Localization Algorithm for Maximizing Wireless Sensor Network Lifetime

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***Abstract*— Wireless Sensor Networks (WSN) is widely used in many applications such as military surveillance, forest monitoring, industrial automation, etc. Several processes of WSN like routing, sensing, security implementations, localization need energy for their operation. In most of the WSN application like remote military area surveillance, as each sensor node lives on their battery energy where an uninterruptable power supply is not possible, the energy becomes a very big constraint. When the battery energy becomes dry, the sensor node is isolated from the network and this failure further cause's severe impact. We propose a novel approach to conserve the energy during localization process. Our approach collects the location and distance information from each sensor node using Unmanned Aerial Vehicle (UAV) and let the powerful Central Control Station (CCS) computes the sensor node's location using intelligent arc selection algorithm. Our approach reduces the energy consumption at each sensor node during localization by removing computational overhead at each sensor node and there by extends the lifetime of the sensor network significantly.**

Keywords*— Wireless Sensor Networks, Arc Selection Algorithm, Localization, Remote Control Station.

I. INTRODUCTION

WIRELESS Sensor Networks (WSN) is widely used in many applications such as military surveillance, forest monitoring, industrial automation, etc. Several processes of WSN like routing, sensing, security implementations, localization need energy for their operation. In most of the WSN application like remote military area surveillance, as each sensor node lives on their battery energy where an uninterruptable power supply is not possible and also it is impossible to construct a wind energy station or solar energy plants over the military field. Hence the energy becomes a very big constraint. The Energy in the WSN is consumed by many factors. (Ref: Fig 1).When the battery energy becomes dry, the sensor node is isolated from the network and this failure further causes severe impact. Without the contact of sensor nodes nothing can be preceded further. We propose a novel approach to conserve the energy during localization process.

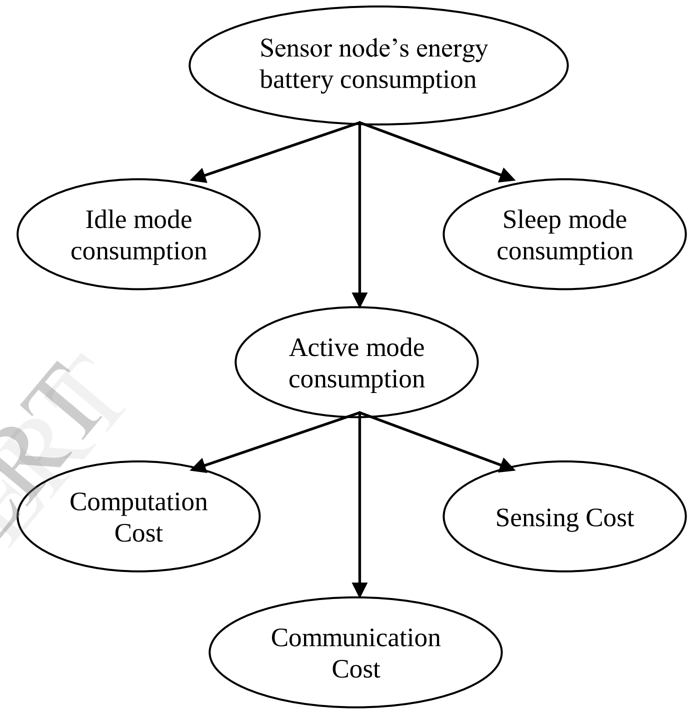

Fig 1: Energy Consuming Factors in a Common Sensor Node

Our approach collects the location and distance information from each sensor node using unmanned aerial vehicle (UAV) and let the powerful central control station (CCS) computes the sensor node's location using intelligent arc selection algorithm. Our approach reduces the energy consumption at each sensor node during localization by removing computational overhead at each sensor node and there by extends the lifetime of the sensor network significantly. There is no Centralized localization in any of the existing approaches. But in our energy conserving localization algorithm we provide a centralized localization by doing all computations in the central control station. The function of the sensor node is only to send the distance location message to the flying anchor node called UAV (Unmanned Aerial Vehicle). The UAV transmits the message to the central control station and starts computing the position of the sensor node by using our energy conserving localization algorithm.

