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ОПТИМИЗАЦИЯ ЛОКАЛИЗАЦИИ УЗЛОВ В ТРЕХМЕРНЫХ БЕСПРОВОДНЫХ СЕНСОРНЫХ СЕТЯХ

OPTIMIZATION OF NODES LOCALIZATION IN 3D WIRELESS SENSOR NETWORKS

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Аннотация

WSN являются наиболее часто используемыми сетями в различных приложениях, но считаются чувствительными к энергопотреблению, так как их источником питания являются батареи малой емкости, незаменяемые и не

перезаряжаемые из-за трудностей в достижении их местоположения и высокой стоимости замены с этого момента. очень важно найти хорошую локализацию сенсорных узлов в WSN, при этом выход из строя одного (или нескольких) узлов не влияет на всю сеть. Системы GPS впервые использовались для получения прерывистой информации о местонахождении узлов и их возможностях, но эта стратегия столкнулась с проблемой потери сигнала из-за естественных преград, таких как горы и океаны, которые маскируют сигналы спутников. Эти методы заменены алгоритмами локализации, позволяющими использовать наилучшую конструкцию для производительности сети, при этом потеря узла (или более) не влияет на всю сеть. В этом исследовании мы представляем группу исследований по локализации WSN с упором на 3D WSN. И мы протестируем два типа 3D WSN, чтобы выбрать лучший, основываясь на различных параметрах, таких как энергопотребление.

Summery

WSNs are the most used networks in various applications but are considered sensitive to power consumption that its power source is batteries with low capacity and non-replaceable and non-rechargeable because of difficulties in reaching their location and the high cost of replacing from this point it is so important to find a good localizing of sensor nodes in WSNs with failure of one (or more) node not affecting the entire network GPS systems were first utilized to get intermittent information about nodes locations and their capabilities but this strategy faced the problem of losing signal because of natural barriers like mountains and oceans which veil satellites signals. These methods are replaced by localizing algorithms allows using the best construction for network performance with losing a node (or more) not affecting the entire network. In this research we present a group of studies about localizing WSNs with focusing on 3D WSNs. And we will test tow types of 3D WSNs to choose the best one relying on various parameters like power consumption.

Ключевые слова: Беспроводные сенсорные сети, алгоритмы локализации, GPS

Keywords: Wireless sensor networks, localizing algorithms, GPS

Introduction:

WSNs are some devices connected to each other, their mission is to gather information and interchange it through wireless connection channels with many nodes then to other networks through a specific port . WSNs have unique characteristics make them suitable for many applications, recently it has been noticed the interesting growing of applications depending on these networks as the small size of these sensors and thier low cost allow spreading them in high numbers. And the ability of the node to set itself in the network makes it able to be spread in many environments especially those difficult to reach. WSNs are constructed of huge number of small self-powered equipment known as sensor nodes being spread in a territory for surveillance, where nodes collect data from the environment then send it to other device (base station) without the need of human assistance, then the station sends data to the user through internet or satellites. This idea is as old as radios but WSNs depends on latest technology of small computer parts, and they adopt network managing system to best utilize power and connection resources, which is a revolutionary idea in this field. WSNs are started many years ago by American defense ministry to support battle fields with huge number of sensors to read war circumstances, the project was named (smart dust), then it was transformed to civil applications.

WSNs are considered low volume and complexity in view of equipment and sensors that they depend on limited power supply and conducts data through wireless connections or various ways to a collector in limited network or a network connected to other networks though a gateway. WSNs are constructed of base stations and group of nodes connected to each other

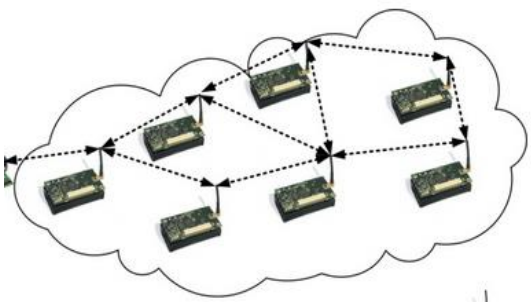


Fig. 1 WSNs

Research importance and goals:

