Efficient Node Placement Technique for Reducing Cost in Wireless Multimedia Sensor Network over Flat Terrain

A Dissertation Submitted

By

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Under the guidance of

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*Supervisor should finally encircle one topic out of three proposed topics and put up for approval before Project Approval Committee (PAC)

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ABSTRACT

The wireless sensors nodes are distributed on an area to communicate with one another to form a network. But there are certain challenges in Wireless Sensor Network (WSN). One among them is deployment of the nodes to meet the optimization of the desired design goal. Improper deployment of nodes results in maximizing cost. Proper node placement plays a vital role in proper functioning of WSN. Energy consumption, lifetime, coverage, cost and node failure are some of the parameters that are maintained by controlled node deployment. To provide the optimized deployment for the sensor nodes, researchers have proposed different deployment strategies. It this paper omni-directional camera sensors and audio sensors are to be distributed on a single-tier heterogeneous centralized network architecture in a flat terrain for indoor application. We have proposed a placement algorithm which minimizes the cost by reducing the number of sensors since omni-directional camera sensors are high in cost. This algorithm mainly focuses on the critical target, node failure and proper placement of the sink node for reducing energy consumption. This algorithm guarantees that sensors cover all the targets and there is connectivity between the sensors the sink node. The proposed algorithm is compared with the existing Greedy Algorithm and the results demonstrate the effectiveness of the proposed algorithm.

CERTIFICATE

This is to certify that Ms. **Imtisenla Imchen** has completed M. Tech Dissertation titled **Efficient Node Placement Technique for Reducing Cost in Wireless Multimedia Sensor Network over Flat Terrain** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation has ever been submitted for any other degree or diploma.

The dissertation report is fit for the submission and the partial fulfilment of the conditions for the award of M. Tech Electronics and Communication Engineering.

Date: 4th May 2015

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Imtisenla Imchen

DECLARATION

I hereby declare that the dissertation entitled, **Efficient Node Placement Technique for Reducing Cost in Wireless Multimedia Sensor Network over Flat Terrain**, submitted for the M. Tech degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma

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CHAPTER 1
INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

Wireless sensor network [1] has been a wide area of interest for the researchers in the recent years and it has been progressing extensively which is used in so many applications. Wireless sensor network consists of many sensors that are equipped with a processor, memory, sensing object, and batteries. It is difficult to embed large storage memory chip on a sensor so a radio is used to send the information to the base station. Basically there are two types of WSNs: structured and unstructured WSN. In unstructured WSN, there are so many nodes deployed in decentralized manner so network management such as sensor failure detection, coverage and coverage is a difficult task. Once the sensors get deployed, the network is left unattended. Whereas in structured WSN, nodes are deployed in a systematic manner so lesser nodes are required and moreover networks are managed at low cost with maximum coverage, proper connectivity.

There are 5 types of wireless sensor network: terrestrial, underground, underwater, multimedia and mobile.

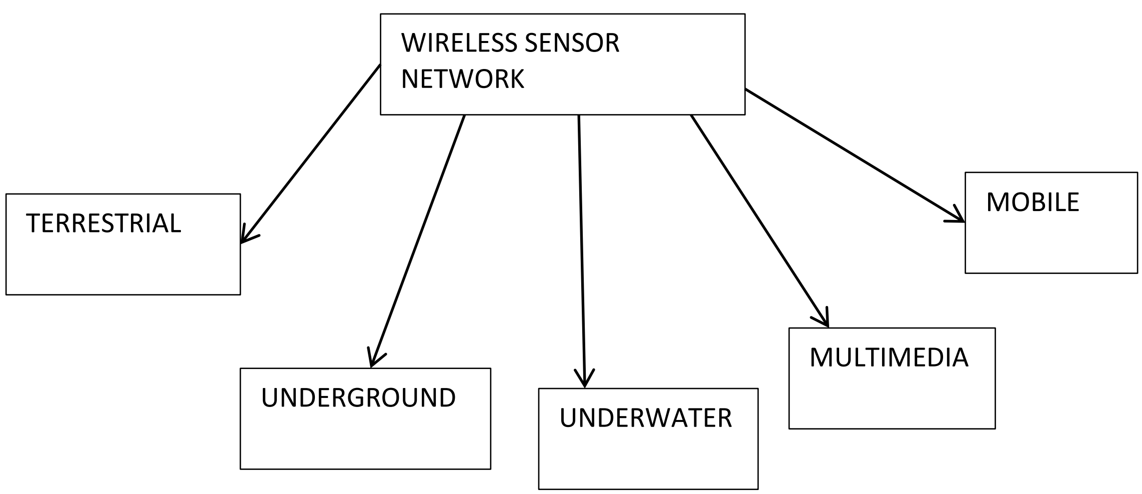

Fig 1.1Types of WSN

Terrestrial WSN consist of many sensors nodes deployed in an unstructured or structured manner on a land. In unstructured deployment, sensors can be dropped from a moving vehicle randomly on the target area and in structured deployment; sensors can be placed deterministically or in grid.

Underground WSN as the name implies have sensors buried under ground for monitoring underground conditions. It is an expensive network because the communication through the soil rocks, water and minerals requires a reliable communication and careful planning of node deployment. The deployment and maintenance of the nodes are difficult. The signal losses and attenuation makes it more challenging. Conservation of energy is a major issue because once the sensors are deployed it is difficult to replace it again.

Underwater WSN are more expensive than Underground WSN and fewer sensor nodes are deployed. The transmission of acoustic waves makes it possible for the communication under the water. Some challenges which make it the most expensive than Terrestrial WSN and Underground WSN are that once the nodes are deployed, it cannot be recharged or replaced, it has limited bandwidth, longer propagation delay compared to other WSN, signal fading, and node failure due to environmental conditions.

Multimedia WSN track information's in the form of multimedia such as images, audio and video. Multimedia sensors are equipped with camera and microphones. Multimedia WSN should be deployed in structured manner to ensure coverage. Multimedia data requires high bandwidth for transmission. A technique that provides high bandwidth with low energy consumptions has to be used. Challenges in Multimedia WSN are high band width demand, high energy consumption, QOS, data processing, filtering and compression.

Mobile WSNs are those networks where the nodes are not static and can adapt to the physical environment. These nodes can sense and communicate like any static nodes. In static WSN, data transmission is through routing or flooding but for mobile WSN, dynamic routing is used. Challenges are deployment, self-organization, navigation, coverage, maintenance and data processing.

WSN are mainly applicable for two types: monitoring and tracking. The following are the different applications under monitoring and tracking.

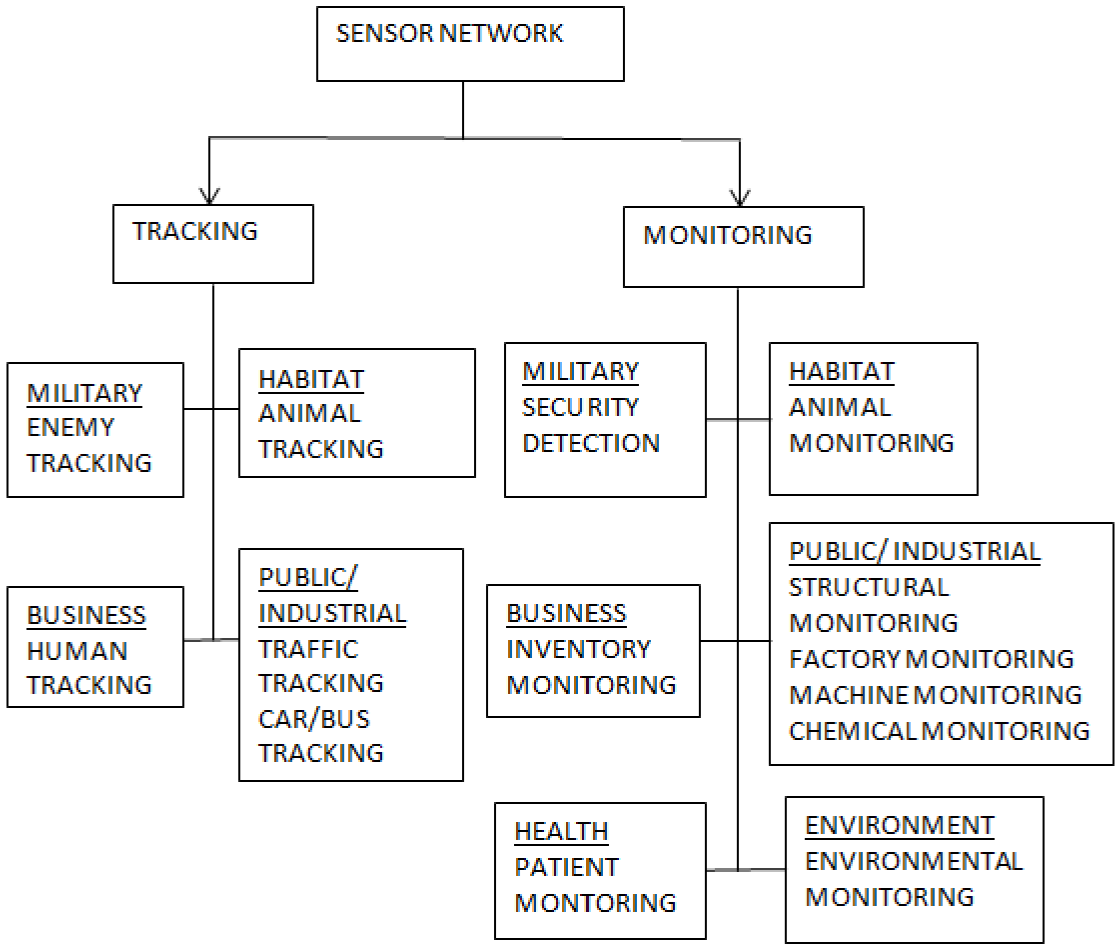

Fig 1.2.WSN Application

A wireless sensor network contains sensors which are regularly or irregularly or both combined placed for natural and physical scanning and recording of its status. Scanned specifications are pressure, power line voltage, light intensity, humidity, vibration intensity etc. The nodes which are distributed interface with the sensors to scan assets or may be their environmental condition. The data's received transmits to the base station in a wireless way and these can be processed separately or can be linked to a manager system where the process data's are evaluated, and the evaluated data can be taken out using software. The sensor nodes are used for sensing, measuring, collecting, tabulating and thus data from the environment can be collected and this data's are transferred to the user. The sensors can store less data and sometimes it can be in a position where there is no signal range. This is the reason why radio trans-receiver is used for the wireless connection to send the data to the user. In a sensor node battery is the main power source but also secondary power supply is available from external source like solar panel. WSNs have lots of applications like security, controlling, monitoring, target tracking in military, risky environment, process management, health checking.