II. RELATED WORK

Daniel et al (2013) explains the localization in sensor network by collecting information from the sensor nodes by a flying anchor node called UAV. Here, acoustic events like explosions or artillery are localized. But there is no centralized localization and also signal processing is at each sensor node, which causes heavy computation cost.

Aiging et al (2012) said that the modified trilateration method is used. Complex algorithm is executed in each sensor node to select the anchor nodes. But, localization processing is with each sensor node, which causes heavy computation cost and also no centralized localization,

Chia-Ho Ou (2011) says, In this scheme each sensor node receives beacon messages and computes its location. Here also there is a heavy computation at sensor node.

Jang-Ping et al(2010) explains, In this paper, Each node collects the locations of its one-hop and two hop anchor nodes via message exchange. Here Inter-sensor communication causes heavy computation cost and there is no centralized localization.

Guerrero et al (2010) said that here each node receives the information from UAV hence heavy computation at each sensor node.

W.-H. Liaoet al (2010) said that each node receives many beacon messages from anchor node and multilateration method is used. Here localization processing is with each sensor node, which causes heavy computation cost and also there is no centralized localization

Chia-Ho Ou et al (2008) explained that here each node receives many beacon messages from anchor node and no centralized localization thereby arises high computation cost at each senor node.

Kuo-Feng et al (2005) said that here also each node receives many beacon messages from anchor node thereby causing overhead of beacon message transmission which leads to heavy computation at sensor node.

A. Limitations of the Existing Localization Approaches

The various limitations of the existing localization approaches are:

--Involve large beacon transmission and reception, which increases the communication cost at each sensor node.

--Insist each sensor node to execute heavy computations, which causes high energy consumption.

--Inter-sensor communication is used in many existing localization schemes, which causes unnecessary communication cost.

III. PROPOSED WORK

A. Objectives of the Proposed Localization Approaches

The assorted objectives of the proposed localization approaches are:

--This approach computes the location of each sensor nodes in central control station. Hence each sensor node is free from localization computation cost.

--This approach is free from inter-sensor communication, which further conserves energy in each sensor node.

--Hence this approach significantly conserves energy in each sensor node during localization process and thereby extends the lifetime of sensor networks considerably.