3D WSNs gives the third dimension (height) a value, while 2D WSNs do not Ignoring the third dimension is accepted in applications with sensors spread on the ground surface with a network height less than the radius of sending signal of a node. This is not accepted in space or underwater where nodes are spread different heights and measurement information are important so we have a 3D WSN Considering the third dimension is a research dilemma of studying the efficiency of these networks and how to optimize there performance.

Goal : studying localization of nodes to suggest a topology of the network in 3D WSNs to reduce power consumption which is considered an important factor in their role beside increasing their productivity and lifetime to achieve the best performance

Research methods and tools :

To choose the suggested algorithm we constructed a simulation scenario using the simulation program Network simulator 2 which is an open source app depends on simulating intermittent events .We used version 2.35 which is rich in parts and protocols of networks and internally depends on two languages C++ an efficient and fast in execution and is used for writing fixed parts , TCL which is slow in execution but fast in editing and is used to write user instructions , so this simulator gathered the speed of execution and editing from these two languages. Simulation environment is considered a building of many floors with two source nodes and two receiver nodes implanted in different floors and the rest of nodes being implanted randomly or in organized type to figure out the best localizing for nodes.

2. Importance of localizing in WSNs :

Most times we have to spread the nodes randomly from a plane as an example , which results in many problems as lacalizing ones , which is estimation of coordinates of an unknown node in the network , so that data received from nodes loose its value without the location information and that may lead to wrong explanation GPS may be

a good choice because of good precision but in some applications using GPS receivers is useless in view of high power consumption and weight and cost and natural barriers , as this system dose not work in inner environments cause it depends on direct facing of the sender and receiver , that's why we need algorithms to localize the nodes , these algorithms share three steps :

- Distance Estimation : between nodes by some technologies
- Position Computation : by estimation of location of a node relative to known node
- Localization Algorithms : connecting data of distance and location to precisely localize the node

3. distance estimation techniques : Two major types

3.1 range free : if two nodes were able to connect then the distance between them is less than the maximal range of signaling by specific distance R , accuracy depends on nodes density and number of reference nodes with known locations and the topology of the network . this method is simple and low cost and best suites the application that do not need such a precise localizing

3.2 range based techniques :

3.2.1 TOA **(Time Of Arrival) :**

Uses the time of signaling and speed of spreading and time of arrival to measure the distance with this equation:

Distance = speed*time

Disadvantages : needs synchronizing the send and receive

3.2.2 **(Received Signal Strength Indicator) RSSI :**

Radio signal strength proportionate inversely with distance , so we can translate signal strength to distance. Disadvantages **:** problems in precision because of the changing nature of radio signal due to the environment

3.2.3 **TDOA (Time Difference Of Arrival :**

Two different signals in sending and receiving and two different speeds then the difference in time of arrival is calculated to calculate the distance

3.2.4 **AOA (Angle Of Arrival) :**

Based on algorithmic antenas to define the receiving angle. The two sides should be able to define the angle. In situation of the target knowing its orientation then we need it to connect to two sensors. When the target dose not know its orientation then we need three sensors

4.Position Computation Techniques :

4.1 lateration : in this method we need three reference nodes near the node we are localizing (Trilateration)، , and when using a 3D space we need 4 nodes (Multilateration) Localizing the node is done by cross of three circles of the reference nodes with a radius being the distance from the reference node to the being localized , disadvantages are that information about distance may be wrong so circles may not cross

