Mean communication range with attenuation constant for fading factors $m=2, 4$ and 6 . The results obtained describe the conduct of mean communication range with attenuation invariant of the medium attenuation constant (α) for different fading factor of Nakagami fading model. The graph provides the impression of impact of attenuation constant (α) on mean communication range. From the results obtained it can be stated that the attenuation constant (α) of Nakagami medium has negative influence on the mean communication range; meanwhile it can be noticed that the fading factor of Nakagami medium is a positive influence on the mean communication range, which verifies the state that although increasing the value of fading factor we will approach towards ideal channel condition. We know that, when the fading factor value of m is set to one, provides the result of Rayleigh fading, while enhancing the value of fading factor the performance of mean communication range will also increase. Hence it can be stated that the Nakagami fading model has enhanced performance than Rayleigh fading.

The result from Figure 2: for attenuation constant $\alpha=2, 4$ and 6 , describe the conduct of mean communication range with different values of attenuation constant within different types of attenuated medium. Having the attenuation constant for free medium as 2 and from the results obtained it can be inferred that the performance of mean communication range has better performance for free medium than attenuated medium. The obtained results also implies the condition that if the fading factor increases, mean communication distance will also increase which justify the condition that the attenuation constant α has a negative influence on mean communication range, while fading factor is having positive influence on mean communication range.

The results obtained in Figure 3: indicates the behavior of mean communication range with attenuation constant $\alpha=2, 4$ and 6 . The results indicate the performance of mean communication range against the transmitted power. It is inferred that the mean communication range, link establishment etc will improve the performance with the increase in transmitted power. The result obtained verifies the condition and describes that the mean communication range increases while the transmitted power value increases. From the results it can be concluded that that transmitted power has positive impact on mean communication range.

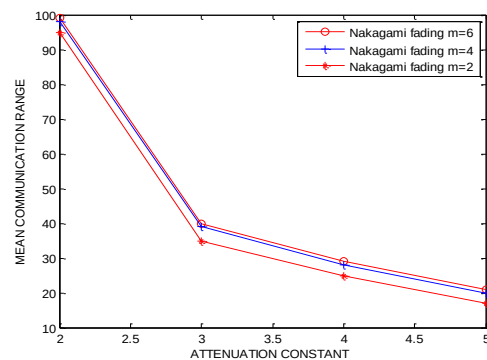


Figure1: Mean communication range with attenuation constant for $m=2, 4$ and 6 .

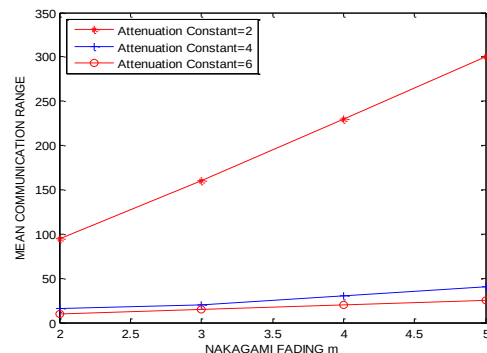


Figure2: Mean communication range with fading factor m for $\alpha=2, 4$ and 6 .

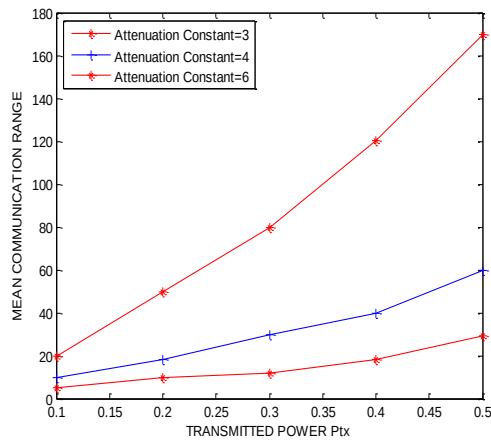


Figure 3: Mean communication range with transmitted power for $\alpha=3, 4$ and 6 .

VII. CONCLUSIONS

This paper briefs about the investigation carried out on signify communication range in context of Nakagami m fading. This research work considered to be more appropriate with practical scenarios. The research work is enhanced with sufficient analysis and simulations to give clear insight to ease the design of wireless sensor group practically. This work can be applied to fading effect and to study the improvably over signify communication range. In present paper we assume each wireless node is having same communication range. In order to find the exact coverage or exact communication range for a wireless sensor network we need to find mean communication range that means, we are finding the average communication range for all wireless node present in the wireless sensor network. This research work can be extended to MIMO scheme, and diversity scheme.

REFERENCES

- [1] Akyildiz, I. F.; Su, W.; Sankarasubramaniam, Y.; Cayirci, E.; "Wireless sensor groups: A survey," Computer Groups, vol. 38, no. 4, pp. 393–422, Mar. 2002.
- [2] Krishnamachari, B.; "Grouping Wireless Sensors" Cambridge University 2006.
- [3] M. Athanassoulis, I. Alagiannis, S. Hadjiefthymiades, "Energy Efficiency in Wireless Sensor Groups: A Utility-Based Architecture," in proc. Of 13th European Wireless Conference, Paris, France, April 2007.

- [4] Gupta, P.; Kumar, P.R., "Critical power for asymptotic connectivity," Decision and Control, 1998. Proceedings of the 37th IEEE Conference on , vol.1, no., pp.1106,1110 vol.1, 1998
- [5] Dousse, O.; Thiran, P.; Hasler, Martin, "Connectivity in ad-hoc and hybrid networks," INFOCOM 2002. Twenty-First Annual Joint Conferences of the IEEE Computer and Communications Societies. Proceedings. IEEE , vol.2, no., pp.1079,1088 vol.2, 2002
- [6] Piret, P., "On the connectivity of radio groups," Information Theory, IEEE Transactions on , vol.37, no.5, pp.1490,1492, Sep 1991.
- [7] P. Gupta and P. R. Kumar, "Critical power for asymptotic connectivity in wireless groups," in Stochastic Study, Control, Optimization and Applications: A Volume in Honor of W. H. Fleming. Boston: Birkh'auser, 1998.
- [8] A. E. Gamal, J. Mammen, B. Prabhakar, and D. Shah, "Throughputdelay trade-off in wireless groups," in Proc. IEEE INFOCOM, vol. 1, Hong Kong, 2004.
- [9] Santi, P.; Blough, D.M., "The critical transmitting range for connectivity in sparse wireless ad hoc groups," Mobile Computing, IEEE Transactions on , vol.2, no.1, pp.25,39, Jan.-March 2003
- [10] Desai, M.; Manjunath, D., "On the connectivity in limited ad hoc groups," Communications Letters, IEEE , vol.6, no.10, pp.437,439, Oct. 2002
- [11] Dousse, O.; Thiran, P., "Connectivity vs capacity in dense ad hoc groups," INFOCOM 2004. Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies , vol.1, no., pp.,486, 7-11 March 2004.



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