Interconnected wireless devices have a network of wireless sensors. It allows multimedia streams which are audio and video to be retrieved. The evolution of single chip camera is the result of recent advancement in CMOS technology which could be made in inexpensive transceivers easily. Furthermore, microphones are being extensively used for so many years in wireless sensor node. The connection between the sources of multimedia which has modest communication gadgets has driving research in the multimedia sensors networking. WMSNs are applied in many areas of fields such as computerized signal handling, networking, communication, control, and measurements lately [2]. The collaboration of all these fields helps to establish WMSNs that permit the improvement of the multimedia such as features and sound streams and still pictures, and also giving this information continuously, store and process the information in real time, correlate, and combine media information beginning from heterogeneous movement sources.

Wireless multimedia sensor networks have many different types of applications such as:

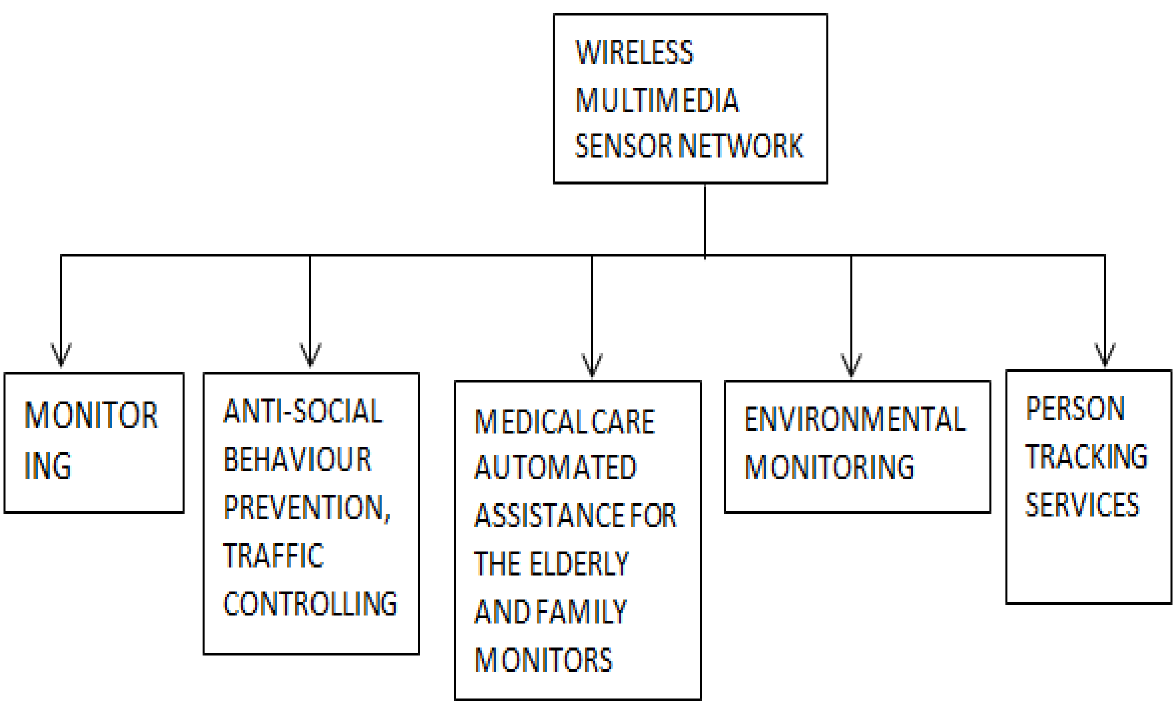

Fig 1.3.WMSN Application

- Monitoring sensor networks: The improvement of the video, image and audio sensor of WMSNs enable monitoring of the sensor field. The coverage and the information are much better as compared to the earlier WSNs.

- Anti-social behaviour prevention: Multimedia sensors take the record of anti-social behaviour activities like thefts, breaking the laws and regulation or misbehaving in public or isolated area can be recorded.

- Traffic controlling: One of the main difficulties faced in large cities or urban area is traffic. Multimedia sensors placement can be useful for prevention of the traffic jams, traffic congestion or road blockage. Also it can be used for showing an empty area for parking the vehicles [3]. Moreover multimedia sensor can show the information about the road where there is less traffic. It can also help them to know their velocity meter and the total number of cars.

- Medical maintenance and care: Telemedicine sensor networks together with the third generation multimedia network provide health care services all over the world. Patients can carry medical sensors with them or attach the sensors in their body to screen parameters such as pulse, body temperature, breathing activity, beat oximetry, ECG. Moreover, remote medicinal organization can have well established observing of the patients by mean of features and sound sensors, area or different type of sensors [4].

- Old aged or senior citizen people’s assistance: WMSN provides a method for observing and surveying the behaviour of old aged people who help to find the main problems or main cause of their illness [4]. Video and audio sensors automatically gets connected to the elderly people which can be looked upon by their relatives if they are not with them or if they are away from home but wants to get information about the old aged relative.

- Natural environment monitoring: Sensors can take the photos of the natural environment. The information from the photos can be used for monitoring. Weather and temperature can be predicted and this helps in closer monitoring of the habitat [5].

- Person tracking services: By using the cameras and different techniques a person can be seen and located. If there is a missing person or some criminals who want to hide from the security police, they can be located from any CCTV’s or different cameras.

1.2 NETWORK ARCHITECTURE

WMSNs are made of many types of sensor gadgets that have different sorts of ability in terms of detecting, handling, and correspondence. Many sorts of congestions are created by these heterogeneous sensor gadgets like scalar data, still pictures, sound, video. A heterogeneous architecture are planned to make to reduce these varieties. WSN are designed in such a way that the architectures of the network are very much scalable. Through flat, homogeneous architectures becomes scalable and is usually achieved in which every sensor has the same physical abilities and can only cooperate with nearby sensors. The WMSNs prompted to the acknowledgement of heterogeneous system architectures.

These architectures are essentially arranged into: single tier and multi-tier.

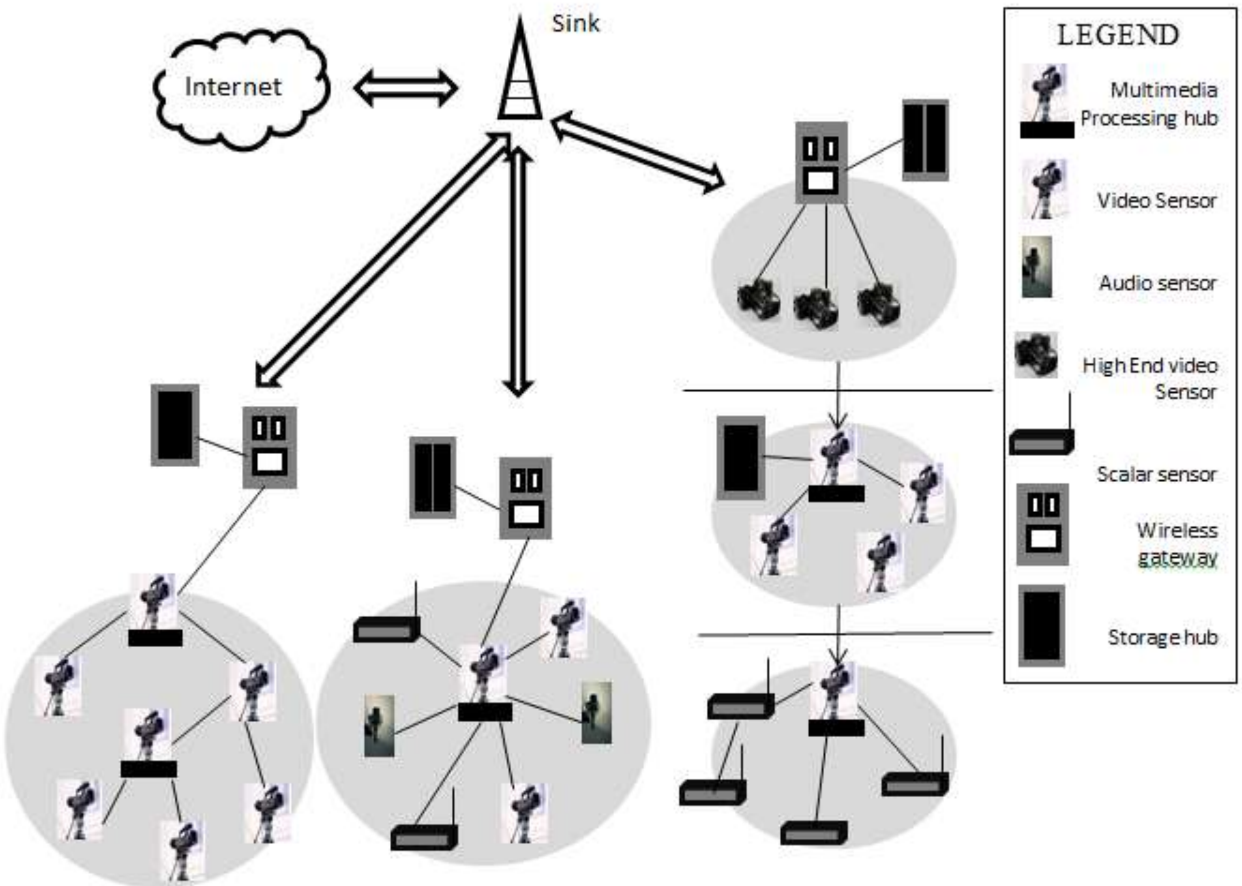

Fig 1.4.Network Architecture

1.2.1 Single-Tier Architecture

The left portion of the Fig 1.4 demonstrates a single tier level system of video sensors. This architecture may have higher interacting capabilities which are achieved by a subset of the placed sensors. Handling hubs are being called for these types of nodes. And these can be efficiently used for interacting between local areas.In single level structural planning; the data of multimedia processed and assessed by the sensor hub is broadcast to wireless entrance through some hopping way through the path. The passage of the wireless is connected to a storage hub for storing the multimedia content locally. Thus processed and estimated data can be stored at a middle position so that the storage limitations are avoided and to do more advance processing jobs when offline. Rather than organized storage architecture, an equally dispersed storage system can be operated. In this equally distributed architecture, information is recorded by the nodes inside the network. This operation may result in less energy consumption because the multimedia data's are not required to be wirelessly delivered to rural and deserted areas. The wireless entrance may be joined to the focal sink, which operates the software network query and task.