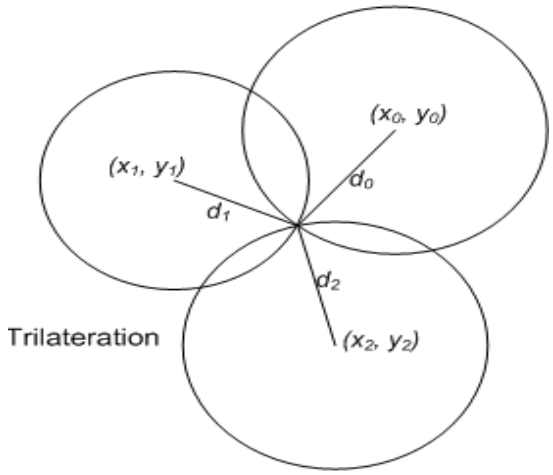


Fig. 2 Position Computation Techniques

4.2 **Triangulation :**

At least Three reference nodes are used then calculating the location of the node by angles of reference nodes which form a triangle and by depending on trigonometry

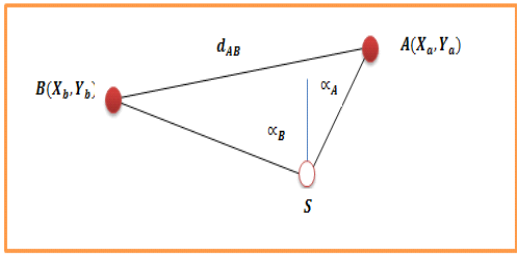


Fig. 3 Triangulation

4.3 Pattern Matching Localization:

Is called also (Fingerprint Algorithm) and contains two phases :Offline : parameters of received signals are registered in database named radio map. Online : sensors are activated to measure the map Estimation of node location is made by comparing characteristics of received signals with that registered in the map. This method suffers climate changes because it saves the parameters in the first phase so it needs to re-register in the new climate

5. Localization Algorithms

5.1 MDS (rang-free anchor-free methods):

Every single node forms a local map of the distribution of other nodes which are located two jumps far from it depending on basic connection operations between them.Then all sensors connects to each other to gather these local maps to form the final type of localizing in the network , this algorithm suffers difficulty in forming the final map and imprecise localizing of sensors and it uses algorithms DV (distance , hop) to form the distance algorithm

5.2 **(LPD) The Local Position Discovery :**

Building a lacal scheme of locations of sensors , local map in every cluster starting from gate node in every cluster

5.3 **(Localization with Mobile Beacon (LMB) :**

Localizing of all nodes depends on a single moving node that sends its location information containing coordinates ,when the unknown node receives three messages of moving nodes it calculates its location

Reference studies :

disadvantages	advantages	adress	year	Editors	NO
Time of computing and cost	Precise localization based on	A practical Localization Algorithm based on WSN	**2010**	Zhikui Chen	1
Bad performance when there is motion of some unknown nodes	Use the error coefficient in each stage to correct the	Improved DV-Hop Localization algorithm based on RSSI	**2019**	Je Wu	2

	distance estimate in the next stage				
Distance between nodes should be marginal relative to sending signal strength	Calculating the capacity received is simple	An effective localization algorithm using RSSI	**2018**	Nath and Patwari	3
Not efficient in localizing nodes precisely	Calculating the mean error gives a good idea of the node position circuit	Evaluation of localization Algorithms	**2009**	Allen and Gaura	4
Localizing main node is based on GPS which is not always available in some topography	Determining the position of the nodes using the method of deflection in positioning, where the known distance between the node and the main nodes and between the nodes	A weight based DV-HOP improved localization algorithm	**2017**	Shi and Fang	5

Simulation and Results :

NS2 programs are suitable to simulate and plan 2D&3D WSNs. They contain many libraries to simulate WSNs. In every user code there is presenting of coordinates of nodes in variants X and Y in 2D WSNs , Z is added in 3D WSNs. Sending data packets in 1000 bite \ second to fix the sending rate according to 80.11 role which is a wireless parameter with many versions supports high bit rate that sometimes reaches 11 mbps and is used for applications of WSNs and localizing issues. The covering range of every node is considred 60 m through free distribution space. The protocol Dynamic Source Routing (DSR) to direct the data so addresses of nodes from source to target included in the sent packet , sending is continuous to ensure sending to the last node , and there are two procedures :

