Comparison of localization algorithms in different densities in Wireless Sensor Networks

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Abstract

Location information is one of the most important information in wireless sensor networks (WSN). The great WSN applications and techniques necessitate that the sensor nodes positions must be determined. Localization algorithms have used to estimate sensor nodes position. This paper is intended to study and compare different localization algorithms. The algorithms under investigation are: general, M_refine, and nearest. All these algorithms are compared according to the following factors: density and beacon nodes. Some conclusions that are extracted belong to the mean location error, energy consumption, and the Max references.

Keywords—*Wireless Sensor Network, localization, density, the energy consumption, location error, Nearest, M-refine.*

1. Introduction

WSNs are used to perform a specific task for an application they have become increasingly popular, due to their broad application areas.

One of the most significant challenges for WSNs is the need for localization. Localization problem is concerned as an important aspect in the research of WSN. However location service is a basic service of many emerging applications in sensor networks. To localize sensor nodes, a good solution would be to use a global positioning system (GPS) [1] but this is quite impractical because it is too expensive to realize and is useless indoors.

Many location estimation algorithms for WSNs have been proposed recently. The location estimation algorithms for WSNs can be categorized as range-based and range-free. Range-based methods use absolute point-to-point distance or angle information to calculate the location between neighbouring sensors. The second class of methods, range-free approach, employs to find the distances from the non- beacon nodes to the beacon nodes [2]. Several ranging techniques are possible for range measurement, such as angle- of-arrival (AOA) [3], received signal strength indicator (RSSI) [4], time-of-arrival (TOA) [5] or time-difference-of-arrival (TDOA) [6].

Most of the existing works using different mathematical techniques such as triangulation, multilateration [7], etc. In these methods, information provided by every beacon node is used.

In addition, the localization system must also comply with a number of constraints that are common to WSNs, like energy consumption, mean location error and the reference nodes.

In this paper, different localization algorithms have studied and compared according to the different factors. We show that the results of energy consumption, mean location error and the number of references change in accordance with the algorithms.

the present paper is organized as follows: in section 2, we discuss related work, section 3 description of localization algorithms, and section 4 presents outline of our comparison, section 5 shows simulation results, section 6 discuses our comparison , and section 7 concludes our work.

2. Related Work

Recently, there has been a growing interest to study and build the localization systems of wireless sensor networks. One example is Microsoft's RADAR [8]. Other research includes GPS.

Moreover, many systems use some kinds of range-based methods and others rely on rang-free techniques.

In range-based methods, ToA, TDoA, AoA and RSSI are used to obtain distances or angles between

wireless nodes. RSSI value could be provided by the sensor nodes. The RSSI value could obtain a good accuracy in short distance [4]. In the other hand the range-free localization algorithms depend on network connectivity.

However the ns2 [9] simulator is one of the most widely used tools by researchers to implement and evaluate the localization algorithm in WSN and ns2 supports simulations of different technique (such as TOA and RSS).

Adnan M. Abu-Mahfouz and Gerhard P. Hancke [10] present an extension to the current version of ns-2, which enables a normal user, who has basic knowledge of ns-2, to implement and simulate any custom localization system within a wireless network. The technical content of this investigation would be beneficial to researchers who want to implement new or existing localization algorithms and anyone new to ns-2 who wish to know more about how a simulation project is built and structured.

In this paper, different localization algorithms have studied and compared according to the different factors.

3. Description of localization algorithms

Three localization algorithms have been implemented for the performance comparison, using the same assumptions.

These algorithms will be explained briefly and then a comparison of them will be presented, where each algorithm is classified based on the set of references used.

These algorithms collect RSSs which is measured by sensor nodes and uses this information to estimate distance between sensors. Then they calculate the coordination of sensor by using Triangulation [7] or multilateration method.

3.1 Multilateration algorithms

Several localization algorithms use multilateration method to find the position of the nodes, multilateration method uses at the least three beacons, all the available beacons using to estimate the position of the unknown location nodes. Tow algorithms based on this method were implemented. The first one is General, while the second one M_Refine is implemented based on the successive refinement approach [11], the nodes keep and re-estimate their position.

3.2 Nearest algorithm

Nearest algorithm requires three references to estimate location of an unknown sensor node. As shown in figure1, the unknown nodes select only the nearest three references. The selected references have the minimum measured distance to the unknown node [12].