The single tier architecture is also placed for systems which contains heterogeneous components. This type of architecture nodes are divided into bunches, where the central cluster head controls other feature, sound, and scalar sensors in the same bunches. The group head are utilized to perform more concentrated operations such as intensive multimedia processing or intensive multimedia collection. In this architecture, the bunch heads can likewise be utilized as processing centers. The cluster head collects the information is then sent for further processing operation and storage to the entrance wirelessly or a storage hub.

1.2.2. Multi-Tier Architecture

The right part of cloud shown in Fig 1.4 is a multi-tiered network, with heterogeneous sensors, ie sensors may be of different types. This architecture is a hierarchical structure which uses network properly and it has many applications. The multitier architecture has scalar which are low end sensors to perform easy tasks at the lower hierarchical levels. The gathered or collected data's perform more difficult detecting tasks such as continuous video monitoring which can change its behaviour to adjust and impart any happenings that happen within the surroundings. High-end sensor nodes perform this task by high-end sensor nodes which contain camcorders at higher various levels. Moreover, just when there is enough energy in the detected phenomenon which is accounted by the low-end gadgets, image and feature handling and storage can be started. These type of hierarchical architecture makes lifetime of the network to increase and also enhancing the adaptively and productivity of the conveyed heterogeneous sensors. The clusters are contained in each tier in the multi-tier architecture. As a result, each cluster performs the operations independently and the communication between these sensors reduces the energy consumption.

1.3 DESIGN CHALLENGES

Knowledge from wide area of research field is needed for designing the WMSN. The fields in which one has to be expert and skilled are communication, signal processing, control theory, embedded systems etc. Many challenges are there for WMSNs out of which some are mentioned below:

1.3.1 Source Coding of Multimedia:

The challenges are that the generation and processing of the data and transmission of multimedia such as audio video and still images. A high percentile of congestion is generated by multimedia for this reason the transferring of the multimedia information is linked with the source coding of multimedia. There should be compact or compressed or encryption of the data to process various coding techniques. By using the redundancy in the multimedia such as video or still image minimize the information to be transferred. This is done with the help of source coding of the multimedia. By collecting the linkage between the different pixels in the picture, information data’s can be lost. Two different types of compression technique are, one is intra frame compression and the other is inter-frame compression. In intra frame compression, the linkages between the pixels are taken out similar to the images which have been taken out. In the second compression the consecutive frames are correlated because large portion of the back ground image remains unchanged and between the frames there is a movement of different types of objects. This compression will reduce and degrade the quality of the video which in turn will decrease the transmitted information. Distortion is also being called for this. So far these compression techniques results in good distortion level rate to send the multimedia efficiently. Although a very good compression technique is used and with fine distortion rate performance, source coding techniques cannot be used for WMSN resource constrained because encoding obliges complex encoders and intense transforming algorithms which will expand the energy utilization to a great extent. Therefore these are not useful for inexpensive multimedia sensors.

1.3.2 High Bandwidth Demand

Even if multimedia coding techniques will result in the minimization of the data size, the current work of wireless sensor nodes will perform worse than the compressed information. Higher bandwidth is required by the video streams transmission that is very much higher than what can be used by currently available sensors. New transmission methods are needed that will give larger bandwidth at a level of certain energy consumption.

1.3.3 High Quality of Service Requirement

WSNs generally have a service approach that is suggested by the networking and communication techniques. There is no strict regulation in terms of energy utility, postponement, jitter, or throughput. Multimedia applications oblige these sorts of regulations for conveying without wastage of the detected sensation phenomenon. The quality of service requirements are affected by the still picture transmission or feature streaming affects in the network. Different levels of quality of service guarantees that each multimedia stream should consists of information. The advancement of algorithms that bolster application-particular quality of service requirements is required by the design of WMSN. Energy utilization, delay, dependability, distortion, or system lifetimes are the requirements which may be in terms of bounds.

1.3.4 Multimedia In-Network Processing

Energy-efficient data delivery in WSN and WMSN caused excessive use of multimedia in-network processing. In WMSNs the quality of the multimedia content requires unique approaches yet in WSN in-system transforming has been basically used for calculation operations. The aggregate streams needs to be in group and the picture or video needs to be decoded to get huge data from a surge of traffic. This will require a large storage and significant transforming abilities at intermediate nodes. In the way of deciphering a moderate hub perform errands on numerous movement streams. Therefore in-system processing is not suitable for WMSNs

1.3.5 High Coverage Requirements

Coverage [11] is one of the important issues in WSN. It has received a great deal of attention from many researchers because of its ability to optimize resources. Sensor nodes gather information from the environment within a certain range. Sensor nodes should be deployed to achieve sufficient coverage and that every point or target should be covered by at least one sensor node. Coverage affects power saving, connectivity, network configuration and number of nodes to be deployed. Under the coverage performance, number of nodes has been minimized by many researchers.

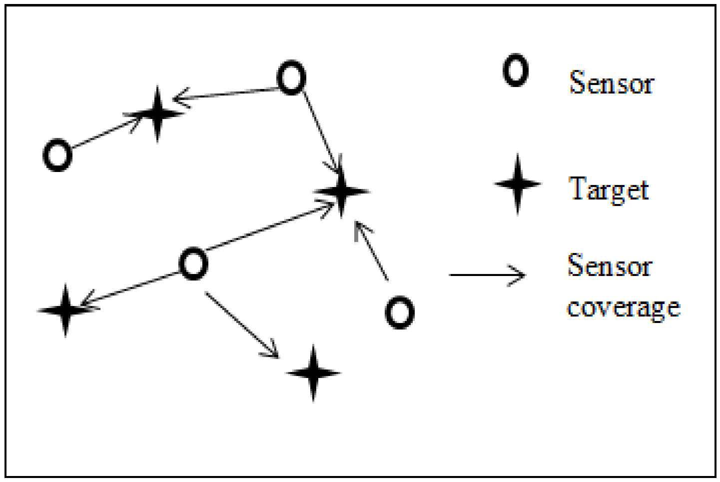

Fig 1.5.Coverage Plane

1.3.6 Low Energy Consumption

Sensor nodes [6] typically rely upon the battery for energy to process data. However, its replacement is not possible in most of the deployment. So managing of energy is an important issue to increase the life of each node. Transmission of data generate high amount of traffic, which requires longer transmission time and higher energy consumption. Lifetime of nodes entirely depends on the energy consumption behaviour. Many different methods [12] have been projected by researchers for longevity of the nodes.

1.3.7 Cost Management

There is a cost [15] for deployment of each node: fixed and variable. Fixed cost refers to the cost of the node which depends on the number of nodes and variable cost is the cost of deploying the sensors. Variable cost vary according to different deployment points, distance between current position of nodes to the destination, roughness of terrains, energy consumption etc.

1.4 OMNI-DIRECTIONAL SENSING

Directional camera sensors [22] can acquire picture along a specific way. Subsequently, a few parts of the happening occasion are not secured by the directional field of perspective. Field of perspective is the edge at which a camera sensor can take exact picture of something. But omni-directional camera sensors are the sensors that can take picture in 360 degree. By utilizing omni-directional camera set up instead of of directional camera helps in covering more bit of range of concerned happening occasion.

happening occasion.

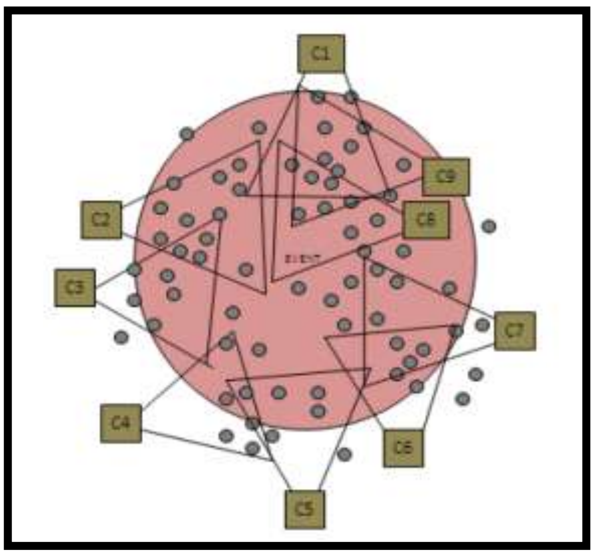

Fig 1.6.Directional Camera Sensors

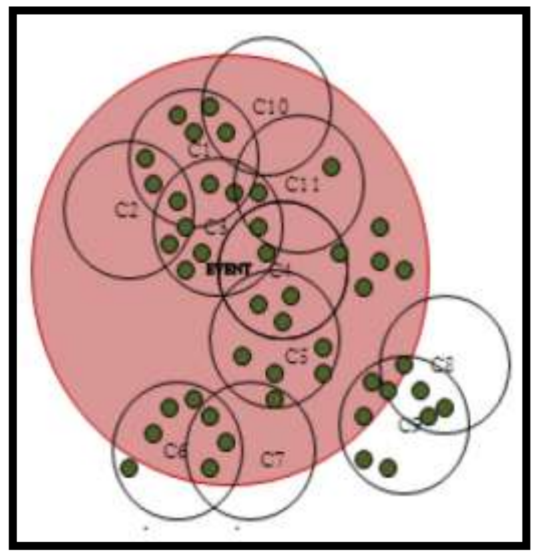

Fig 1.7.Omni-directional Camera Sensors

As an outcome more exact data in regards to happening occasion is caught and occasion data loss will be lessen. Again in instance of directional camera sensors, occasion data caught by some of the external hubs that lie outside Field of perspective of camera sensors are lost.

