Abstract— Localization is widely used in Wireless Sensor Networks (WSNs) to identify the current location of the sensor nodes. A WSN consist of thousands of nodes that make the installation of GPS on each sensor node expensive and moreover GPS may not provide exact localization results in an indoor environment. Manually configuring location reference on each sensor node is also not possible for dense network. This gives rise to a problem where the sensor nodes must identify its current location without using any special hardware like GPS and without the help of manual configuration. In this paper we review the localization techniques used by wireless sensor nodes to identify their current location.

Index Terms--- Range Measurement, Wireless Sensor Networks, Anchor Nodes, Localization

I. INTRODUCTION

Wireless sensor devices have a wide range of application in surveillance, monitoring etc. Most of the devices in wireless sensor network are made up of off-the shelf materials and deployed in the area of surveillance and monitoring. The responsibility of each sensor node is to identify the changes in its particular region or area. The changes are as movement of animals, decrease or increase in temperature, rainfall etc., and these changes are periodically reported to the aggregation point or the central server. The central server or the aggregation server identifies the area with the help of the location reference sent by the sensor node. Initially during deployment each sensor nodes are given their location reference. This is done either manually or the sensor nodes automatically calculate the distance with the help of GPS devices attached to it. Installing a GPS device or manually calculating the location cannot be possible in the context of large network because of the excessive cost and workforce involved respectively. To overcome this, sensor nodes are made to identify their locations with the help of neighboring nodes. This paper focuses on the localization techniques used by the sensor nodes to identify their location. Several researches are going on in the field of localization to identify the exact location.

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C. Angle based localization

Angle based localization uses the received signals angle or Angle of Arrival [14 - 16] to identify the distance. This method requires special antenna’s that are expensive. Because of this reason AOA is mostly used in Base Station’s (BS).

D. Range based localization

This localization is carried out based on the range. The range is calculated using the Received Signal Strength (RSSI) [17] or Time of Arrival (ToA) [18, 19] or Time Difference of Arrival (TDoA) [13, 20]. In RSSI based localization the receiver sends the signal strength with respect to the sender, and sender calculates the distance based on the signal strength. ToA and TDoA use timing to calculate the range. Time synchronization is an important factor when using ToA and TDoA.

E. Distance based localization

Distance based localization technique uses hop distance among each node to localize the node. It uses DV-hop propagation method [21, 22] or DV-distance [22] propagation method for localization.

III. LOCALIZATION TECHNIQUES

The localization techniques can be grouped into two types namely range based and range free approach. Fig. 2 shows the localization techniques grouped into different types.

\[ d_{xy} = \frac{1}{2}[(\tau_{\text{trans}}^x - \tau_{\text{trans}}^y) - (\tau_{\text{recv}}^x - \tau_{\text{recv}}^y)] \]

where,

- \(d_{xy}\) is the distance between node X and node Y,
- \(\tau_{\text{recv}}^x\) is the received power of node X,
- \(\tau_{\text{trans}}^x\) is the transmitted power of node X,
- \(\tau_{\text{recv}}^y\) is the received power of node Y,
- \(\tau_{\text{trans}}^y\) is the transmitted power of node Y.

Fig. 3: Range Estimation using ToA

Once the distance is discovered, multilateration is implemented to find out the location reference of the node. RF signal travel at the speed of light, this make the RF propagation to get varied in indoor environments. This made a high localization overhead. In order to overcome the RF propagation in indoor environment, in [13], a combination of RF signals with Ultrasound was proposed. The speed of Ultrasound is lesser when compared to the speed of light. Based on the TDoA of the two signals the distance is calculated. Another method for locating a node using TDoA is done by observing the time for a signal to reach two or more receivers. It is made sure that all the receiver nodes are time synchronized. The TDoA is calculated as follows: [23]

\[ \tau = \frac{(r_2 - r_1)}{c} \]

where,

- \(\tau\) is the TDoA,
- \(r_2\) & \(r_1\) are the range from the transmitter to the two receivers,
- \(c\) is the speed of propagation.

ii. Without using anchor nodes

A device that has GPS attached need not require a support from anchor nodes for localization. Triangulation [24] technique is used in GPS to identify the location of the node. The assistance of satellites is required for finding out the location of the sensor node that has GPS device.

B. Range free approach

There are few localization techniques that do not require special hardware for localization. They compute their distance based on DV hop or DV distance. The range free approach can be broadly classified into two types as follows,

i. Using anchor nodes

Techniques, namely Probability Grid [21] and Kcdlocation [24] works on DV based distance localization. In these
techniques few nodes act as anchor nodes, which in turn are used by other nodes for localizing themselves.

ii. Without using anchor nodes

Convex Position Estimation technique [28] works without an anchor node. The network is modeled by a central sever giving equations for revealing the distance between the nodes. It uses a good optimization technique to find out the location of the nodes based on the equations.

IV. PERFORMANCE OF LOCALIZATION SCHEMES

Table 1 shows the performance comparison of different localization schemes. Each localization technique serves different purposes. More the number of anchor nodes less the localization error. In dense environment the location error tends to increase. This can be controlled by making the network dense.

| Localization Techniques used | Accuracy |
|------------------------------|----------|
| GPS                          | 2 to 15 meters |
| Angle based approach         | 1 to 6 meters |
| Range based approach         | 4 to 8 meters |
| DV based approach            | 10 to 20 meters |

Table 1: Comparison of Localization Techniques

V. CONCLUSION

This paper covered the different localization techniques used and their problems. The scalability of range free approach is more when compared with range based approach. The localization techniques help by reducing the deployment cost of wireless sensor networks. Currently, there is a trade-off between the localization accuracy and algorithm runtime. Many security and energy issues related to localization that can be considered for future work.

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