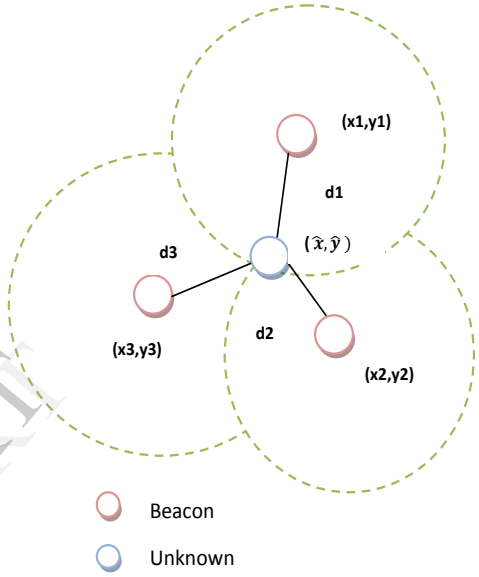

Fig. 1. Nearest Localization Algorithm

4. Outline of our Comparison

In this investigation, we present the performance comparison of Three localisation algorithms (General, Nearest, M_Refine), using the same assumptions.

All these algorithms are compared according to the following factors: density and beacon nodes. Some conclusions that are extracted belong to the mean location error, energy consumption, and the Max references using. The following figure describes the framework of our location estimation system.

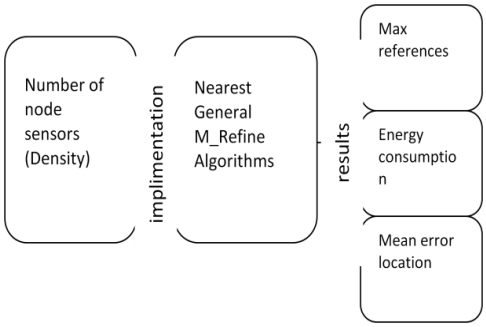

Fig. 2. Framework of location estimation system

5. Simulation

The three localization algorithms are compared according to different densities and number of beacons. For each network, three tests are made. One for each algorithm, the following table describes the different environments of testing.

	Number of nodes	Number of beacons	field	Localization algorithms
Network 1	8	5	200 m	• Nearest • General • M_Refine
Network 2	12	5	200 m	• Nearest • General • M_Refine
Network 3	15	8	200 m	• Nearest • General • M_Refine
Network 4	19	3	200 m	• Nearest • General • M_Refine

Table 1. Environments of testing

At the beginning of simulation each node has 2.0 joule. The figure 3 shows the average consumption energy vs density. The compare between three location algorithms was done considering only energy consumption. The result shows that M_refine algorithm consumes more energy than Nearest and General algorithms. General algorithm consumes as energy as Nearest algorithm.

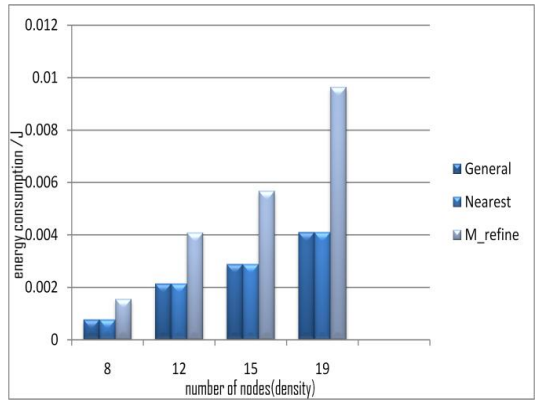

Fig. 3. The energy consumption in several environments

The figure 4 shows the average mean location error vs density. The compare between three location algorithms was done considering only mean location error. The result shows that M_refine and General algorithm have less mean location error than Nearest.

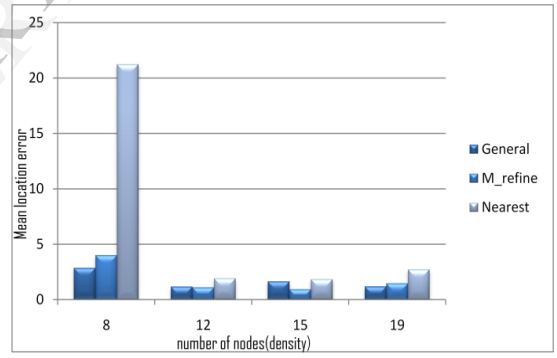

Fig. 4. The mean error location in several environments

The reference node is an unknown node which obtains its positions, and it could act as a reference for other unknowns. The figure 5 shows the Max number of references vs density. The compare between three localization algorithms was done. The result shows that the number of references for the Nearest algorithm was fixed (three references). General and M_refine algorithms uses all the available references.

