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Analysis of Coverage and Connectivity on Channel Randomness in WSN

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Abstract:
The wireless Sensor network (WSN) comprises a large number of sensors that are densely deployed in the area of interest to observe a particular phenomenon. There are various applications such as habitat monitoring, military surveillance, weather monitoring etc. where WSN can be used. I critical environment, where human intervention is not possible, battery of sensor node cannot be replaced in case of power drainage. This adversely affects the requirement of good quality of the field as well as extended lifetime of Wireless sensor Network. Therefore, coverage and connectivity which is also a Quality of Service (QOS) is challenging research area in Wireless sensor.

Keywords: WSN, Wireless sensor network, QOS, sensor, Energy efficiency, scalability, fault tolerance, data aggregation,

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have drawn significant attention of the research community in the last few years, because of the rapid advancement in wireless communications, networking and digital electronics devices. The miniaturization of computing and sensing technologies enables the development of tiny, low-power and inexpensive sensors, actuators, and controllers. WSNs generally contain a large number of low-cost, low power and multifunctional sensor nodes that have limited sensing, computing and communication capabilities. A sensor network is designed to sense the event of interest, collect and process the data, and transmit the sensed information towards the sink. Sensor nodes when properly networked and programmed can be useful in sensing the event in the hostile environment where human intervention is not possible [1].

II. SENSOR NOE ARCHITECTURE

Architecture of a sensor node and its major component are illustrated in Fig. 1.1. A sensor node has five basic components: Sensing Unit, Controller, Memory Unit, transceiver unit, power unit and some additional components such as location finding System [3,4].

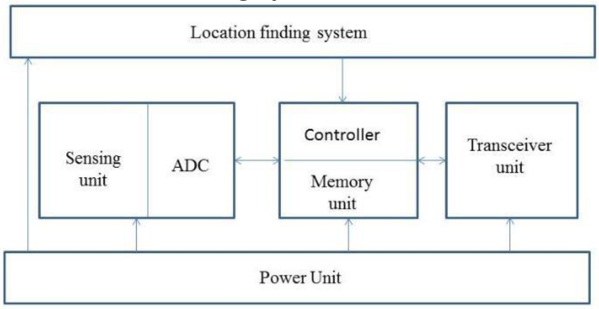

Figure.1. Hardware Architecture of a Sensor Node

The controller is a primary component of a sensor node. Its main task is to collect data from all other sensor nodes, process the data and decide to forward it. The controller also controls the functionality of the other components in the sensor node. The memory component is basically used to store intermediate data or program instructions in random access or read only memory. The communication device is used to interchange data between individual nodes. This device comprises short range radio transceiver. A transceiver is a device that has a aggregated transmitter and receiver in one unit. A sensor is a hardware component that generates a signal when there is a change in the physical condition of the environment such as temperature, humidity, pressure. Because of power constraint the sensor is tiny in size and has low data rate sensing capability. In a sensor node, power supply is one of the most important components. Generally each component in the sensor node is powered by battery. The main consumption of energy is done by communication, sensing and data processing. Therefore, due to limited battery power, each component must operate in an energy efficient manner. In our research work, we have proposed to study coverage and connectivity using deterministic and probabilistic sensing and communication models. Further, to achieve high accuracy and fault tolerance we proposed to develop a model for k-coverage and q-connectivity. To make the model more realistic we planned to use log normal shadowing path loss model and its effect on coverage and connectivity

III. COVERAGE AND CONNECTIVITY IN WSN

Coverage and Connectivity are two most fundamental and important research issues is sensor networks and over the year have been studied intensively by the researchers. The coverage problem determines how well each point around monitoring region is covered by the sensors.

Coverage in WSN: Given a set of sensors S= {s1,s2, …..sn} in a two dimensional area where si(i=1,2,…N) each sensor is located at (xi, yi) and has a sensing radius rs. Any point in the 2-D monitoring region is said to be covered if it is in the sensing radius of at least one sensor node as shown in Fig. 3.1.

