Effective Approach for Localizing Jammers in Wireless Sensor Network

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Abstract: ***Jammers can harshly interrupt the communication in wireless network .Defender can eliminate the jamming attacks by getting the information of Jammers position. Our aim is to design a framework that localizes one or multiple jammers with a high accuracy. Almost all of existing jammer-localization methods utilizes indirect measurements (like hearing ranges) that are affected by jamming attacks which does not localize jammers accurately. We use a direct measurement technique-the strength of jamming signals (JSS).The jamming signals can be embedded in other signals thus it may be difficult to estimate the JSS. We used estimation scheme based on ambient noise floor. We define an evaluation feedback metric to reduce the estimation errors and from this jammer localization problem is formulated as non linear optimization problem, whose global optimal solution is close to jammers' true positions. Our error-minimizing-based framework will achieve better performance than the existing schemes. In our work we took the average jammer location obtained by centroids based method and JSS based direct measurement technique.***

Keywords: localization, Jamming, radio interference

1. Introduction

A wireless sensor network is a network which contains sensors that are distributed spatially. These sensors do the work of monitoring environmental conditions like pressure, sound, temperature etc. The WSN is constructed of hundreds to thousands of node's, each of these node is connected to one or more sensor. Wireless sensor network contains of parts: a radio transceiver which has connection to an internal or external antenna, microcontroller, electronic circuit which interfaces with the sensors and energy source like a battery or an embedded form of energy harvesting.

Wireless networks are day by day growing in size and thus the security and secrecy becomes a critical issue in the areas like military. To prevent people from communicating with each other, jamming the communication channel is one of the most efficient way and that is easy to implement. As the wireless sensor network have open access to the wireless medium and shared nature an attacker can easily do jamming attack in order to disturb the entire network. The network is affected by the jamming attacks either by preventing the senders from sending messages by making the medium busy or by decreasing the signal noise ratio(SNR) at receiver side so that packet collision is caused. Although there are some existing methods to avoid jamming attacks, such as channel surfing, frequency hopping, demonstrate a certain degree of resistance to jamming attacks, still more advanced devices and complex protocols are required. Against the jammer more active operation's such as capturing, destroying it, and deactivating the jamming device can be taken.

The locations of jammers will allow to eliminate the attacks from which the network can be prevented from being destroyed. We focus on localizing one or multiple stationary jammers. Our goal is to improve the accuracy of jammer localization. Existing jammer localization methods mostly rely on parameters which are obtained from the affected network topology, such as neighbor lists, packet delivery ratios, and nodes' hearing ranges. But these indirect measurements are not sufficient for accurately localizing the jammer. Furthermore they can localize one jammer and are unable to cope with the situation where multiple jammers are present which are close to each other.

To overcome the problem which is caused by the indirect measurements we proposed new approach which is to use address the limitation caused by indirect measurements of the jamming effect, we propose to use the direct measurement of the strength of jamming signal (JSS).For this First, jamming signals are taken and embedded in the network traffic. The received signal strength (RSS) measurement which is associated with a packet does not correspond to JSS. To overcome this problem, a method is developed which can effectively estimate the JSS which utilizes the measurement of the ambient noise floor. First, jamming signals are embedded in the regular network traffic. The commonly used received signal strength (RSS) measurement associated with a packet does not correspond to JSS. To overcome this challenge, we devise a scheme that can effectively estimate the JSS utilizing the measurement of the ambient noise floor, which is readily available from many commodity devices.

2. Related Work

To prevent people from communicating with each other, jamming the communication channel is one of the most efficient way and easy to implement. Jamming attacks affects the network either by preventing the transmitters from sending messages due to the busy medium, or by dramatically decreasing the signal-noise ratio (SNR) at receivers to cause a large number of packet collisions. Although, some existing countermeasures against jamming attacks, such as channel surfing, frequency hopping, demonstrate a certain degree of resistance to jamming

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attacks, advanced devices and complex protocols are required.

Localizing jammers is very crucial task in wireless sensor network. The locations of jammers allow a better physical arrangement of wireless devices that cause unintentional radio interference, or enable a wide range of defense strategies for combating malicious jamming attackers. We focus on localizing one or multiple stationary jammers.