But by utilizing omni-directional camera such kind of data lost is minimized. Such thing happens as omnidirectional camera captures picture consistently along all the directions, so number of external hubs present for its situation is least, as the vast majority of them are secured by field of perspective of these omni-directional camera sensors.

CHAPTER 2
REVIEW OF LITERATURE

Pace and Loscri [6] compared two placement techniques, evenly/uniform placement and energy spaced placement of nodes for wireless nodes. Its main objective is energy consumption reduction. In evenly/uniform placement, the relay nodes are placed in the evenly spaced position on a straight path from the source to the destination nodes. All the nodes have the same residual energy for this technique. In energy spaced placement, residual energy is taken into account where the positions of the nodes are placed incrementally from the position of all previous nodes. The energy consumption is high in case of evenly placed and its lifetime is much shorter than the energy spaced but its video quality is good. Whereas for energy spaced placement, the energy consumption and its lifetime is high.

Poe and Schmitt [7] uses three deployment plan: Uniform random, square grid and a pattern based Tri-Hexagon Tiling (THT) node deployment. The challenges taken by them are coverage, energy consumption and delay reduction. In uniform random deployment, all the sensors have a same probability of being deployed at any place in a deployment area. In square grid, nodes are deployed in a square grid uniformly. In a square cell, half of the area is covered exactly by 3 node coverage sensors since it is a symmetric cell. In THT node deployment, nodes are placed in a semi-regular tiling which uses triangle and hexagon cell. Here a small area is covered by all the 6 nodes in hexagon cell which is the best area for placing the sink because all the nodes will share the same load and hence energy consumption will be less. Energy consumption and delay rate is the lowest in THT deployment plan. In random deployment all the areas are not covered because of its random placement whereas all the areas are covered quite well in square grid and THT node deployment.

Al-Omari and Shi [8] considered a problem of choosing how many nodes to use and where to deploy them for proper coverage and connectivity with minimum cost. The authors proposed three strategies one of which is at-front. This strategy does not plan for further deployment visits and only studies the unfriendly environment and the WSN lifetime to calculate the number of nodes required. At first it has ample amount of nodes for meeting the user-defined availability but later on it shows a weak scalability as the WSN lifetime and node failure rate increases. The next is on demand strategy which does not conduct any planning for node placement but have a deployment visits when number of node become lesser than the threshold number of nodes. Then the third is pro-active strategy which considers the node failure and the cost ratios. In all the strategies the authors assumes that the nodes that have previously been deployed and the nodes that have deployed recently has the same probability of failure rate. The pro-active deployment strategy shows better cost result compared to at-front and on-demand strategies when the failure rate increases. The at-front strategy shows the worst strategy for cost minimization and scalability for the node failure. Moreover pro-active can adapt to any number of nodes and number of trips and achieve a total low cost.

X. Wang and S. Wang [9] mainly focus on the coverage and energy consumption of nodes. The authors use different virtual force directed co-evolutionary particle swarm optimization (VFCPSO) method to satisfy the requirements. Four different VFCPSO used were centralized VFCPSO (C-VFCPSO), hierarchical VFCPSO (Homo-H- VFCPSO). In centralized VFCPSO, virtual repulsive force between sensor nodes and PSO methods are used for deployment of nodes. In PSO, each node renews its result with only the global best result and its local result. This technique increases the coverage and lifetime of nodes but leads to high computation time. In D-VFCPSO, PSO is used and it constantly updates its position optimally but it can lead to high energy consumption and decrease quality of service because of the data exchanges between the nodes which occurs very frequently. In both Hetero-H-VFCPSO and Homo-H- VFCPSO, deployment plane are divided into different clusters where each clusters contains a cluster head with many sensor nodes. Hetero-H-VFCPSO contains C-VFCPSO in its cluster whereas Homo-H- VFCPSO has D-VFCPSO. Homo-H-VFCPSO is built in many different hierarchical structures which has good scalability and is able to search globally. All the techniques decrease the energy consumption. Homo-H-VFCPSO performs the best among the four techniques for coverage. The computation time of D-VFCPSO is the least and the cumulative time of C-VFCPSO is the least among all. But when average of all time computed is taken the Homo-H-VFCPSO performs comparatively better among all.

Table 1.Comparison of Different Deployment Strategies

Author Paper	Objectives	Techniques	Energy Consumption	Video Quality	Coverage	Computation Time	Cost
Pace and Loscri [2]	Reduction of Energy Consumption	Evenly/Uniformly	High	Good	---	---	---
		Energy Spaced	Low	Average	---	---	---
Poe and Schmitt [3]	Coverage, Reducing Energy Consumption, Reducing Computation Time	Uniform Random	High	---	Not all areas are covered	Medium	---
		Square Grid	Medium	---	Good	High	---
		THT	Low	---	Good	Low	---
Al-Omari and Shi [4]	Coverage, Optimizing Cost	At-front	---	---	Good	---	High
		On-demand	---	---	Good	---	Average
		Pro-active	---	---	Good	---	Low
Wang and Wang [5]	Coverage, Reducing Energy Consumption	C-VFCPSO	Low	---	Good	High	----
		D-VFCPSO	Low	---	Poor	Medium	---
		Hetero-H-VFCPSO	Low	---	Good	Medium	---
		Homo-H-VFCPSO	Low	---	Best among 4 VFCPSO	Low	---
Kouakou et al. [7]	Coverage, Connectivity Optimizing Cost	Triangular lattice pattern	---	---	Good	---	Average
		CED	---	---	Good	---	Low

Kouakouet. el[10] proposed a heuristic method Cost Efficient Deployment (CED) for the full coverage and connectivity of 3 Dimensional WSN with obstacles which results in optimized cost. In their work, the 3D space is represented by a set of grid point. Then cost performance value (d_c) is calculated for each grid points (the deployment area grid points which covers the highest monitoring space points per deployment cost). The nodes are deployed at the point where the highest d_c value exists. If there are any obstacles found, extra nodes are added for the proper coverage. Then for the connectivity, the entire deployed sensor in range gets connected to each other. If there are any unconnected nodes then the nodes are moved towards its nearest sensor which is connected with other sensor, if the problem still exists, some more node are added to ensure connectivity. The authors compared the proposed method with the triangular lattice pattern (grid points in triangular lattice). The triangular lattice pattern method shows coverage with least number of sensors but the cost was high. On the other hand proposed method obtained coverage with more number of sensors but the cost was proved to be lesser than the other.

The Zhu et al. [11] states that coverage and connectivity are two of the most critical problem in WSN. These two constraints if fulfilled will bring a significant change within the performance of WSN. The author also states that coverage has a relationship associated with energy consumption. So preserving of energy is taken under consideration. Some techniques that have been used for energy consumption as well as coverage are optimizing coverage deployment methods, those sensors not required for sensing and transmission and processing goes to sleep modes and by adjusting the sensing range of sensor.

Optimizing coverage is for both static and dynamic deployment. In static, coverage is resolved in two ways: Efficient coverage area (SECA) and K-coverage. In fig 2.1 SECA is the node x's coverage range R (πr^2) subtracted by the overlapping coverage areas A.

$$\text{SECA} = \text{R} - \text{Am} = \pi r^2 - \text{Am}$$

K-coverage is used where larger environment monitoring is required. We find all the sub regions and check whether each sub-region is k covered or not. Dynamic coverage is based on virtual force; graph based and repair policies of coverage hole. The virtual force algorithm is specially used for random deployment to boost the coverage. After initial random deployment, the areas which are already covered have a repulsive force on the sensor and those which are uncovered have an attractive force on the sensor. This technique increases the area of coverage. Graph based is based on Voronoi diagram which contains nodes and the areas are divided into different polygon shapes. It works on the principle of electromagnetic force and assumes the sensor as electromagnetic particles. When the electromagnetic particles are nearby, electromagnetic force will push them apart.

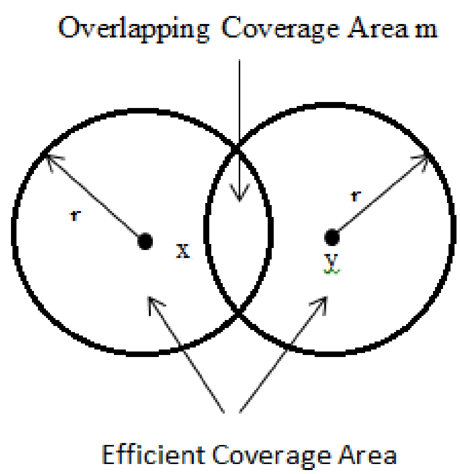

Fig 2.1Efficient Coverage Area

This will result in one sensor for each polygon. Repair policies for coverage hole is designed for coverage hole recovery. If there is hole in the network due to node failure, it is replaced by one or multiple nodes of its neighbour. Sleep scheduling mechanism has three modes. Some nodes which are not required are kept in sleep mode and keeping only the required nodes in active mode. A certain time limit is assigned for each node to be in sleep mode and when it reaches the threshold time limit, it goes to the listen mode to examine if it must be activated. Adjustable coverage radius range of sensor is not kept fixed. The ranges are adjusted according to the coverage requirements. This is mainly to reduce the overlaps among the sensor coverage and maintain Quality of Service. For connectivity, the position of active node should be in range with other nodes which are active so that they form connected network.