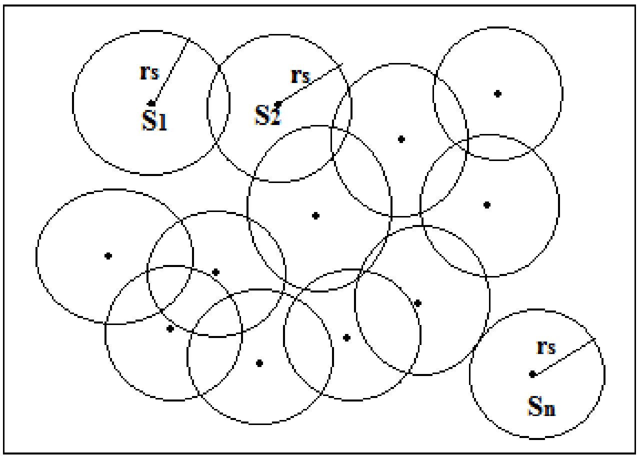

Figure.2. Coverage in Wireless Sensor Networks

Based on application, coverage can be classified into three classes, area coverage, target coverage and barrier coverage.

Area Coverage: In area coverage, a set of sensors is distributed in the monitoring region to monitor the given area. In the area coverage problem the goal is to monitor each point of the region of interest with minimal number of sensor nodes. If each point is covered by at least different working sensor nodes, the area is said to be - covered.

Target Coverage: Target coverage is the term used for monitoring a limited number of predetermined targets in the region of interest. This type of coverage is more suitable for military surveillance. The requirement of target coverage is that each target must be monitored continuously by one or more sensors, provided that every sensor has the capacity to monitor all targets within its sensing range.

***Barrier Coverage*:** Barrier coverage refers to the detection of movement across a barrier by sensor. A strip area with a sensor network deployed over it is considered to be barrier protected, if each and every crossing track through the strip is protected by sensor network. There are several applications of barrier coverage such as deploying sensors on the battlefield to detect illegal intruder, to detect the spread of deadly chemicals, etc.

IV. COVERAGE AND CONNECTIVITY UNDER CHANNEL RANDOMNESS

The Coverage and connectivity had attracted the attention of researchers working in the designing of WSN. Some applications of WSN require coverage and connectivity to make the system more fault tolerance and reliable. In most of the works in this area binary disk model of the channel propagation is used. Therefore, randomness and irregularity present in radio communications because of various environment effects are not considered

System Model

In the system model, it is assumed that sensors are deployed randomly in the 2-D desired sensing area. These sensor nodes are deployed according to a homogeneous Poisson distribution with high density λ. A node with radius can cover up a circular area while neglecting the border effect.

Sensing Model

Sensing coverage is in general modeled by a binary disk model. It is assumed a sensor has circular sensing area so that it senses in all direction uniformly. A sensor node observes an event of interest existing in its sensing range with probability 1 and with probability 0 otherwise.

$$f(d(s,p_t)) = \begin{cases} 1 & \text{if } d(s,p_t) \le r_{max} \\ 0 & \text{if } d(s,p_t) > r_{max} \end{cases}$$

Log-Normal Shadowing Path Loss Model

This model is representing the radio propagation in real natural world. Path loss is because of dissipation of the radiated power from the transmitter and the effects of shadowing

$$PL(d) = PL(d_0) + 10\eta \log(d/d_0) + X_\sigma$$

Where $PL(d_0)$ is the path loss corresponding to a reference distance d_0, η denoted the exponent of path loss that shows the rate of increasing path loss with distance, and X_σ is a Gaussian random variable with mean value as zero and standard deviation σ expressing log-normal shadowing effect

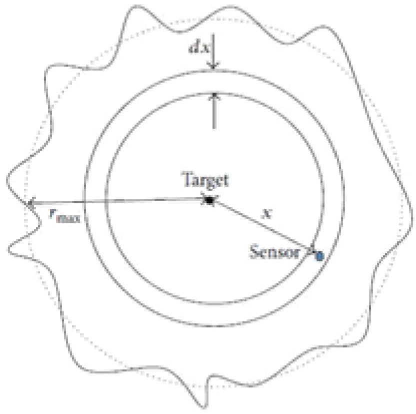

Figure.3. Impact of Shadowing Environment on Sensing

Connectivity in presence of Shadowing

Let us assume a WSN where N sensor nodes are randomly distributed in accordance to a homogeneous Poisson process with intensity (average) λ in the area A . Here depicts number of nodes per unit area. The probability of a randomly picked sensor node with area A has q neighbours is given by the following equation

$$P(q) = \frac{(\lambda A)^q}{q!} e^{-\lambda A} \qquad \text{Where, } (q = 1, 2, 3.....)$$