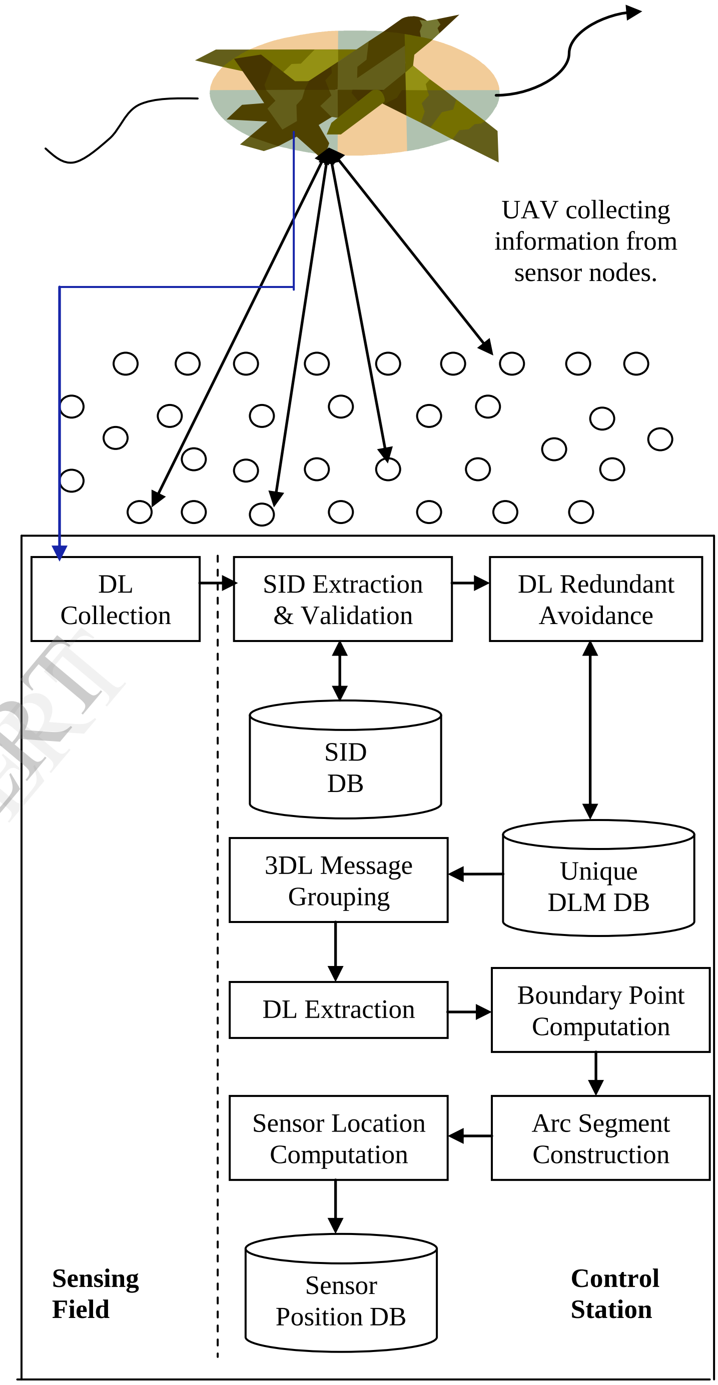

Fig 2: Proposed Architecture of Location Engine

Fig 2 gives the details about the proposed system architecture of location engine in which UAV collecting the information from the sensor nodes and send to the DL collection placed at the sensing field.

IV. IMPLEMENTATION DETAILS

A. Module Description

The proposed localization approach consists of three major modules such as:

1) *Module 1:*
   - --Distance Location (DL) Collection.
   - --Data Validation
   - --Three Distance Location (DL) Grouping
2) *Module 2:*
   - --Distance Location (DL) Extraction
   - --Boundary Point Computation
   - --Report Generation on Localization Coverage
3) *Module 3:*
   - --Arc Segment Construction
   - --Sensor Location Computation

Let see the sophisticated details about the above major three modules comes under the proposed localization approach (Fig 2).

1) Module 1:

1.1) Distance Location (DL) Collection

UAVs travel on the wireless sensor field to collect the distance and corresponding location information from the sensor nodes. When UAVs enter into the sensing range of the sensor node, it receives the sensor id (SID) of that sensor node. The signal strength of the SID packet is measured and the corresponding distance (D) is calculated. Also the UAVs record their corresponding location (L) at the time of SID reception. These SID, distance (D) and location (L) are stored in the UAV as DL Messages.

1.2) Data Validation

After collecting the location and distance information, the UAVs reach the control station. The control station validates the data collected from the sensor nodes using their sensor ids (SIDs) i.e the SID s are extracted from the DL messages and compared with the valid SIDs stored in the SID database. Invalid SIDs are ignored and only the valid and unique DLMs are stored in the DLM database.

1.3) Three DL (3DL) Grouping

Our localization algorithm needs three DL messages for the successful localization of a sensor node, where the three DLMs collected within the range of that sensor node. Since DLM database stores all the valid DLMs collected from different nodes in their different ranges, the optimum 3 DLMs are selected and grouped for the beginning of the localization process.

2) Module 2

2.1) Distance Location (DL) Extraction

The localization algorithm begins with 3 DL messages. Here the selected DL messages are processed and the corresponding distance, SID and location information are extracted.