Pandey et al. [12] brought the concept of two-tier, hierarchical heterogeneous WSN. It uses two nodes one of which has limited computational capability called litenodes and the other nodes which are sophisticated nodes (SN) or cluster heads. The author considered two constraints: Traffic constraint and Connectivity constraints. Traffic constraints are used for the SN such that it is able to handle any traffic coming from LN and that all LN can reach at least one SN. Connectivity constraints ensures that all SN's have connections such that it can transfer data to the sink. SN should be placed in an area such that it can deal with the traffic and connectivity constraints. SN has two interfaces, one is to take the data's form the LN's and the other is to transfer the data collected to the neighbouring SN's. The authors solve the placement problem of SN for LN's which are deployed randomly.

Binary Integer Linear Programming Approach- Here SN's are placed at grid points. This solves the traffic problem but to solve the connectivity problem, greedy steiner tree algorithm is used. This algorithm find the connected SN components and find the shortest distance between disconnected SN and then Steiner nodes are added to connect those SN.

Greedy placement approach- SN's are placed by clustering and by choosing the best place where there is less LN traffic and where connectivity is maintained.

Genetic Algorithm is used for a scenario where LN's are randomly deployed. Here it calculates the fitness value of each LN. This is best for randomly deployed LN and Binary Integer Linear Programming Approach is best for regular grid topologies. Later a hybrid approach is made between Genetic algorithm and Binary Integer Linear Programming Approach and Genetic algorithm and Greedy placement approach.

Guvensan and Yavuz [13] state that there directional sensor nodes are different from omni directional sensor nodes and discuss about the deployment of the directional sensors. Directional sensor nodes such as video sensors, Ultra sound and infrared sensors use the directional sensing model. Both the sensor has a different effect on the coverage, connectivity and network lifetime. Mathematical Sensor makes decision on the basis of the sensor sensitiveness. The binary detector detects the sensor as to whether the sensor covers or senses a target or not. Elfes's detector and Neyman-Pearson detector detects the target using its probability function of the range of sensing. Whereas physical sensing is about the direction in which the sensors can sense. Omni-directional are able to sense throughout 360^0 whereas directional sensor can sense only through a finite angle. Similar to WSN, directional sensor network (DSN) has issues for the coverage, connectivity, lifetime and traffic. Challenges faced by DSN are limited angle of view which requires more number of nodes, line of sight obstacles like trees, buildings etc.

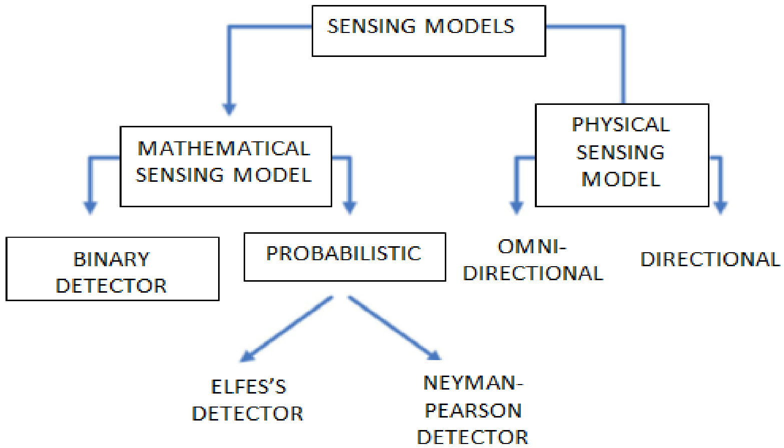

Fig 2.2.Sensing Model

Directional sensors have a characteristic of motility and mobility which can increase the coverage of the network. The authors states that the directional sensors can be deployed in two ways: Controlled and Random. Based on the target based deployment, coverage can be improved. The authors have presented some of the methods by other researchers like Integer Linear Programming, Centralized Greedy Algorithm, Distributed Greedy Algorithm etc. Integer Linear Programming method decreases the number of sensors used with maximum target coverage. For large scale Greedy Algorithm is used where Centralized Greedy Algorithm finds the most inactive sensor where there are maximum coverage and then activates it. In Distributed Greedy Algorithm, all the nodes have a unique. Value called priority and make a decision on the priority level of nearby nodes which are within the range.

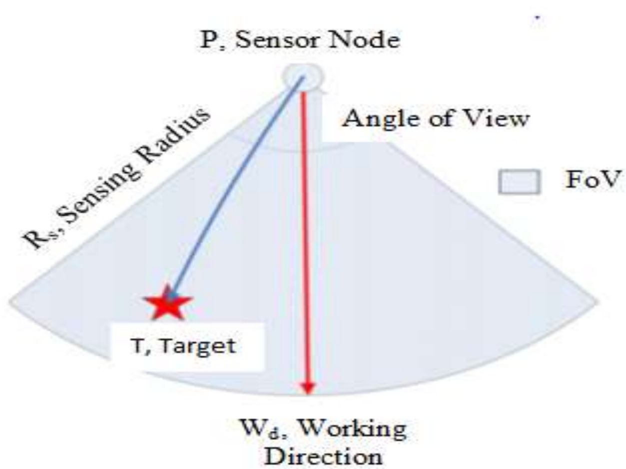

Fig 2.3.A Directional Sensor Node

Horster and Leinhart [14] solved a problem of placing the cameras in which minimum number of cameras should be used and the coverage should be obtained while reducing the cost. These cameras had finite field of view (F.o.V) which is placed at a grid points. The authors use ILP to solve this problem for which every grid points are covered by at least one camera. For a sensor with same camera (F.o.V), two experiments are performed. One with the small spatial frequency f_a (f_a=minimum distance between two grid points) and the other with large f_a. The coverage decreases as f_a decreases because the distance between two grid point decrease. Then for different cameras (F.o.V), two experiments were performed where the distance between two grid points were kept same but the F.o.V varies. The first experiment uses 2 camera pose and the second experiment uses 8 camera pose. As the camera with different poses increases, the total cost decreases.

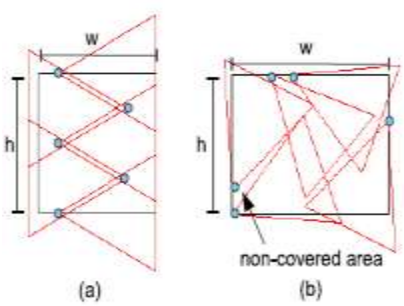

Fig 2.4.Same Camera (F.o.V)
(a) small f_a ,Camera Pose=2
(b) Large f_a ,Camera Pose=16

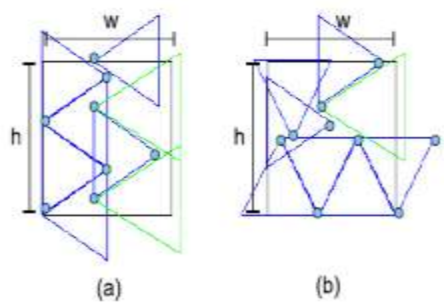

Fig 2.5.Different camera (F.o.V) same f_a
(a) Camera Pose=2
(b) Camera Pose=8

In [15], Ravindara et al. proposed two cost models for minimum deployment cost problem with different deployment strategies in wireless multimedia sensor network. These strategies were Deterministic, Random and Hybrid. The main aim was to minimize the overall network deployment cost in terms of number of sensors, deployment cost and energy consumption of the network. The sensors and targets were placed in flat and elevated surface of 3-D plane. The two cost model covers the coverage and connectivity issue for multimedia sensors. For the first cost model which is related to coverage issues, they used Integer Linear Programming and proposed heuristic solution which is Greedy approximation. For the second cost model which is related to connectivity, they used Shortest Path Algorithm. Finally they compared all the cost modelling for different deployment strategies over flat and elevated terrain and they concluded that different deployment cost fluctuates with the change in strategies and terrain. Also the performance of the Greedy approximation algorithm was comparable to ILP.

In [16], Mengmeng et al. used Integer Linear Programming (ILP) to solve the problem of coverage and reducing the number of sensors used. The authors states that large number of sensors were deployed for maximum coverage but it results in high energy consumption and shortened network lifetime. So they applied a rule such that the neighbouring sensors which are redundant should be kept in sleep mode to make only some sensors keep working. ILP also solves the coverage problem by dividing a particular region into different sub regions where each node is coverable in different sub areas. ILP functions and constraints were then setup to obtain maximum coverage.

In [17], for WSN it is required to travel in the shortest path with low cost. For this reason the position of the nodes should be known to have the information about the received data. The information about the network connectivity and estimated distance information should also be known. Pushpalatha et al. proposed Dijkstra's algorithm where each node contains a record of the previous node, weight of the source to that node and the status either permanent or tentative. This allows finding the shortest path between the source and the destination node with low cost. This algorithm makes decision for the best path to be routed and find the shortest path.

In [18], Mohamed and Kemal, studied in detail about the strategies and node placement in the WSN. They have categorized the positioning of nodes into two types: static and dynamic. For statics type, in order to improve the performance, optimized node placement should be achieved. For dynamic type, rearranging of the nodes after the deployment was done for increasing the network performance with good coverage. But the repositioning of the nodes is a difficult task, as where to move it for better performance, when to move it and how to locate the network when the nodes are in motion. So the authors had their opinion that static positioning perform overall better performance when the nodes cost were not taken into consideration. Whereas, the dynamic positioning are an option when the cost is a major issue.