V. RESULT ANS PERFORMANCE ANALYSIS

We are doing the performance analysis of a network for k -Coverage and q -Connectivity. Here all nodes are using the lognormal shadowing model for sensing and communication. All the Simulations are performed utilizing MATLAB to find the k -Coverage and q -Connectivity results. Simulation parameters (values) used in the simulation is given in Table 4.1, 4.2, 4.3. To find out the effect of node density and shadowing, we have conducted the following simulations:

- Effect of standard deviation and node density on sensing coverage
- Effect of node density on connectivity
- Effect of communication range on connectivity

Effect of Standard Deviation and Node Density on Sensing Coverage

Table. 1. Simulation parameters for Coverage

S.No	Parameters	values
1.	Number of sensor nodes (N)	100
2.	Area (A)	$1000m^2$ to $3000m^2$
3.	Path loss exponent	3
4.	Transmission power of a sensor node(Ps)	20 W
5.	Threshold of received signal	-58 dB
6.	Effective sensing range(r_{max})	10m

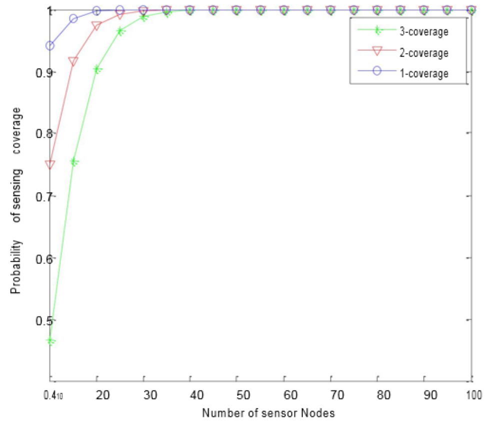

Figure.4. Coverage probability versus sensor nodes at standard deviation = 2 (A=1000 m^2)

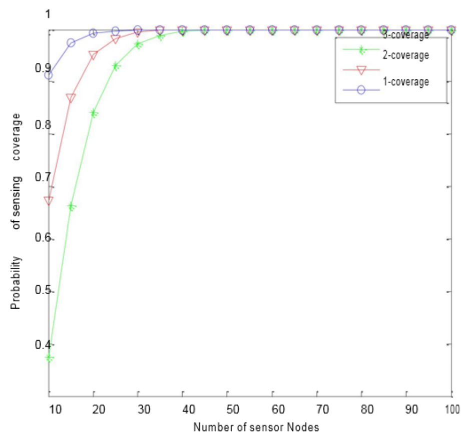

Figure.5. Coverage probability versus sensor nodes at standard deviation = 4 (A=1000 m^2)

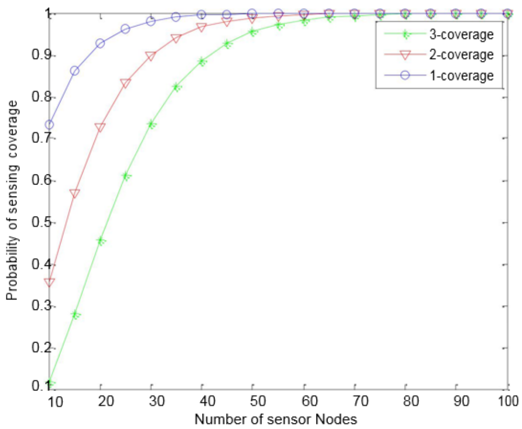

Figure.6. Coverage probability versus sensor nodes at standard deviation = 2 (A=2000 m^2)