(Route Maintenance Route Discovery DV-HOP algorithm)

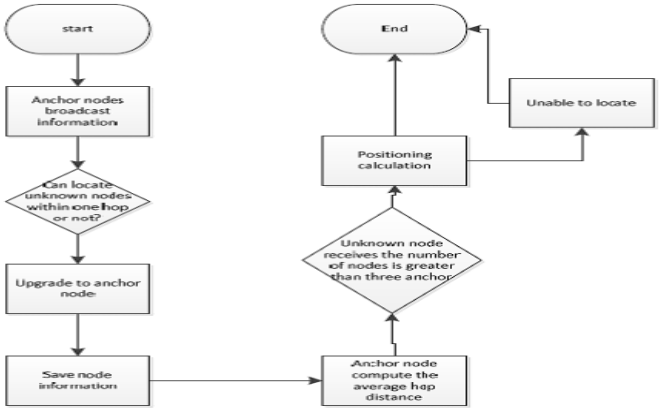


Fig. 4 Route Maintenance Route Discovery DV-HOP algorithm

Algorithm basics :

Reference node broadcasts and when a node receives the messages it transmits them to other nodes ,and from the jumps needed for the packet to reach the node we can localize it , then we have three known locations of nodes and then we calculate the rest of nodes in same way Trial of cubic construction (increasing number of nodes and changing dimensions of the network in three senarios) :

Measured parameters (max number of packets received , lowest number of nodes)