Tianzhen Cheng, Ping Li[2] has discussed Double circle localization algorithm in "An Algorithm for Jammer Localization in Wireless Sensor Networks". This algorithm is used to find the location of jammers in wireless networks. It uses two methods Minimum bounding circle (MBC) and Maximum inscribed circle (MIC). It is implemented under different conditions including different node densities, jammers transmission power and antenna orientation. But this method deals with localizing a single jammer so this not sufficient because in a huge wireless network there will be need for localizing multiple jammers.

Don Torrieri and Sencun Zhu [4] has discussed M-cluster algorithm in "M-cluster and X-ray: Two Methods for Multi-Jammer". M-cluster method is used to localize single or multiple jammers which overcomes problem of double localization method. The M-cluster algorithm is based on the grouping of jammed nodes with a clustering algorithm, and each jammed-node group is used to estimate one jammer location. M-cluster algorithm, we consider the falsely covered boundary nodes and calibrate the result in a similar way. Second, we discover that when many bifurcation points belong to one jammer, the clustering technique may falsely divide them into two clusters, resulting in two jammers. This method is not efficient because it provide less accuracy for localizing jammers and uses a no clustering techniques within it.

Tianzhen Cheng a, Ping Li a, Sencun Zhu and Don Torrieri[3] has discussed a x-ray method in "M-cluster and X-ray: Two Methods for Multi-Jammer". The X-ray algorithm relies on the skeletonization of a jammed area, and uses the bifurcation points on the skeleton to localize jammers. In M-clustering algorithm it considers the falsely covered boundary nodes and calibrate the result in a similar way. Second we discover that when many bifurcation points belong to one jammer, the clustering technique may falsely divide them into two clusters, resulting in two jammers. But in X-ray algorithm this error is discovered by using a filter that measures the distance between two estimated jammers. .It uses k means clustering algorithm and requires no of steps.

Thus we proposed a new framework for localizing the jammer in wireless sensor network. It uses two method first JSS ie estimating the signal strength and second is centroid method. In JSS it will give the coordinates of the boundry nodes from which location of jammer will be tracked. In centroid method it will give the location information of the jammed nodes. Then getting the average of both these values we will get the true location of the jammer in a network

3. Proposed System and Framework

Jammer can be localized using various jamming localization techniques. Current jammer-localization approaches mostly rely on parameters derived from the affected network topology, such as packet delivery ratios, neighbor list, and nodes' hearing ranges. The use of these indirect measurements derived from jamming effects makes it difficult to accurately localize jammers' positions. We proposed a new system which will track jammer location using the direct measurement of the strength of jamming signal (JSS) which will give the coordinates of the boundry nodes .And second approach we will use is Centroid method which will give the coordinates of the jammed nodes .The structure of our system is shown in figure.

A. System Architecture

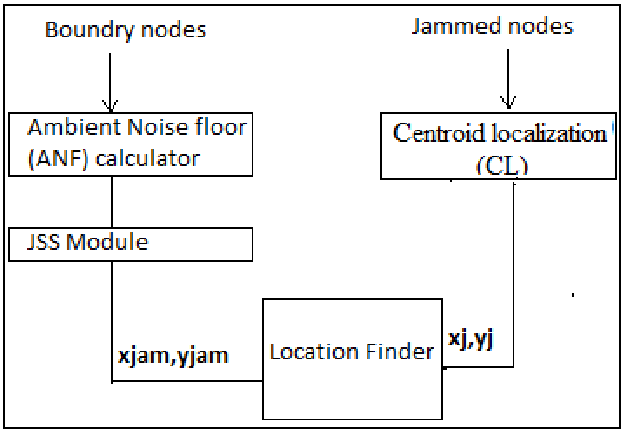

Figure 1: Proposed system architecture

Our jammer localization approach will work as. For given a set of JSS, for every estimated location, we will get the quantitative evaluation feedback which indicates the distance between the estimated locations of jammers and their true locations. For example, we can say a small value of evaluation feedback indicates that estimated locations are close to the true ones, and vice versa. Although we will not get the exact estimation directly, it is possible to get such location, from a few candidate locations which are closest to the true locations. As shown in the above fig the proposed system will work as follows:

(a) Ambient noise floor (ANF) calculator

Ambient noise is the sum of all unwanted signals that are always present like thermal noise, atmospheric noise, and jamming signals and the ANF is the measurement of the ambient noise. The input to the ANF calculator is the boundry nodes. The ANF calculator will calculate the sa and sc values where sa is ambient noise factor when only the jamming signals are active and sc is when the jamming signal and some communication signals are also present. The more will be the value of ANF the more is the signal strength.

(b) JSS module

Each node will take n measurements of ambient noise and this measurement is divided into two sets say sa and ac where sa is such set that contains the ambient noise measurements when only jammers are active and sc is set

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that contains ambient noise measurements when both jamming signals and signals from one or more senders are present. The output of this module will be the coordinates of the boundry nodes.

(c) Centroid localization

Centroid Localization is derived from the idea of centroid, which is the geometric center in geometry. CL uses location information of all neighboring nodes, which are nodes located within the transmission range of the target node. In case of jammer localization, the target node is the jammer, and the neighboring nodes of the jammer are jammed nodes. CL collects all coordinates of jammed nodes, and averages over their coordinates as the estimated position of the jammer. Assuming that there are N jammed nodes (X1; Y1); (X2; Y2); :::; (XN; YN), the position of the jammer can be estimated by:

$$(\hat{X}_{jammer}, \hat{Y}_{jammer}) = \left(\frac{\sum_{i=1}^{N} X_i}{N}, \frac{\sum_{i=1}^{N} Y_i}{N}\right)$$

(d) Location finder

Finally to localize the jammer with more accuracy we will take the average of (Xj,Yj) with less e_z and (X_{jammer},Y_{jammer}) calculated by centroids localization. By taking the average of these two values we can localize the jammer with high accuracy.

$$(Xj, Yj) = \left(\frac{x_{jammer} + x_j}{2}, \frac{y_{jammer} + y_j}{2}\right)$$

B. Mathematical Model

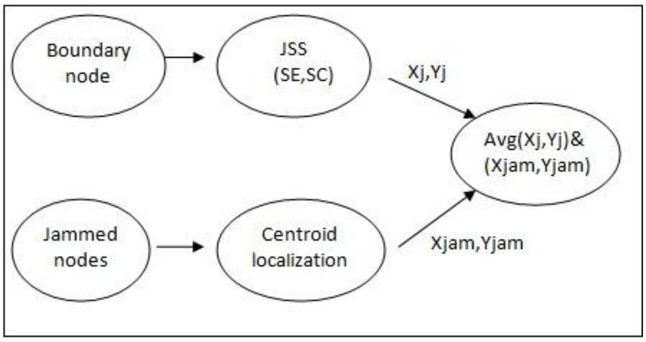

Figure 2: Mathematical model

(1) Initially the boundry nodes are taken as an input. Then JSS calculates the x and y coordinates of these nodes. This is given as below:
JSS (xj,yj) = (x1,x2,x3…. xn)/n,(y1,y2,y3….yn)/n
where x1,x2….xn are the x coordinates of boundry nodes.
where y1,y2….yn are the y coordinates of boundry nodes.
(2) After taking the x coordinates the y coordinates are calculated of the same nodes. It is given as below: Centroidlocalization(xjam,yjam) = (x1,x2,x3….xn)/n,(y1,y2,y3….yn)/n
Where where x1,x2….xn are the x coordinates of jammed node.
(3) At final stage we take the average of both these x and y coordinates from which we will get the location of the jammed nodes which will predicate the jammer location.
Avg((xj,yj) & (xjam, yjam) = (xj + xjam)/2, (yj+ yjam)/2

Algorithm 1: JAMMER LOCALIZATION FRAMEWORK

(1) p = MeasureJSS()
(2) z = Initial positions
(3) while Terminating Condition True **do**
(4) e_z =EvaluateMetric(**z**, **p**)
(5) if NotSatisfy(e_z) **then**
(6) z = SearchForBetter()
(7) end if
(8) end while
(9) Min e_z= e_z
(x_j,y_j)=GetEstJammer(z);
(x_{jammer}, j_{ammer}) = GetCentroid();
(x_{est},y_{est}) = Average(x_j,y_j, x_{jammer}, j_{ammer});

Algorithm 2: CALCULATING EVALUATION FEEDBACK METRIC

Algorithm 2 Evaluation feedback metric calculation.