2.2) Boundary points computations

The algorithm considers the location as centre and distance as radius. Hence the boundary points on the circle can be drawn. Among the different boundary points, the algorithm selects only four points in 0^0, 90^0, 180^0 and 270^0. Similarly the boundary points around the three locations can be computed.

2.3) Report generation on localization coverage

Without 3 DLMs, a sensor node cannot be localized. This sub module accesses the DLM data base and generates the report about the possible number of sensor nodes that can be localized.

3) Module 3

3.1) Arc Segment Construction

This module constructs the optimum arcs from the optimum boundary points selected in the previous phases.

3.2) Sensor Position Computation

This module computes compares the points on the optimum arcs selected in the previous step and selects the common point, which is the location of the sensor node. The location of each localized sensor node is stored in the sensor position database.

B. Proposed Algorithm

The Proposed localization algorithm consists of a series of eleven steps from which a position of a deployed sensor node can be identified with minimum computation cost. Here, considering only the three arcs which are intersecting at a common point, instead of taking the entire circle. To precede this algorithm it needs three Distance Location Messages from which position of a sensor node can be calculated.

Input: 3 Distance Location (DL) Messages

Output: Sensor node Location

Algorithm:
Step 1: Extract 3 Distance Location (DL) Messages
Step 2: Read Distance and Centers from DL Messages
Step 3: Compute boundary point's *p1, p2, p3, p4, q1, q2, q3, q4, r1, r2, r3, r4.*
Step 4: Classify *x* boundary points *(p1, p3), (q1, q3), (r , r3)*
Step 5: Classify *y* boundary points *(p2, p4), (q2, q4), (r2, r4)*
Step 6: Sort *{(p1, p3), (q1, q3), (r1, r3), (c1, c2, c3) } x* quardinates.
Step 7: Sort *{(p2, p4), (q2, q4), (r2, r4), (c1, c2, c3) } y* quardinates.
Step 8: Select the boundary points lies between *x* quardinates of centre
Step 9: Select the boundary points lies between *y* quardinates of centre
Step 10: Construct the arcs using selected boundary points
Step 11: Intersection of any 2 arbitrary arcs gives the sensor node location

Fig 3: Proposed Arc Selection Algorithm

Fig 3 explains about the proposed algorithm in which the location and distance information from each sensor node using UAV and CCS computes the sensor node's location using intelligent arc selection algorithm.

V. PERFORMANCE EVALUATION

To evaluate this approach here we used the following tools and technology like NS2, Network AniMation (NAM) Trace, and MAT LAB.

A. NS2

Network Simulator (Version2), widely known as NS2, is simply an event driven simulation tool that has proved useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP)can be done using NS2 .In general, NS2 provide users with a way of specifying such network protocols and simulating their corresponding behaviors.

B. Network AniMation (NAM) Trace

NAM trace is records simulation detail in a text file, and uses the text file the playback the simulation using animation. NAM trace is activated by the command "$nsnamtrace-all $file", where ns is the Simulator handle and file is a handle associated with the file which stores the NAM trace information. After obtaining a NAM trace file, the animation can be initiated directly at the command prompt through the following command >>namfilename.nam Many visualization features are available in NAM. These features are for example animating colored packet flows, dragging and dropping nodes (positioning), labeling nodes at a specified instant, shaping the nodes, coloring a specific link, and monitoring a queue.

C. MAT LAB

MAT LAB (MATrix LABoratory) is a numerical computing environment and fourth generation programming language. Developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package Simulink adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

D. RESULTS

Sensors are autonomous multi-functional electronic devices. The sensor nodes are usually scattered in a sensor field. Each of these scattered sensor nodes has the capabilities to collect data and route data back to the sink and the end users. Data are routed back to the end user by a multihop infrastructure less architecture through the sink. The sink may communicate with the task manager node via Internet or Satellite. The protocol stack combines power and routing awareness, integrates data with networking protocols, communicates power efficiently through the wireless medium and promotes cooperative efforts of sensor nodes.

