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NRSSI: New Proposed RSSI Method for the Distance Measurement in WSNs

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***Abstract*— RSSI method is used to measure the distance between beacon nodes and unknown node. This technique is not more relevant because the radio frequency (RF) signals are mostly affected with the noise available in the environment. Therefore, the accurate distance evaluation cannot possible between the known nodes and unknown nodes. RSSI method is having many accuracy challenges which need improvements. Similarly, IRSSI method has also some faults regarding the calculation of model parameter. In this paper, a New Received Signal Strength Indicator (NRSSI) method is proposed. The new proposed RSSI method is achieved with improvement of the parameter values and introduction of the noise factor (or thermal noise). The thermal noise influences the RF signal severely, therefore, it is fused as a part of noise in RSSI method to reduce the measurement error effectively. In this paper, the NRSSI method improves the accuracy of the distance estimation for unknown nodes than RSSI and IRSSI.**

Keywords*— *RSSI, IRSSI, NRSSI, Distance measurement

I. Introduction

Localization is the process by which sensor nodes determine their location. In simple terms, localization is a mechanism for discovering spatial relationships between objects. Node localization is a big problem of wireless sensor networks applications [1]. Jennifer Yick et al. [1] presented concept of wireless sensor networks, wireless communications, design concept of sensor networks and the architectural structure of wireless sensor networks. The node localization algorithm [2] is used to measure the distance using two methods: first is Range-based and second is Range-free. G. Mao et al. [2] presented one-hop and multi-hop connectivity based localization algorithms. The Range-based method estimates distance between nearest sensors. The Receive signal strength indicator (RSSI) [3] is one of the range based algorithm.
Jungang et al. [3] presented RSSI measurement. The radio frequency (RF) signals are always suffer from huge noise occurred from the environment. Therefore, the RSSI fails to measure accurate distance between two nodes. In this paper we have proposed a new method named as IRSSI method which is based on RSSI value measurement. This method describes calculation of model parameter, path loss exponent and Received power strength. N. Patwari et al. [4] calculated area of localization using TOA, AOA and RSS in WSNs. This method focuses pros and cons as well. Devesh Pratap Singh et. al. [5] have proposed a method for improving the coverage inside the WSN but did not considered node localization. The Range free method depends on the contents of received messages not on the other factors. There are some range-free localization algorithm [7] i.e. Centroid localization algorithms, Distance Vector-Hop algorithms, Amorphous algorithms, Multi-dimensional scaling-Mapping and APIT . Localization algorithm [7] based on Range-Based algorithm has higher accuracy than other but in this algorithm there is need of some extra additional hardware in sensor node. Devesh Pratap Singh et al. [9] have given a method for selecting the cluster head inside the WSN with randomness of the nodes and have done improvement in the data recovery inside the WSN. We have considered MatLab 13a for simulation purpose in this paper.

In this paper, we have discussed two methods i.e. RSSI and IRSSI. We have proposed a New Received Signal Strength Indicator (NRSSI) method in this paper. The rest of the paper is organized as follows; Section II is RSSI method, Section III IRSSI method, Section IV NRSSI method, Section V Results and Analysis and Finally, Section VI describes conclusion and future scope.

II. RSSI Method

RSSI method is used to calculate total signal loss in the dissemination process with the concept, theory and experience loss of signal propagation model [3]. Here, we have used the concept of path loss model, known as logarithmic distance path loss model shown in equation 1.

$$PL(d) = PL(d_0) + 10 * nlog\left(\frac{d}{d_0}\right) + X_\sigma \qquad (1)$$

where d is distance between transmitter sensor and receiver sensor, n is path loss exponent. The value of n depends on the specific propagation environment, $X\sigma$ is a zero mean Gaussian distributed variable when mean is 0, d_0 is reference distance of 1 meter, *PL(d0)* is power value in dB with at 1 meter.
A The Received Signal Power indicates the total power at reference distance which is 1m.

$$A(in\ dB) = P_t - PL(d_0) \quad (2)$$

where A is received signal power for distance d_0 between transmitter and receiver, P_t is power of transmitter and $PL(d0)$ is a known reference power value in dB at d_0 from the transmitter.

A) Calculation of RSSI value and Distance

RSSI is the total signal strength power calculated at the receiver end.

$$RSSI(dB) = A - 10 * n * log\,(d) \quad (3)$$

where n is path loss exponent.