In [19], Cucchiara stated that the media streams provided scrutiny of an under controlled environment and real time analysis of a view from the video camera. They presented an overview of different types of research that was going on in the multimedia surveillance system. The main aim of the multimedia surveillance system was to enhance and enlarge the view that was taken from the sensor and cameras with different methods. The one method that the authors mentioned in this paper to enhance the scene was to use biometric technology that also helped to identify a person.

In [20], Leoncini et al. took into consideration the deployment strategies for wireless sensor network. Different experiments have been performed to find the best deployment strategy performed. A scenario has been set up for which one or two dimensional region R is to be monitored together with which degree of coverage (DoC) also has to be maintained. The authors concluded that deployment strategy relies on the environmental condition.

In [21], Yahya Osais et al. used the directional sensors which have a finite angle of view instead of isotropic sensors. The problem in this paper was to solve the minimum cost sensor placement for the directional sensors. This problem was also solved by integer linear programming by properly choosing the direction and location of the directional sensor.

CHAPTER 3
PRESENT WORK

We summarize the symbols that are used in this chapter as given below

Table 2.Notations Used

T: set of targets

Se: set of sensor

S: number of sensors used

L: lifetime of sensor

T_c: most critical target

S_c: most critical target sensor

T_{lc}: least critical target

wo1: weight of fixed cost of omni-directional sensor

wo2: weight of variable cost of omni-directional sensor

wa1: weight of fixed cost of audio sensor

wa2: weight of variable cost audio sensor

fc(i): fixed cost of i^{th} sensor

fmax: maximum possible cost of the sensor

k: terrain (k=1, manageable terrain; k=∞, unmanageable terrain)

3.1 ASSUMPTION

We consider a scenario where sensor nodes are to be deployed on a flat ground **G** to monitor a large number of target nodes**.** We do a three dimensional analysis. We consider that sensor nodes are audio nodes and omni-directional camera nodes. These sensors cannot change their position after being deployed yet there can be a redeployment of nodes which can increase the QoS requirements [9]. All the sensor nodes have a wireless communication capability. We assume that all the sensor node have a same sensing range **Rs** for the coverage of targets and same communication range $\mathbf{R_C}$ for connectivity between the sensors [13]. In our work, we assume that $\mathbf{R_C > Rs}$ so that there is no connectivity loss**.** If the cluster head are not in direct connection with some of the sensor nodes then there is a multi-hop path between them which creates a connection.

Table 3.Assumptions of Fixed Cost and Variable Cost

Weights	Cost (in Rs)
Weight of fixed cost of omnidirectional camera, wo1	1000
Weight of fixed cost of audio sensor, wa1	500
Weight of variable cost of omnidirectional camera, wo2	700
Weight of variable cost of audio sensor, wa2	300

3.2 PROBLEM FORMULATION

A set of sensor nodes **Se**={S1,S2,S3…..Sn} are to be deployed on a flat ground **G**. The ground consists of a set of targets **T**={T1,T2,T3…..Tm} which are to be monitored, placement sites for the multimedia sensors and a placement site for the cluster head. The problem is to find the optimal positions for the set of sensor nodes **Se** such that all the targets **T** are covered with less number of nodes and every sensors node that has been deployed should have connectivity with each other.

3.3 OBJECTIVES

The main objective of our work is:

1. To improve the existing technique [15]. For this we have the following objectives given below to be taken care of.
    a) To place the multimedia sensor nodes on a ground (flat terrain) so as to monitor all the targets with good coverage.
    b) The proposed technique should use minimum number of nodes so that cost of overall deployment is reduced.
    c) Although we use minimum number of nodes, coverage and connectivity should be maintained.
    d) The following criteria should be fulfilled
        i. Cluster heads should be assigned to the highest energy node.

ii. The most critical target should be covered by assigning the second highest energy node.

iii. The second most critical target should be covered by assigning the third highest energy node.

iv. This goes on until the least critical targets are covered by the lowest energy nodes. All this process will decrease the energy consumption and network lifetime.

e) Even after all these measures if there is a node failure, then the redeployment strategies should be employed to maintain the network lifetime.

3.4 METHODOLOGY

The heuristic algorithm given in [15] is modified. In the already existing heuristic algorithm, the sensors are randomly deployed and a maximum set cover is generated which will contains all the sensors that cover the maximum number of uncovered targets. But the modification of the existing algorithm will deploy the sensors in a controlled manner. It will select a sensor node with the highest energy and deploy it near the critical targets. The proposed algorithm is distinctively explained below.

3.4.1 Proposed Algorithm

The Proposed algorithm works as follows:

Step 1. Given, Targets= Total number of targets and

T= Set of Targets

Which are on a ground to be covered.

(a) Initialize, No of sensors used, S=0,

Lifetime of sensors, L=0.

Step 2. Form a Mesh Network and find 3 most critical targets using Euclidean distance.

Step 3. Choose a sensor node called cluster head which has the highest energy and place it at the epicenter of the 3 most critical targets. (All the information from the sensors is send through the cluster head).

Step 4. Check whether each target is covered by at least one sensor.

If it is covered,

(a) go to Step 7.

If it is not covered,

(b) Find the most critical target T_c from set of targets T.

(i) Select the most critical target sensor S_c for T_c.

(ii) Since a new sensor S_c is already used,

increment the number of sensor used (S) by 1

increment lifetime of sensor (L) by 1.

(iii) Now, the remaining target set becomes

$T=T-T_c$.

Step 5. The number of targets becomes,

Target= Target-1.

Step 6. Now if the remaining set of target is null

(a) Go to Step 4.

If it is not null

(b) Check if any Least critical targets in set T is covered by S_c.

If it is not covered

(i) Go to Step 4.

If it is covered

(ii) Targets set becomes, $T=T-T_{lc}$ and

(iii) Go to Step 5.

Step 7. Check if there is any sensor failure

If no sensor failure

(a) Go to Step 10.

If there is sensor failure

(b) F= number of sensor failure.

Step 8. Lifetime of sensor becomes, L=L-F.

Step 9. Is Lifetime of sensor = Number of sensors used (ie. L=S)

If L=S

(a) Go to Step 10.

IF L!=S

(b) Add new nodes.

(c) Go to Step 9.

Step 10. End of the process.

Formulas Used

1. Euclidean distance between two targets T1 and T2 having coordinates

$(a1, b1)$ and $(a2, b2)$ =$\sqrt{(a1 - a2)^2 + (b1 - b2)^2}$

2. Epicenter of 3 targets T1, T2 and T3 having coordinates

$(a1, b1)$, $(a2, b2)$ and $(a1, b1)$ =$\left(\frac{a1+a2+a3}{3}, \frac{b1+b2+b3}{3}\right)$

3. Cost model of Deployment= (w1*(fc/fmax))+(w2*(node2/n)*k)

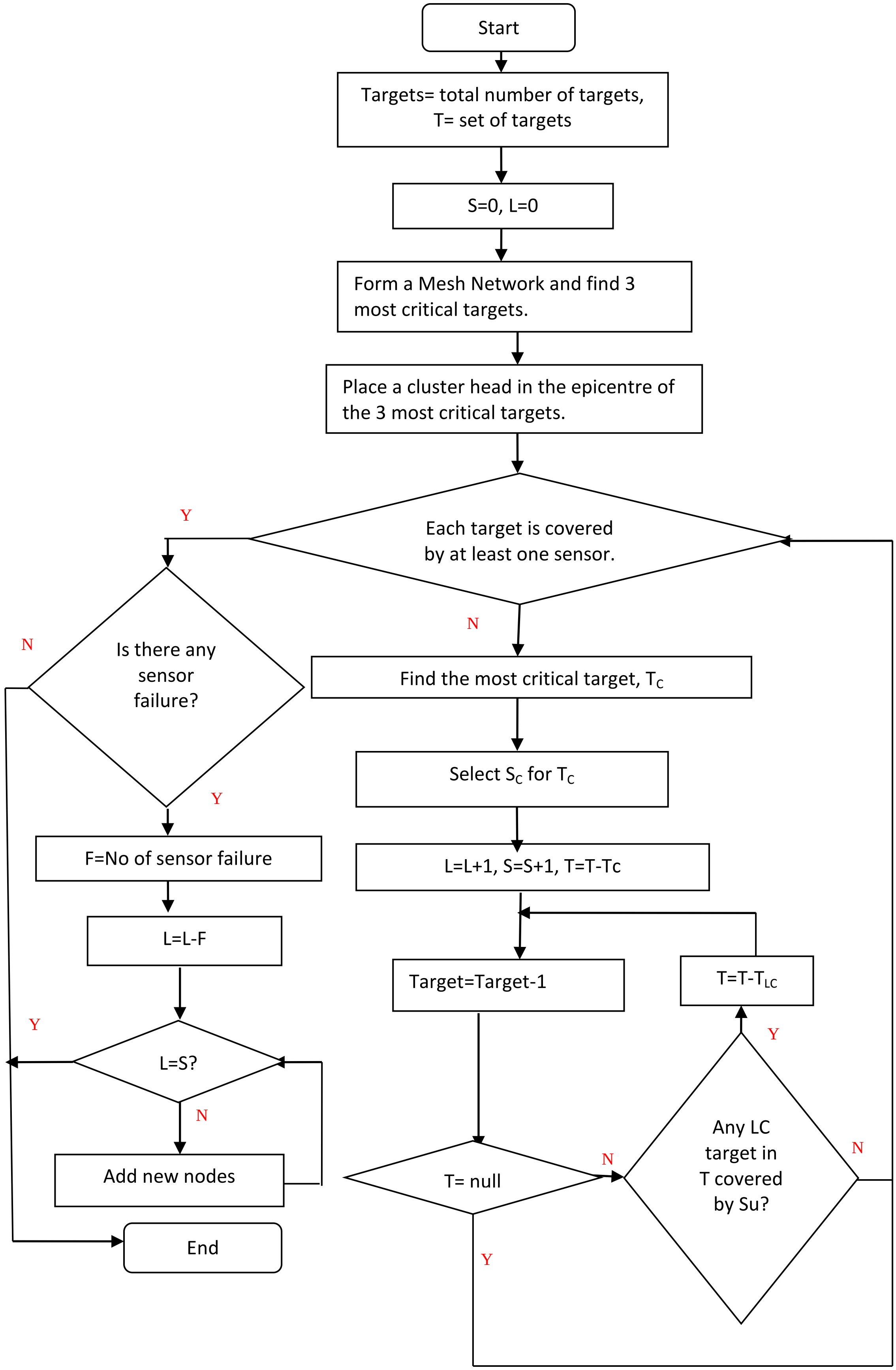

Fig 3.1.Flow Chart of the Proposed Algorithm

CHAPTER 4
RESULTS AND DISCUSSIONS

The proposed algorithm is implemented using MATLAB 7.12.0. The network covers 50x50 area. A total number of 10 targets are used; weights of different sensors are taken as given in Table 3. The overall total cost of deployment is to be calculated. This cost will depend upon the placement point, slope, Terrain (roughness). Terrain (k) is taken as 1.5 since we are working on flat terrain and it is a manageable terrain. The proposed algorithm is compared with the existing Greedy Algorithm [15].