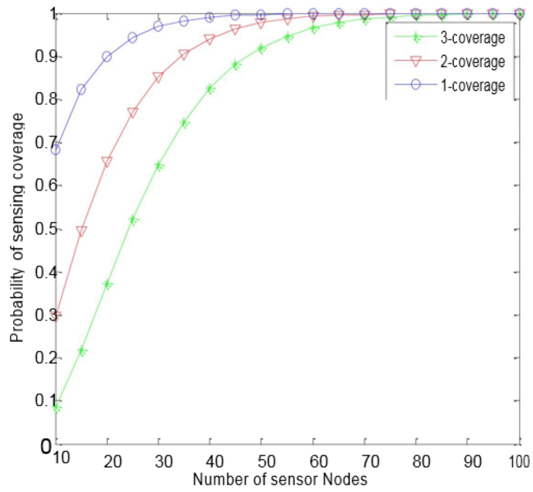

Figure.7. Coverage probability versus sensor nodes at standard deviation = 4 (A=2000 m^2)

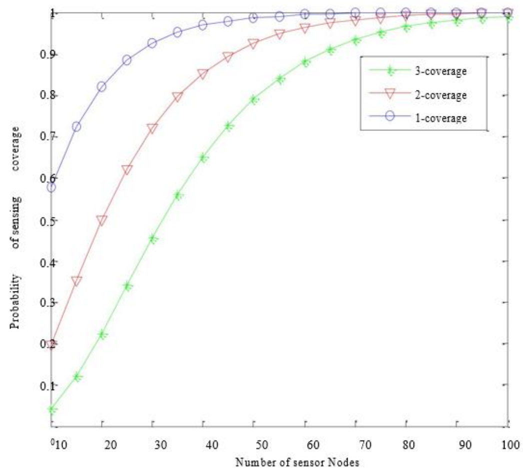

Figure.8. Coverage probability versus sensor nodes at standard deviation = 2 (A=3000 m^2)

We have drawn Figure (5.1), (5.2), (5.3), (5.4), (5.5) for different shadowing parameters (= 2, 4) and Area values (A=1000, 2000, 3000 m^2). When standard deviation is changed from 2 to 4, probability of coverage decreases. So, we require more sensor nodes to achieve the same coverage for = 4 as compared to = 2. Also we can see the effect of increasing Area on probability of coverage for constant number of sensor nodes. When area is increasing Probability of coverage is also decreasing.

Effect of Node Density on Connectivity

Table. 2. Simulation parameters for Connectivity

Parameter	Value
Number of sensor nodes (N)	100
Area (A)	1000 m^2 to 4000 m^2
Effective sensing range (r_{max})	10m

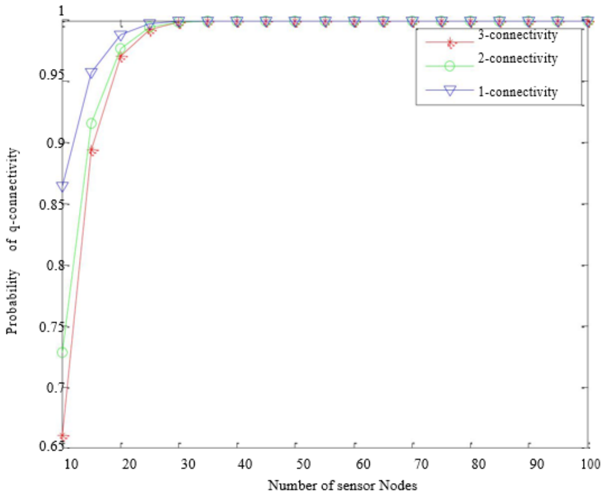

Figure.9. Probabaility of -connectivity versus number of sensor nodes (A=1000 m^2)

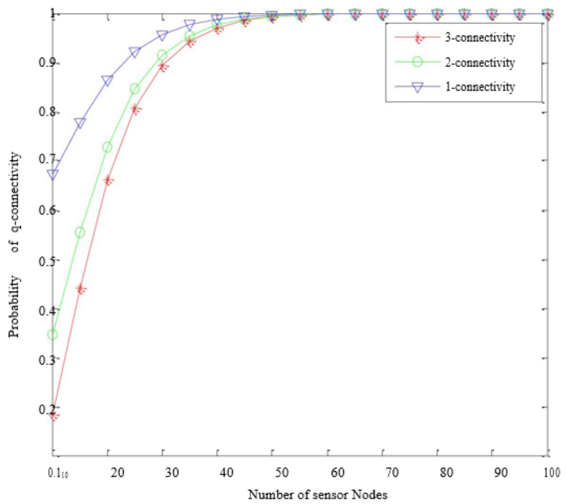

Figure.10. Probabaility of -connectivity versus number of sensor nodes (A=2000 m^2)