The *distance (d)* from known node to unknown node is calculated as;

$$d(in\ m) = 10^{\left(\frac{A-RSSImax}{10*n}\right)} \quad (4)$$

where *RSSImax* is the maximum received signal power RSSI Algorithm

B) RSSI Algorithm

Steps are shown in Table I for RSSI algorithm as;

TABLE I
RSSI Algorithm

Step1. Start
Step2. Randomly distribute the node in forest fire, suppose one known node as Unknown node.
Step3. Define the value of parameter path loss exponent, Gausian distribution value, power of transmitter.
Step4. Calculating distance, path loss and received signal power at distance 1m(A).
Step5. Calculate Received Signal Power at respected distances from node and find Maximum value.
Step6. Convert maximum RSSI value into distance.
Step7. Calculate the distance by nodes position.
Step8. End

III. IRSSI METHOD

Improved Received Signal Strength Indicator (IRSSI) measurement method basically depends on the path loss exponent, received signal power at reference distance. In this method, both parameter models are calculated by the averaging the total path loss exponent for the each region and averaging the total received signal power at reference distance for each region.

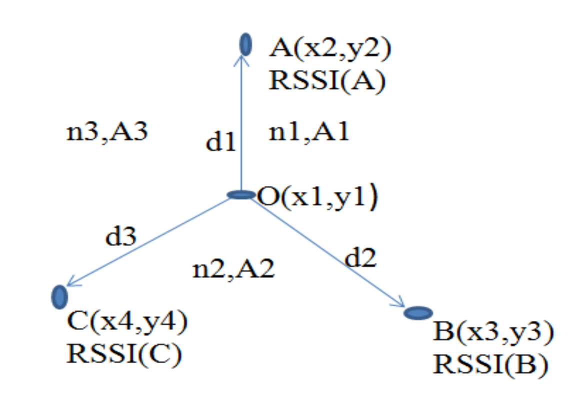

Fig. 1. IRSSI Working

A) Model Parameter Calculation

In Fig. 1, sensor A, sensor B and sensor C are at distance *d1, d2* and *d3* respectively from node sensor *O*. There is path loss exponent *n1* and received signal power *A1* are acting between sensor A and sensor B with the RSSI values of *RSSI(A)* and *RSSI(B)*. Similarly, *n2, A2* for region between sensor B and sensor C with the *RSSI(B)* and *RSSI(C)*. For *n3, A1* for region between sensor C and sensor A with the power value of *RSSI(C)* and *RSSI(A)*. The path loss exponent *n1 and* received signal power *A1* are calculated with following equations 5.

$$n1 = \frac{RSSI(A)-RSSI(B)}{10*log\left(\frac{d2}{d1}\right)}.$$

$$A1 = RSSI(B) + \frac{RSSI(A)-RSSI(B)}{log\left(\frac{d2}{d1}\right)} * log(d2) \quad (5)$$

Therefore, we can get the new parameter value of the path loss n and received signal power A for the overall area after combining all the values of both parameters.

$$n = \frac{n1 + n2 + n3}{number\ of\ n}$$

$$A = \frac{A1 + A2 + A3}{number\ of\ A}$$

Now, with consideration of new value of n and A, we can calculate the IRSSI values which results more accurate distance.

$$IRSSI(dB) = A - 10 * n * \log(d) \quad (6)$$

B) Distance Calculation

The *distance* (d_c) is calculated with the help of maximum IRSSI using equation 7.

$$d_c = \frac{10^{(A-IRSSImax)}}{10*n} \quad (7)$$

A is new received power at reference distance; *IRSSImax* is maximum value and n is new path loss exponent.

In presence of more noise factor, it is essential to introduce correction factor for finding the accuracy of distance. Therefore, the exact distance measurement is carried out in order to correction factor. Hence, the *amendment distance (d)* is calculated using equation 8.

$$d = d_c(1 + \mu) \tag{8}$$

where μ correction factor.

C) IRSSI Algorithm

The IRSSI Algorithm steps are shown in Table II is used for finding the distance of unknown node from the *beacon node* or *anchor node*;

TABLE II
IRSSI Algorithm

Step1. Start
Step2. Randomly distribute the node in forest fire, suppose first known node as beacon node.
Step3. Define the value of parameter path loss exponent, Gaussian distribution value, power of transmitter and A by RSSI method.
Step7. Calculate new parameter *n1* to *n* and *A1* to *An* by IRSSI method.
Step8. Find the average value of *n* and *A* .
Step9. With use of *n, A* calculate the IRSSI values and obtain the maximum value of IRSSI.
Step10.With the use of *IRSSImax, n* and A we can Calculate the distance.
Step11. After calculating the distance we can calculate the distance amendment by fixing correction factor.
Step12.End

IV. NRSSI METHOD

The New Proposed Received Signal Strength Indicator (NRSSI) method is introduced in this paper with consideration of two important parameters i.e. minimum path loss exponent and thermal noise. The proposed method is based on temperature related noise factor. This method is suitable for alert generation to forest rangers when fire caught in particular area of the forest.