In this results, fig 4 describes about deploying of 100 nodes followed by fig 5 explains about the UAV's 1, 3, & 5 flying over the sensor node then fig 6 express about collecting various messages from deployed sensor nodes by UAV. Likewise from fig 7 to fig 8 illustrates about the same as we see above but here we computes from 300 nodes. Fig 9 depicts about the trace file that traces all the details like how many messages received, location, timing, etc. Finally Fig 10 and Fig 11 tells about Deployment of 500 nodes as well UAVs 1, 3 & 5 receiving message from deployed sensor nodes.

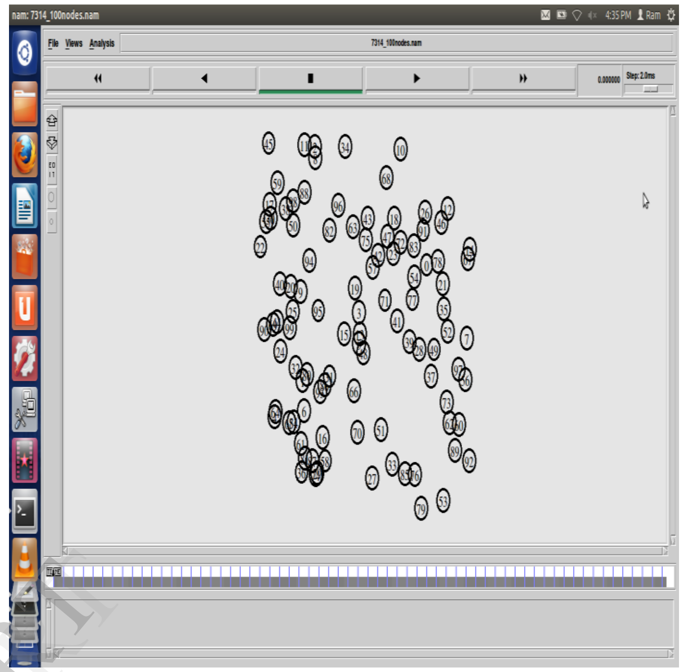

Fig 4: Deployment of 100 nodes

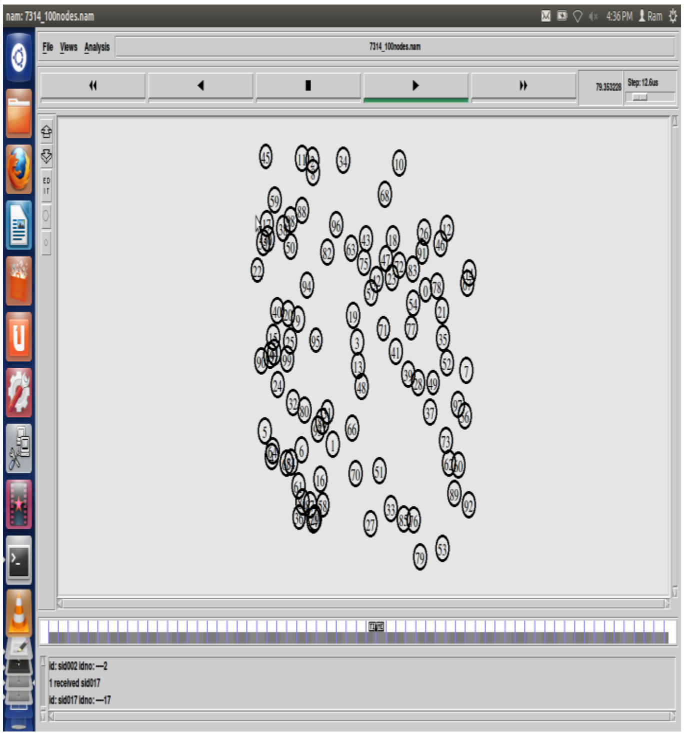

Fig 5: UAV's 1, 3 & 5 flying over the sensor node.