Figure (6.1), (6.2) show the variation between probability of *k*-connectivity with number of sensor nodes (*N*). As the number of sensor node increases, the graph shows changeover from low alue of connectivity to high value of connectivity From these graphs we can conclude that for network connectivity greater than or equal to 90%, we require at least 15 sensors (Area A=1000 $m^{2)}$.

Effect of Communication Range on Connectivity

Table.3. Simulation parameters for Communication range

Parameter	**Value**
Number of sensor nodes (N)	100,150,200
Area (A)	1000 m^2
Effective sensing range (r_{max})	5 m to 25 m

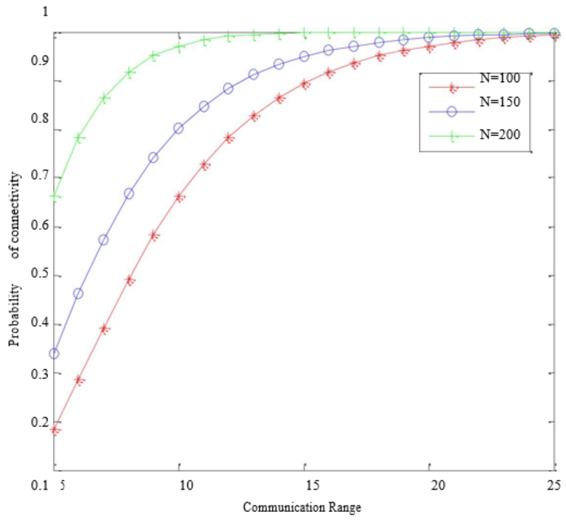

Figure.11. Probability of Connectivity versus communication range (A=1000m^2)

In figure (6.3) we have plotted probability of connectivity vs. communication range. From this we can find that network connectivity is affected by communication range. When the communication range increases, the connectivity of the network also increases.

VI. CONCLUSION & FUTIRE SCOPE

Fault tolerance is one of the most important QoS parameter in the designing of WSN. In this chapter we have evaluated -coverage and -connectivity under lognormal shadowing model. We have shown the effect of node density and shadowing parameter on coverage. We observed that the probability of network connectivity and coverage depends on the standard deviation and node density. For a high value of standard deviation, the probability of network coverage decreases. So we can conclude that there is a significant impact of node density and path loss model (log-normal) on coverage and connectivity.

The contribution to this paper are a set of studies various mathematical models and analysis of these mathematical models through simulation. The main contribution of this paper are summarized below-

- We have developed k-coverage and q-connectivity model to make the network fault tolerable and reliable Effect of node density on connectivity
- Log normal shadowing path loss to capture the radio irregularities has been used to to make the k-coverage and q-connectivity model more realistic

The model developed in this paper has been evaluated analytical as well as through simulations. After examining the simulation results the following observations hav been are made on finding of this work

- More number of sensors is required to maintain the thershold level of coverage when standard deviation of the shadowing environment increses.
- Coverage and connectivity increses when the density of sensor node increases.

When the communication range increses the connectivity of the network also increses

- Every bracketed in-text reference number must have a corresponding end-text reference with full, accurate bibliographic information

- Format bibliographic information as exemplified below. Consult the “How to Present End-Text References” document for examples of other kinds of resources.

VII. FUTURE SCOPE

There are various possibilities of for further investigation of the research work presented in this paper. Some of these possibilities are given below as future direction of research

- This work can also be extended for mobile wireless sensor network so that target tracking can be performed continuously.
- The model developed in this work can be extended for 3-D wireless sensor network such as under water sensor network.
- Substantially more precise propagation models indicating the varition in the radio range with respect to time may be designed.

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