A) Thermal Noise

Thermal noise [10] also familiar by name as Johnson-Nyquist noise, it was first discovered by J.B. Johnson and explained by Harry Nyquist. This RF noise is generated as a result of thermal agitation; it is critical parameter within radio frequency signal. Thermal noise has a big importance within receiver end where this form of noise along with other forms of noise limits the sensitivity of the receiver. The general equation of thermal noise *(p)* for RF signal is as;

$$p = k * T * B \tag{9}$$

where k is Boltzmann constant ($1.3803*10^{-23}$), T is temperature in kelvin and B is Bandwidth.

B) Calculation of NRSSI

In the proposed method, we have taken some assumptions i.e. discard the negative values for path loss exponent, distance and error. We have introduced the thermal noise which arises due to up and down in the temperature.

$$NRSSI = A - 10 * n * log(d) - p \tag{10}$$

C) Calculation of Distance with NRSSI

With result of NRSSI value, we have to select the maximum NRSSI value for distance *(d)* calculation by equation 10.

$$d = \frac{10^{A-NRSSImax}}{10*n} \tag{11}$$

D) NRSSI Algorithm

The NRSSI method is shown in Table III for unknown node's *distance estimation.*

TABLE III
NRSSI Algorithm

Step1. Start
Step2. Randomly distribute the node in forest fire.
Step3. Define the value of parameter path loss exponent, Gaussian distribution value, power of transmitter and A by IRSSI method.
Step4. Calculate the frequency Bandwidth, temperature range and then compute the thermal noise.
Step5. Calculate Received Signal Power at respected distances from node and find Maximum NRSSI.
Step6. Convert maximum NRSSI value into distance.
Step7. End

V. SIMULATION PARAMETER

Table IV depicts the parameters which are used in the simulation of the proposed method and other method:

TABLE IV
Parameter

Parameter	Values
Number of sensor	15
Path loss exponent(n)	2-4
Frequency Band	2400 MHz - 2483.5 MHz(B=60 MHz)
Transmit Data Rate	250kbps
Temperature Range in forest	60°C to 110°C(T=80°C)
Transceiver Efficiency	75%
Receiver Efficiency	55%
Antenna Gain at Transceiver $f1$=2470MHz	2.568
Antenna Gain at Receiver $f2$=2410 MHz	1.008

VI. RESULT AND ANALYSIS

For finding the nearest distance of unknown node from the base station, 15 sensor nodes are deployed in the forest fire area as in Fig. 2, we have considered an ideal condition as assumption with low path loss. Simulations are carried out in 10m x 10m two dimensional environment. In the present scenario 15 nodes are deployed randomly in forest fire area. We have calculated coordinates of all nodes distances, path loss, and Gaussian distributed value.

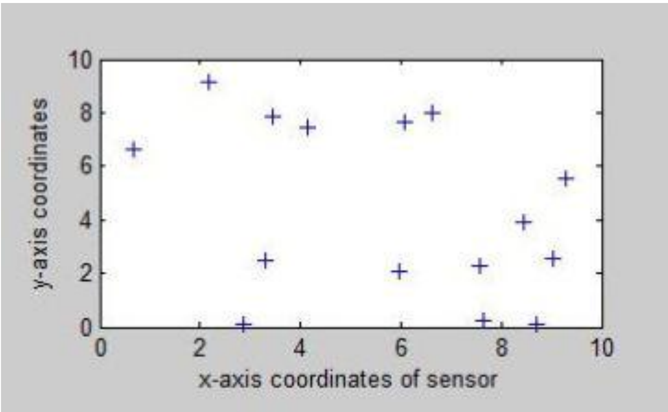

Fig. 2. Random Beacon node

In the simulation the calculation is carries out on the basis of cluster system. The cluster head has maximum power and nearest distance from the unknown nodes in our scenario. In the Fig. 3, circle denotes the cluster head and + denotes the unknown node