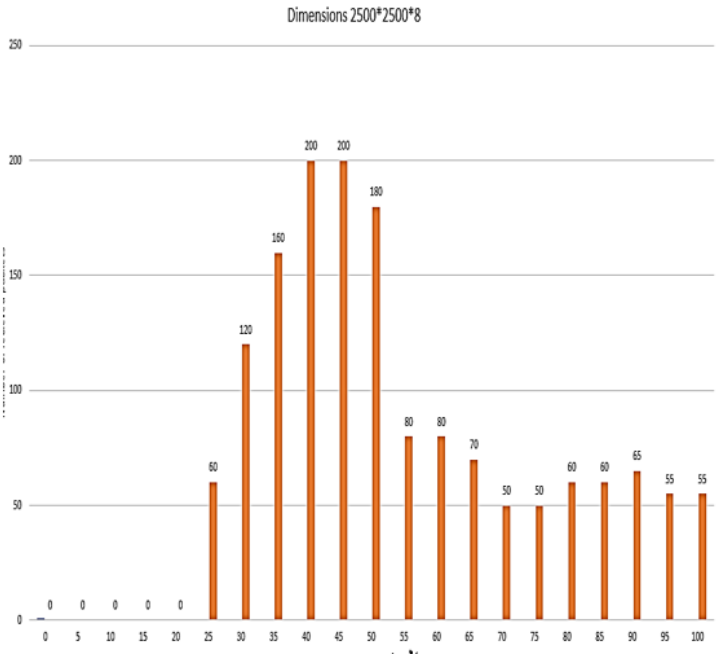


Fig.5 The first scenario diagram

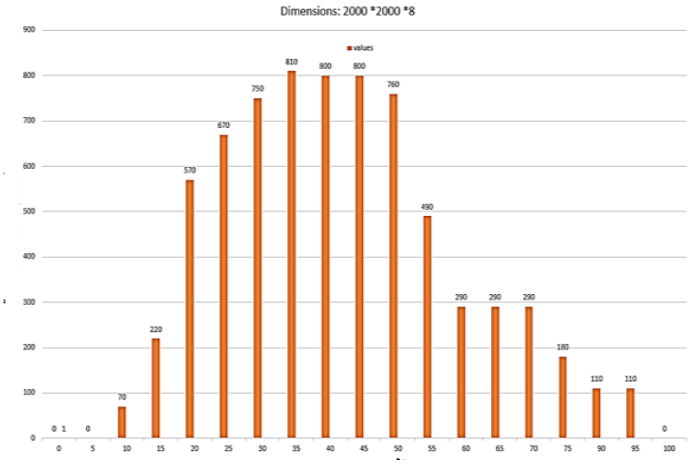


Fig.6 The 2d scenario diagram

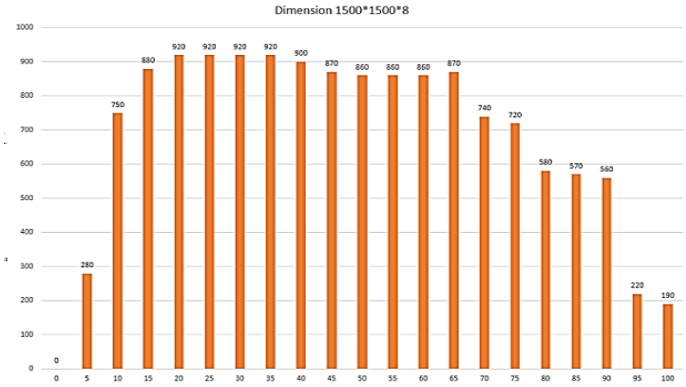


Fig.7 The 3d scenario diagram

Lowest nodes number	Max packets number	Network dimensions	senario
40	200	8*2500*2500	1
35	810	8*2000*2000	2
20	920	8*1500*1500	3

Result:

The best scenario is when we received the max number of packets (920) with lowest number of nodes (20) then the network dimensions are smallest (1500*1500*8) comparing to other situations. The more bigger the volume of network the more nodes we need to build up the road between source and target

Cubic trial (nodes distribution effect) :

Parameters (max number of packets , type of distribution)

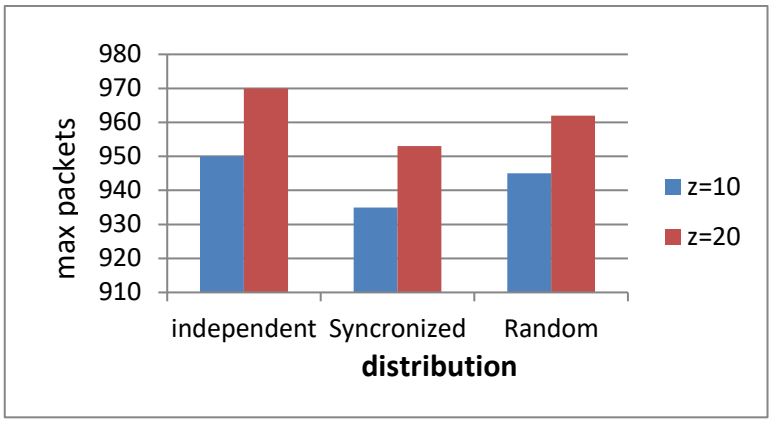


Fig. 8 nodes distribution

symmetrical	alligned	random	Nodes distribution
935	950	945	Max packet num (z=10)
953	970	962	Max packet num (z=20)

Result:

Aligned distribution is better than max packet number because when distribution is random in the cubic some nodes will be in the angles which will limit their participation in building up the road for connecting and transmitting data from source nodes to target

Comparing network performance in organized spherical and six fold environment :

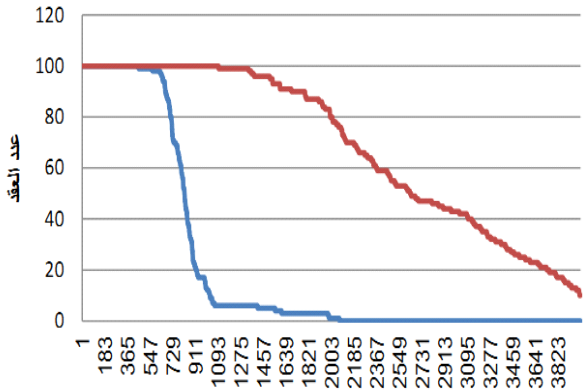


Fig. 9 Comparing network performance

Measured parametres :