1: **procedure** EVALUATEMETRIC($\hat{z}$, p)
2: **for all** $i \in [1, m]$ **do**
3: $\hat{X}_{\sigma_i} = P_{r_i} - P_{f_i}(\hat{z})$
4: **end for**
5: $e_z = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(\hat{X}_{\sigma_i} - \hat{\bar{X}}_{\sigma})^2}$
6: **end procedure**

ALGORITHM 3: MEASURING JSS

Algorithm 3 Acquiring the Ambient Noise Floor (ANF). ANF approximates the strength of jamming signals.

1: procedure MEASUREJSS
2: $s = \{s_1, s_2, ..., s_n\}$ = MeasureRSS()
3: if var(s) < varianceThresh then
4: $s_a = s$
5: else
6: $JssThresh = \min(s) + \alpha[\max(s) - \min(s)]$ ▷ $\alpha \in [0, 1]$
7: $s_a = \{s_i | s_i < JssThresh, s_i \in s\}$
8: end if
9: return mean(s_a)
10: end procedure

4. Results

1) Creation of network topology with wireless nodes

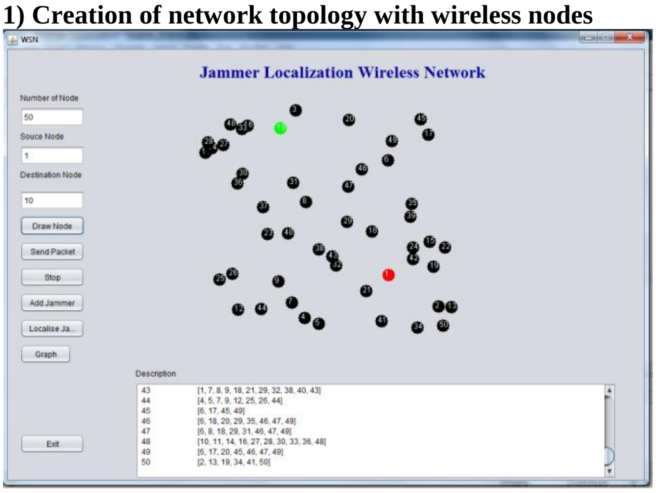

Figure 4 (a): Network deployment

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A wireless sensor network is created with n number of sensor nodes. The number of these nodes is specified by the user. Figure given below shows this. Here we have taken 50 nodes in the network. Also we have to define the source node and the destination node which we have taken 1 and 10 as a source and destination nodes respectively. Red color predicts the source node whereas green color describes the destination node.

2. Performing routing of packets from source node to destination node.

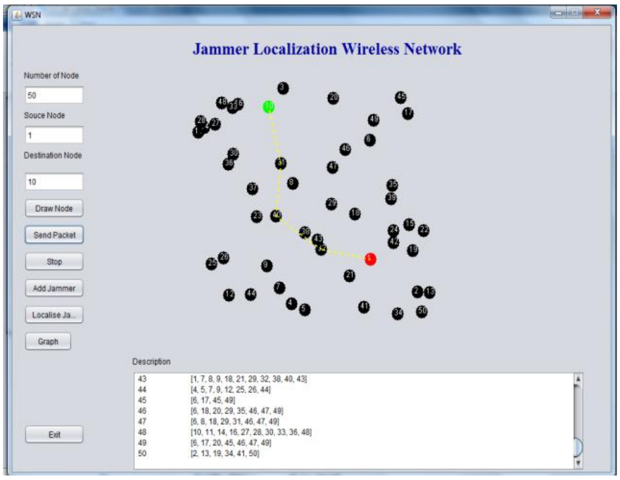

Figure 4 (b): Packet transmission

Once the source node and destination node are defined next is to send the packets from source to destination. A specific path is generated from source to destination node through which the packet transmission takes place. The path is shown by the yellow dotted line. This is shown in the figure given above.