During the simulation work, the targets, omni-directional camera sensors and the audio sensors are denoted as given below:

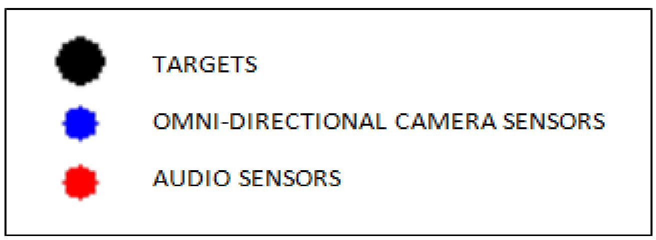

Fig 4.1. Symbol/Colours Used for Different Sensors and Targets

A Graphical user interface is used to input the number of targets. GUIDE (graphical user interface design environment) prepares mechanism for making different kind of interfaces for the users. By typing GUIDE on the Command Window, the GUIDE layout editor is opened and one can make any user interface as one wants.

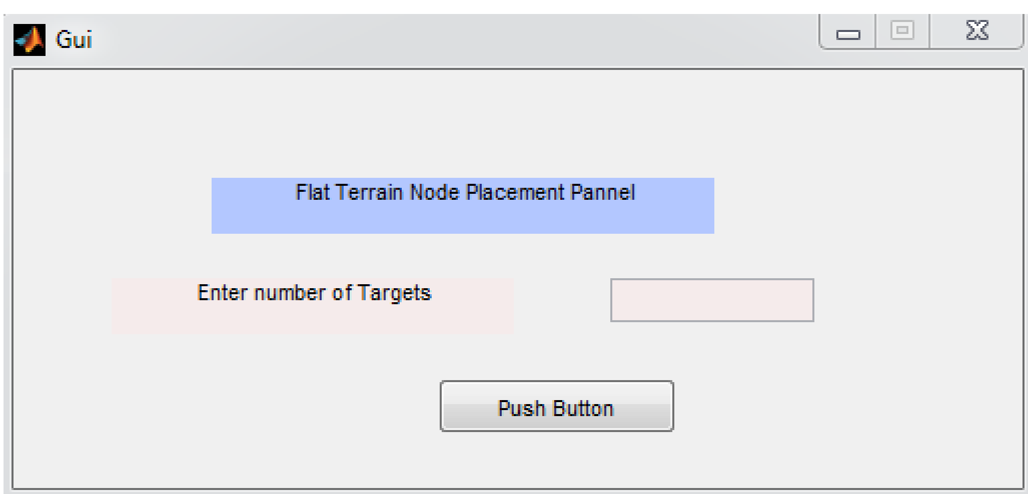

Fig 4.2.A GUI Interface

4.1 SIMULATION OF THE ALGORITHMS WHEN NUMBER OF TARGETS=10

4.1.1 Existing Greedy Algorithm Simulation

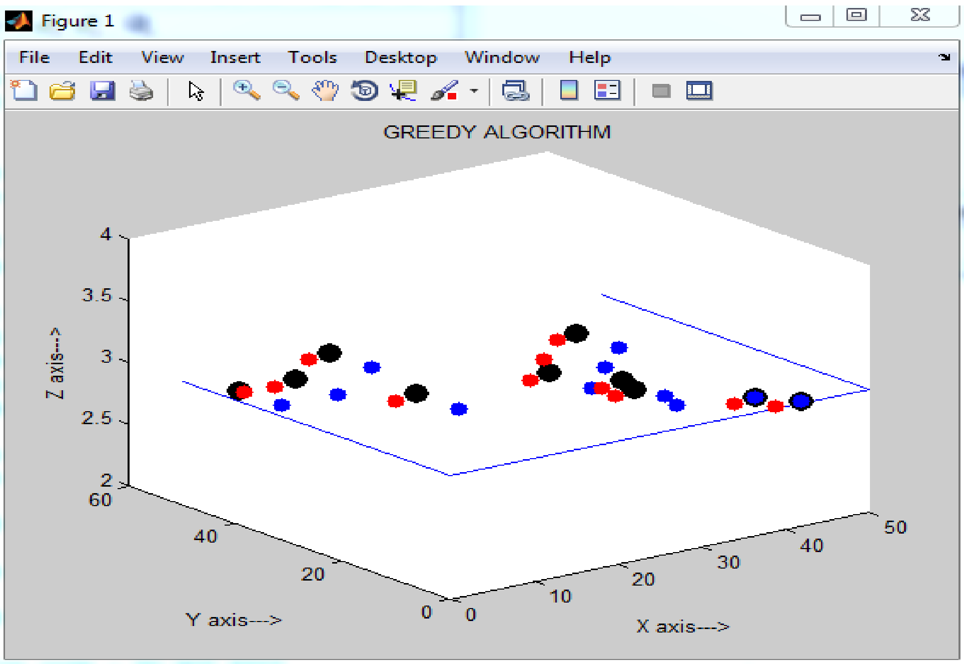

Fig 4.3.Greedy Heuristic Algorithm Placement When Targets=10

4.1.2. Proposed Modified Algorithm Simulation

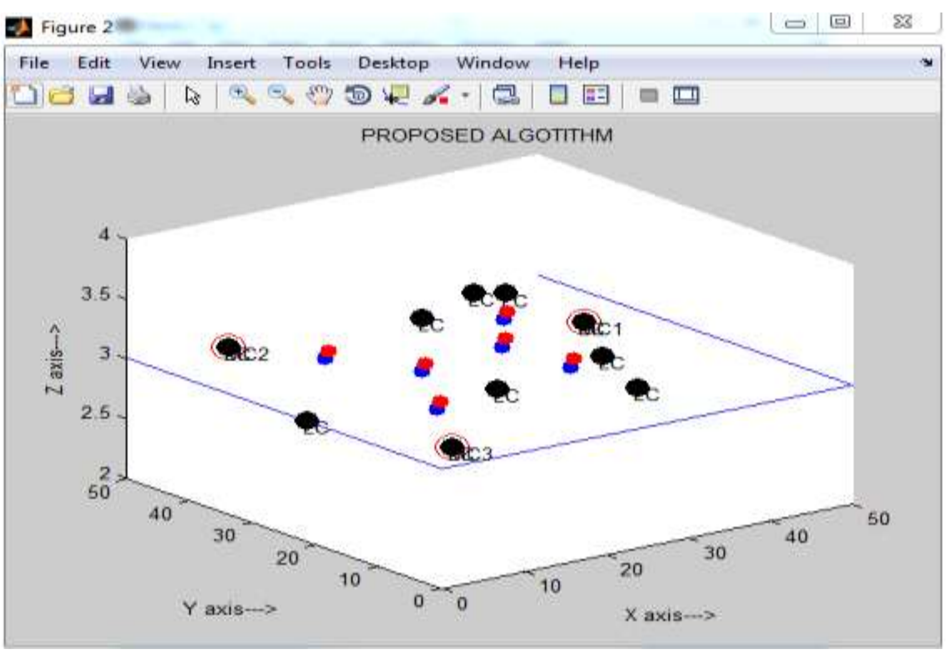