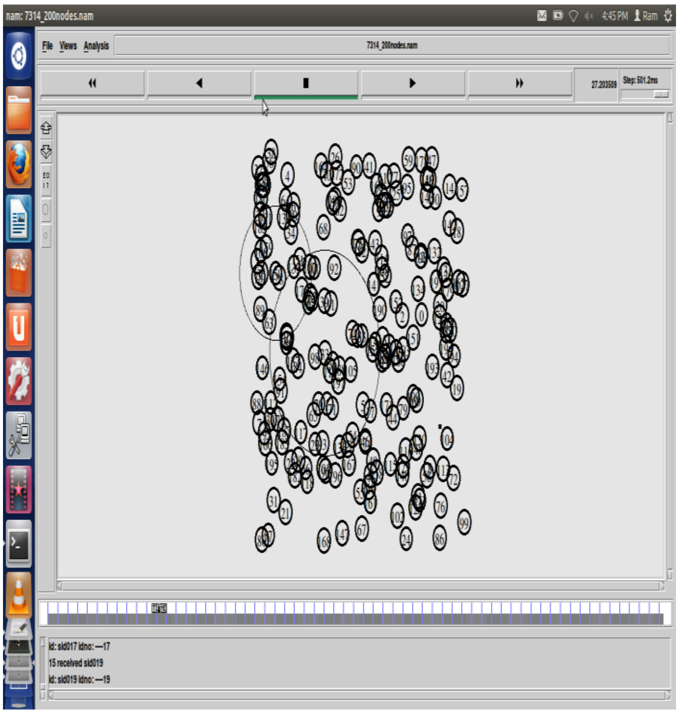

Fig 6: Collecting messages from deployed sensor nodes by UAV.