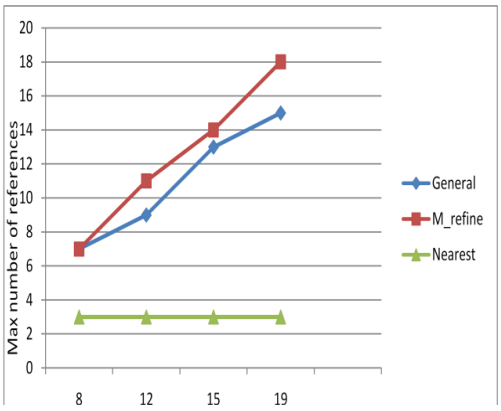

Fig. 5. The Max references in several environments

6. Discussion

After analysing the results of testing the localization algorithms and running them under different densities, the following conclusions are obtained:

- M_refine and General Algorithms show more accuracy in different densities and they have a less mean location error than Nearest.
- Mean location error of M_refine and General algorithms become very good when using a huge density
- M_refine algorithm consumes more energy than Nearest and General algorithms.
- Nearest algorithm consumes as energy as General algorithm in different densities.
- Nearest algorithm use a fixed number of references , and the low references than the other algorithms
- M_refine algorithm use more number of references than Nearest and General algorithms.
- Increasing the Number of references could enhance the accuracy of the mean location error.

7. CONCLUSION

In the wireless sensor networks, the sensor node's location is very important information.

Several WSN applications require that the position of sensor nodes be determined. Localization algorithms use some techniques to estimate positions of sensor nodes. One of these techniques is to use special nodes called beacons, which know their own location by using GPS or manual configuration.

The nodes which not know their location called unknowns, it could compute their position, and act as a reference for other unknown nodes.

This paper was intended to compare between three localization algorithms (General, M_refine, and Nearest) according to the different factors.

Our comparison verified that the results of energy consumption, mean error location and Max references change in accordance with the algorithms.

ACKNOWLEDGMENT

The authors would like to thank Sir Adnan M. Abu-Mahfouz for their advices and answering our questions.

REFERENCES

[1] Sangho Lee, Eunchan Kim, Chungsan Kim, and Kiseon Kim," Localization with a Mobile Beacon based on Geometric Constraints in Wireless Sensor Networks" 1-4244-1502-0/07, 2007 IEEE

[2] Guo Jianquan, Zhao Wei," An Anchor Free Location Algorithm for Large Scale Wireless Sensor Networks" 1-4244-2368-2/08, 2008 IEEE

[3] Jehn-Ruey Jiang, Chih-Ming Lin, Feng-Yi Lin and Shing-Tsaan Huang, "ALRD: AoA Localization with RSSI Differences of Directional Antennas for Wireless Sensor Networks" International Conference on Information Society (i-Society 2012)

[4] Karel Heurtefeux and Fabrice Valois, " Is RSSI a good choice for localization in Wireless Sensor Network" 2012 26th IEEE International Conference on Advanced Information Networking and Applications

[5] Guangliang cheng,"Accurate TOA-Based UWB Localisation System in Coal Mine Based on WSN" 2012, international conference on Applied Physics and Industrial Enginneering

[6] Weile Zhang, QinyeYin, Xue Feng, Wenjie Wang,"Distributed TDoA Estimation for Wireless Sensor Networks Based on Frequency-Hopping in Multipath Environment"978-1-4244-2519 8/10, 2010 IEEE
[7] A.Srinivasan and J. Wu. "A Survey on Secure Localization in Wireless Sensor Networks". In Encyclopedia of Wireless and Mobile Communications, B. Furht (ed.), CRC Press, Taylor and Francis Group. 2007.
[8] P. Bahl and V. N. Padmanabhan, "RADAR: An in-building RF-based user location and tracking system", in INFOCOM. IEEE, March 2000.
[9] T. Issariyakul and E. Hossain, Introduction to Network Simulator (NS2). New York, NY, USA: Springer, 2009.
[10] A. M. Abu-Mahfouz and G. P. Hancke, GP., "ns-2 extension to simulate localization system in wireless sensor networks," In Proceedings of the IEEE Africon 2011 conference, 13-15 September , Livingstone, Zambia, 2011, pp. 01-07
[11] Zhu, X., Wu, X. and Chen, G."Refining hop-count for localisation in wireless sensor networks", Int. J. Sensor Networks, Vol. 12, No. 4, pp.232–243 (2012).
[12] K. Y. Cheng, V. Tam and K. S. Lui, "Improving aps with anchorselection in anisotropic sensor networks," in Proceedings of the Joint International Conference on Autonomic and Autonomous Systems and International Conference on Networking and Services — ICAS-ICNS '05, October 23-28, Papeete, Tahiti, 2005, pp. 49-54