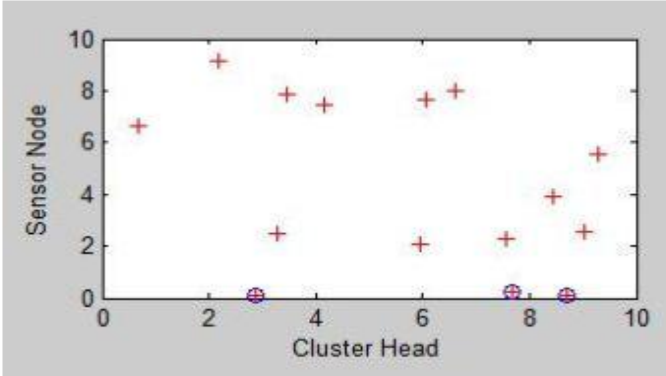

Fig. 3. Cluster and Cluster Head Formation

Distance measured from cluster head to the unknown node which has maximum power value for RSSI, IRSSI and NRSSI methods for a cluster are shown in Table V.

TABLE V
Distance Measurement

Method	Cluster head	RSSI Power(dB)	Distance (m)
RSSI	(8.6941,0.0690)	-29.9959	1.6602
IRSSI	(8.6941,0.0690)	-19.7897	1.9590
NRSSI	(8.6941,0.0690)	-9.7741	2.0752

Fig. 4 shows the proposed method provides better results in comparison of other method. This method is very close to exact distance (i.e. calculated manually) between unknown node and cluster head.

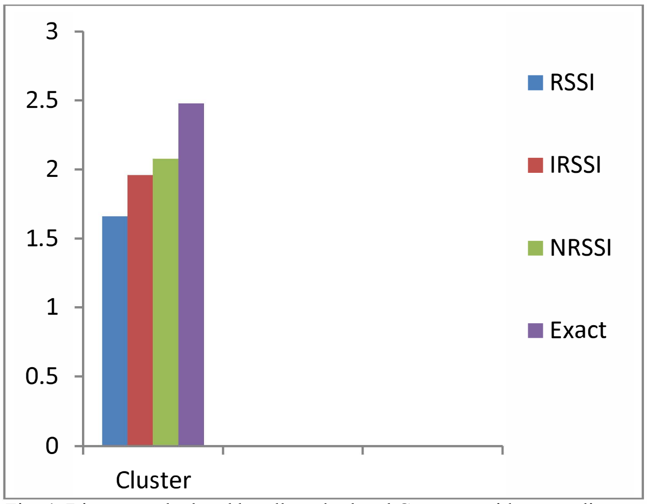

Fig. 4. Distance calculated by all method and Compare with Exact distance

The obtained results are shown in Fig. 5 which depicts the distance estimation. NRSSI methods distance estimation is very close to exact calculation whereas rest are too for. The validation of new proposed method NRSSI, we have 100 numbers of iterations to judge the better and more accurate result.

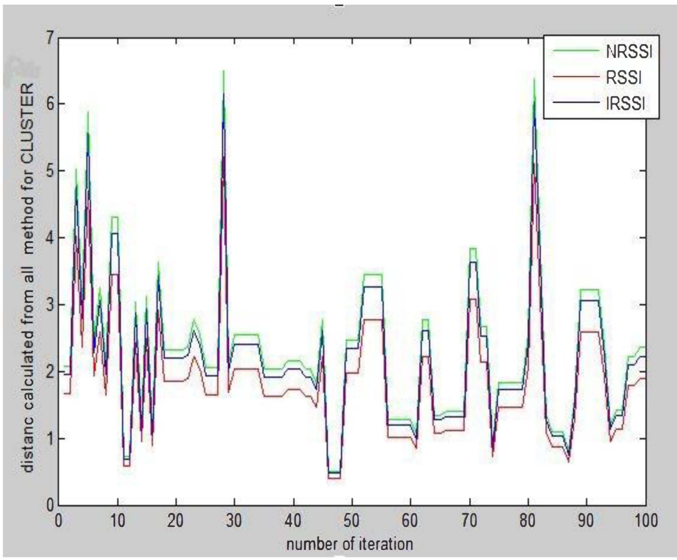

Fig. 5. Iteration Graph for all the method

VII. CONCLUSION AND FUTURE WORK

The result shows that NRSSI method is more accurate in distance estimation than the RSSI, IRSSI method but still the exact distance is not calculated by all methods. Therefore, there is need of some improvement for more accuracy. Its mean the above methods are easy, not costly and not more complex but there is a big effect of environment due to RF signal is affected.

The future work focuses that the considered scenario should be more accurate and need to apply the various clustering techniques like k- mean, leach method or we can apply general circle formula based method.

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