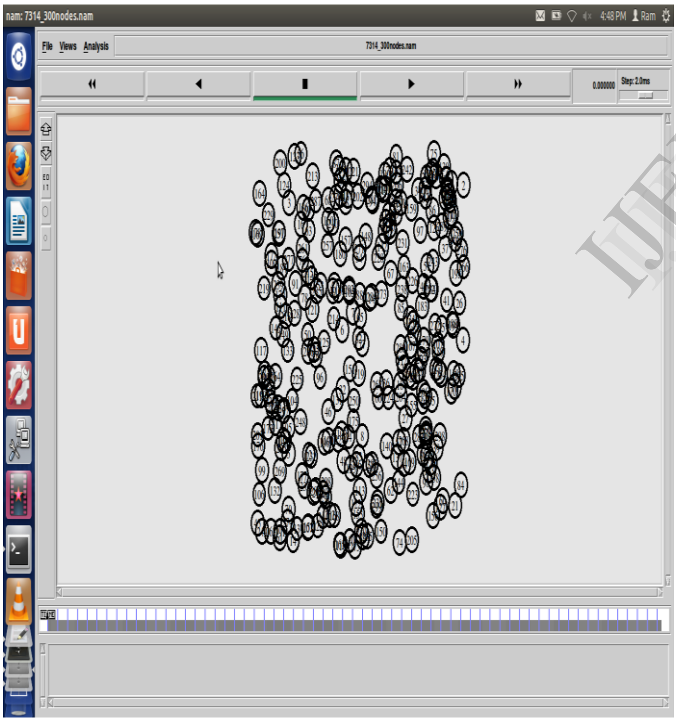

Fig 7: Deployment of 300 nodes

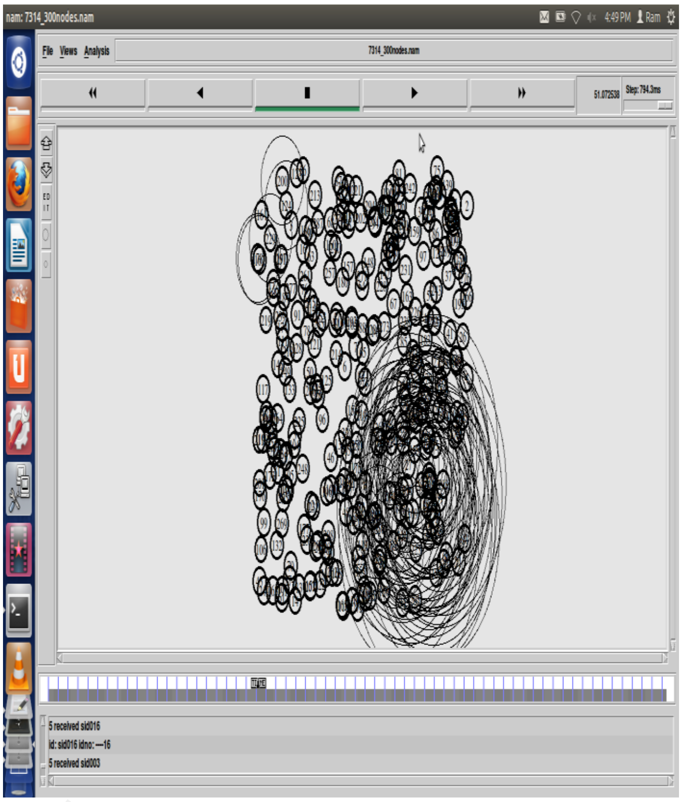

Fig 8: UAVs collecting message from deployed 300 nodes

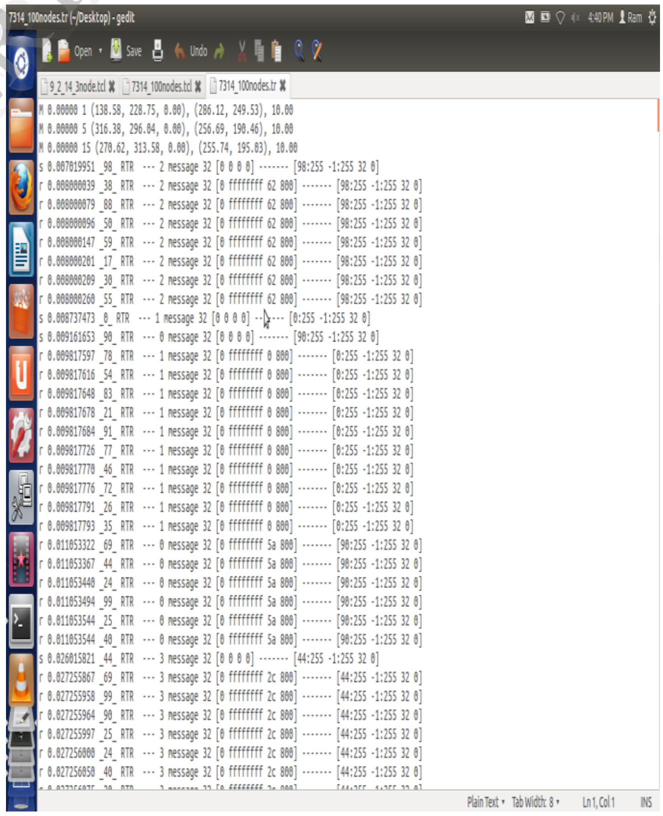

Fig 9: Trace File

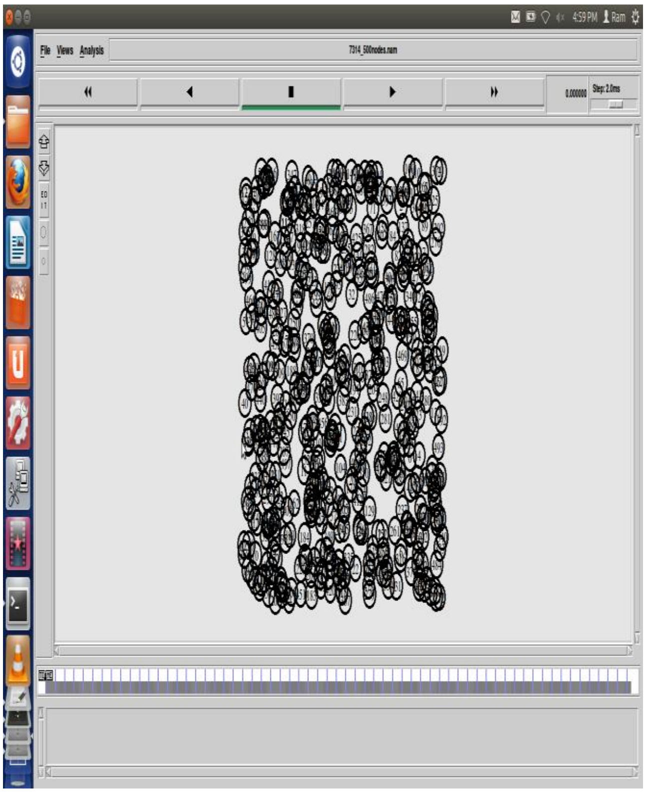

Fig 10: Deployment of 500 nodes

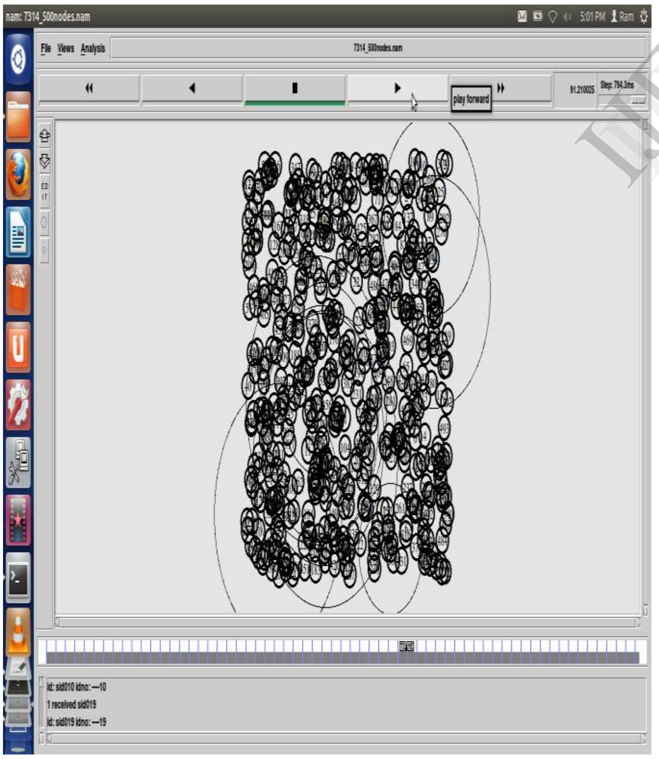

Fig 11: UAVs 1,3 & 5 receiving message from deployed sensor nodes

VI. CONCLUSION

In order to improve the location accuracy in WSNs, a novel algorithm is proposed in the paper. In most of the WSN application like remote military area surveillance, as each sensor node lives on their battery energy where an uninterruptable power supply is not possible, the energy becomes a very big constraint. When the battery energy becomes dry, the sensor node is isolated from the network and this failure further cause's severe impact. We propose a novel approach to conserve the energy during localization process. Our approach collects the location and distance information from each sensor node using UAV and let the powerful CCS computes the sensor node's location using intelligent arc selection algorithm. Our approach reduces the energy consumption at each sensor node during localization by removing computational overhead at each sensor node and there by extends the lifetime of the sensor network significantly.

Simulation results show that our proposed algorithm significantly outperforms the related algorithms. Nevertheless, the improvement of the location accuracy is at the cost of additional communication and computation overhead. Reducing the complexity and studying the effect of distances estimation errors on location accuracy in the proposed algorithm are the future work.

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