Sending receiving times , nodes number	Sending receiving times , nodes number
spherical	sixfold
Nodes die at 911 on H-axis Then performance declines	Nodes die at value 2913 on horizontal axis (times of sending receiving) then performance declines

Result :

Network performance is better in sixfold environment than spherical

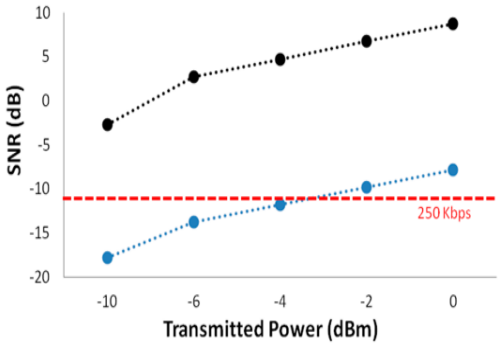


Fig. 10 Comparing signal to noise in sixfold and spherical, Black is sixfold , blue is spherical Signal to noise ratio is better in sixfold

SNR(dB),Transmitted power(dBm)) (spherical	**SNR(dB),Transmitted power(dBm)) (sixfold**
-6,-13	-6,3
-4, -11	-4,5
-2,-10	-2,9

Conclusions :

1.Increasing node number and reducing area gives us more received packets because connection between nodes is stronger with reduced distance

2.Node distribution effect : aligned one is better

3.Sixfold organized environment is better than spherical one in terms of power consumption and performance and ratio of signal to noise

Future perspectives :

1**.** Adding noise to radio connection between nodes and watching the results and calculating Bit Error Rate BER , and comparing ages of nodes , and moving to wide conceptions about quality of service with using protocols with wide applications in 3D WSNs

2. Reliance on new algorithm based on merging many algorithms to benefit from all advantages in increasing its life and power saving

3.Using the concept of correlation between nodes to predict the location of a node depending on locations of neighboring ones

References :

1. HM Ammari, SK DAS. Coverage and connectivity in three-dimensional wireless sensor. IEEE Trans. Parallel Distrib. Syst. (IEEE TPDS). 2009; 20(6).
2. ZOU and K. Chakrabarty, “Sensor deployment and target localization based on virtual forces.IEEE, 2003, pp. 1293–1303.
3. I. F. Akyildiz, D. Pompili and T. Melodia, Underwater Acoustic Sensor Networks: Research Challenges, AdHoc Networks Journal, (Elsevier), March 2005.
4. K. Romer, F. Mattren, ‘‘The Design Space of Wireless Sensor Networks,’’ IEEE Wireless Communications, Dec. 2004.
5. Boukerche. Algorithms and Protocols for Wireless, Mobile Ad Hoc Networks, John Wiley & Sons, Inc., 2009
6. US National Research Council report ("Embedded Everywhere"): the use of wireless sensor networks (WSN) could well dwarf previous milestones in the information revolution.

7. I. F. Akvildiz, D. P0mpili, and T. Melodia, Underwater Acoustic Sensor Networks: Research Challenges, Ad Hoc Networks Journal, (Elsevier), March 2005.
8. D. Puccinelli and M. Haenggi WSN: Applications & Challenges of Ubiquitous Sensing IEEE CAS Magazine, Sep. 2005
9. F. Akyildi, D. Pompili, T. Melodia, Underwater acoustic sensor networks: research challenges, Ad Hoc Networks (Elsevier) 3 (3) (2005) 257–279.
10. Shrivastava A; Bharti,P. Localization Techniques For Wireless Sensor Network. International Journal Of Computer Application India, Vol.116, No.12,2015, 13-15.

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