3. Addition of jammer in the network topology

Here we have added the jammer to the network. This jammer will disrupt the communication that is it will jam the nodes in the network which will cause these jammed nodes to function improperly. Thus the main task is to get the location of this jammer. This location is obtained by taking the x and y coordinates of the nodes.

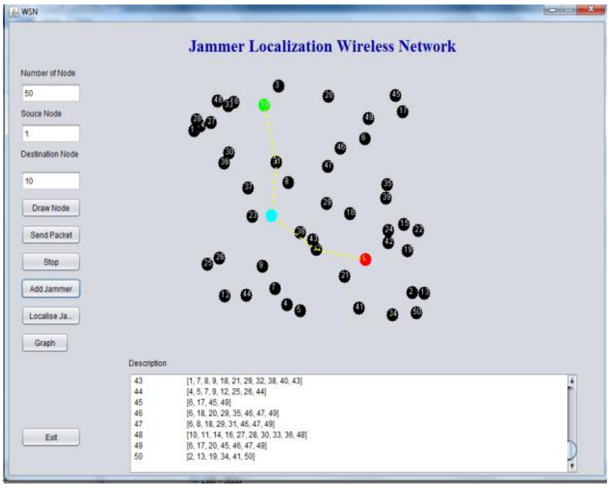

Figure 4 (c): Adding the jammer to the network

Here we have added the jammer to the network. This jammer will disrupt the communication that is it will jam the nodes in the network which will cause these jammed nodes to function improperly. Thus the main task is to get the location of this jammer. This location is obtained by taking the x and y coordinates of the nodes.

4. Jammer localization using proposed method

The jammer localization is done by two methods first the JSS that is jamming signal strength method and the second method is the centroid method. JSS gives the coordinates of the boundry nodes whereas centroid method gives the jammed nodes coordinates. By combining these two methods we go the true location of the jammer. The graph given below shows the location of jammer which is very close to the actual jammer location

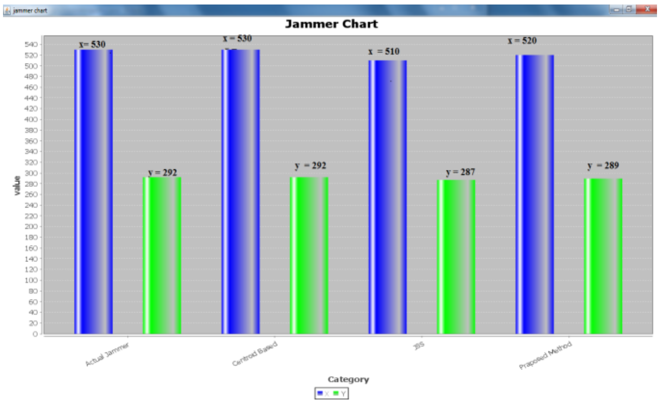

Figure 4 (d): Jammer localization

Here the actual jammer location is (x=530, y= 292). JSS method gives the result in (x=510, y=287) coordinates and centroid method gives (x=530, y=292) coordinates whereas our proposed method gives (520,289) which is very close to the actual jammer location. Thus our proposed method gives more accuracy

5. Conclusion

We designed an error-minimizing-based framework to localize jammers. Most of the existing schemes for localizing jammers rely on the indirect measurements of network parameters affected by jammers, e.g., nodes hearing ranges, which makes it difficult to accurately localize jammers. In our method we localized jammers by exploiting directly the jamming signal strength (JSS).In particular, we combined the centroid based localization with the existing error minimizing framework. By combining these two methods we can achieve the better result to locate the jammer in wireless sensor network.

6. Future Work

The localization method which we have used find outs the location of a single jammer but as the wireless network grows densely so there may be multiple jammers in a single network. Thus our Future work will be finding the localization methods which will localize multiple jammers in a single wireless network.

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7. Acknowledgment

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