Fig 4.4 Proposed Modified Placement When Target=10

4.1.3 Number of Nodes Used by the Algorithms

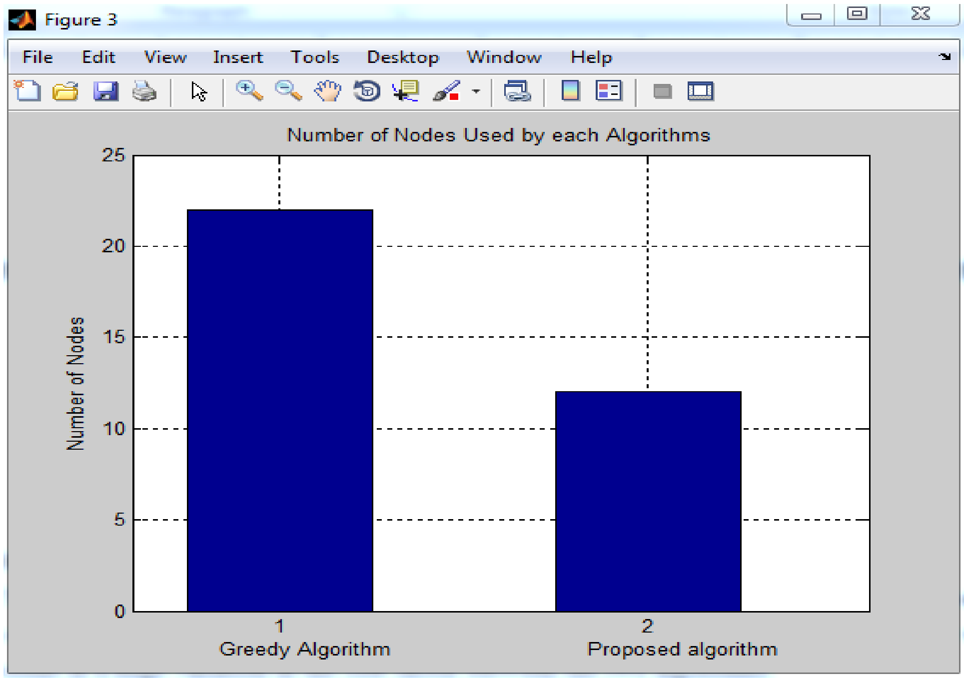

Fig 4.5.Number of Nodes Used by Different Algorithm When Targets=10

4.1.4 .Overall Cost of the Algorithms

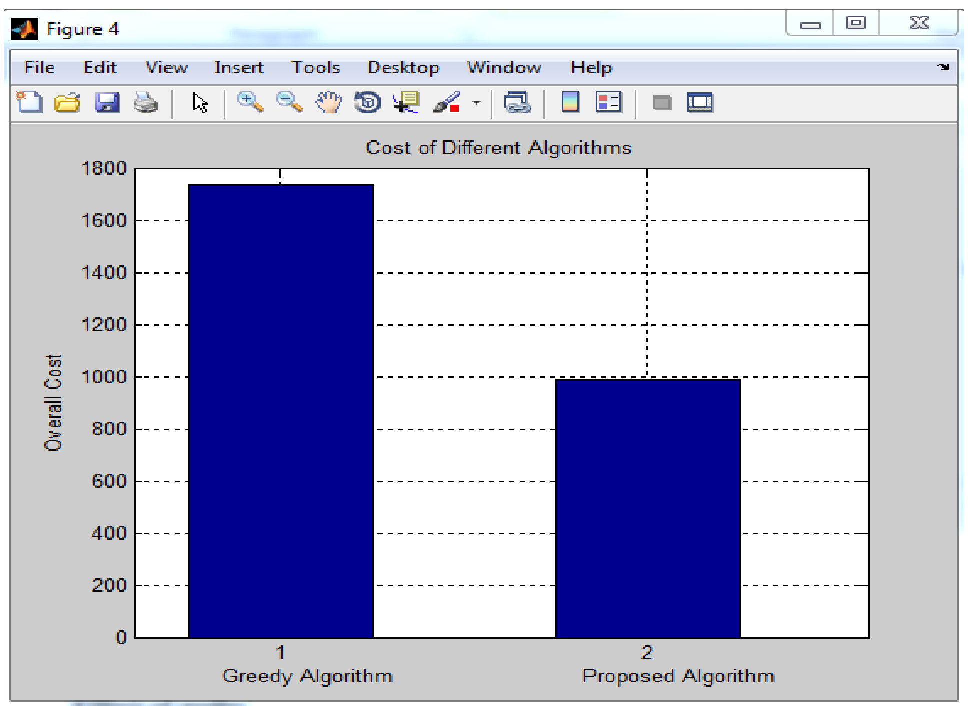

Fig 4.6.Overall Cost of Different Algorithms When Targets=10

4.1.5. Resultant Reduced Cost of the Algorithms

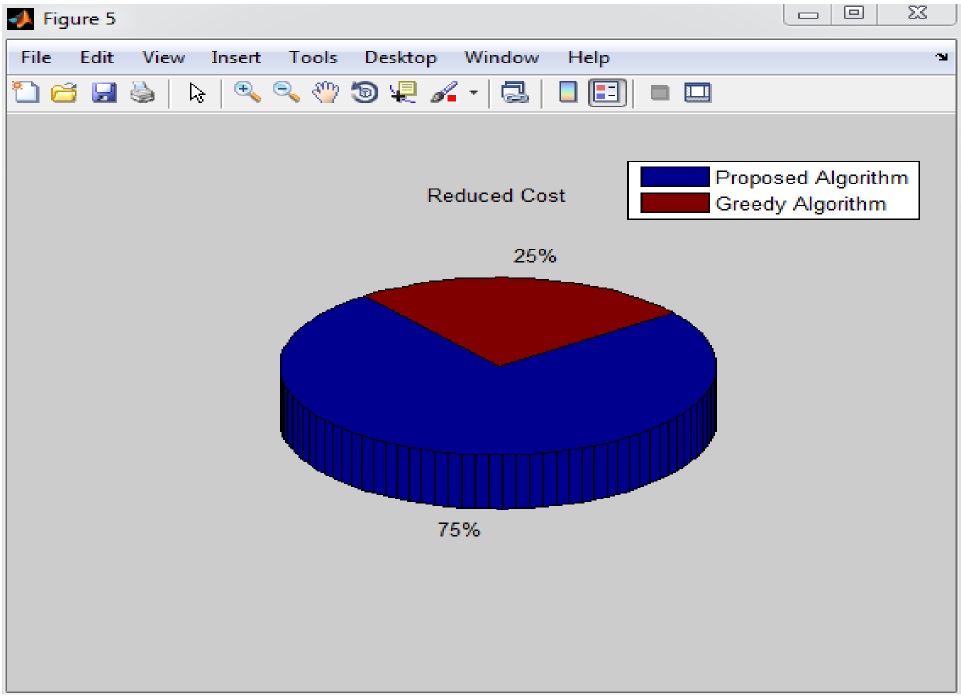

Fig 4.7 Reduced Cost of the Algorithms When Targets=10

4.2 SIMULATION OF THE ALGORITHMS WHEN NUMBER OF TARGETS=30

4.2.1 Existing Greedy Algorithm Simulation

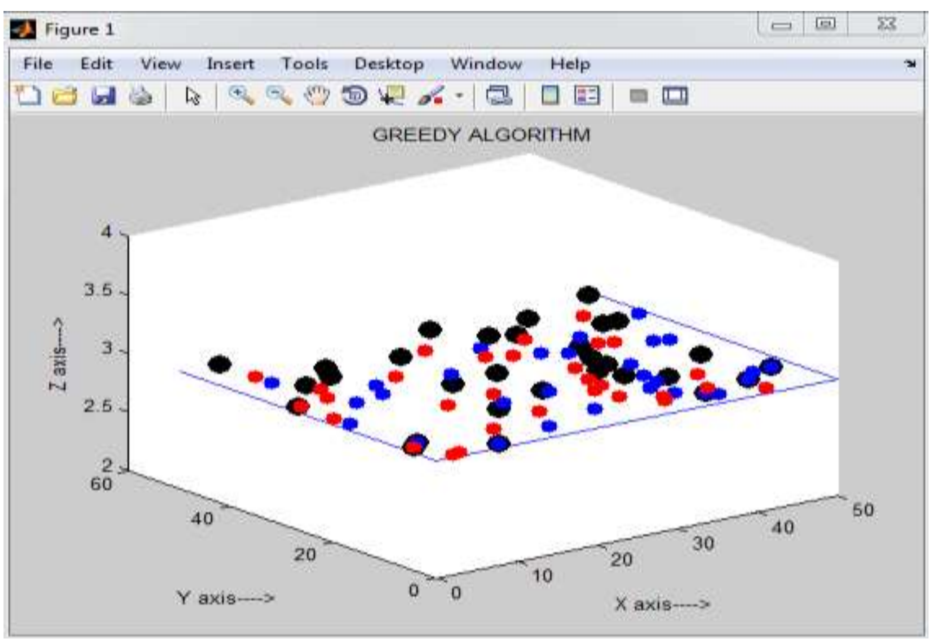

Fig 4.8.Greedy Heuristic Algorithm Placement When Targets=30

4.2.2. Proposed Modified Algorithm Simulation

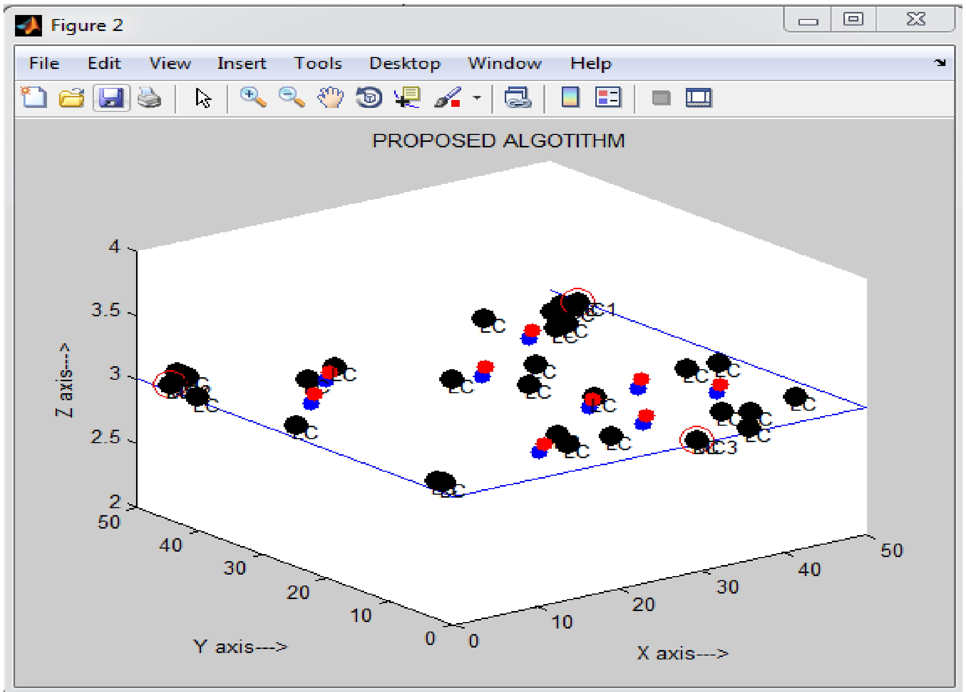

Fig 4.9 Proposed Modified Placement When Target=30

4.2.3 Number of Nodes Used by the Algorithms

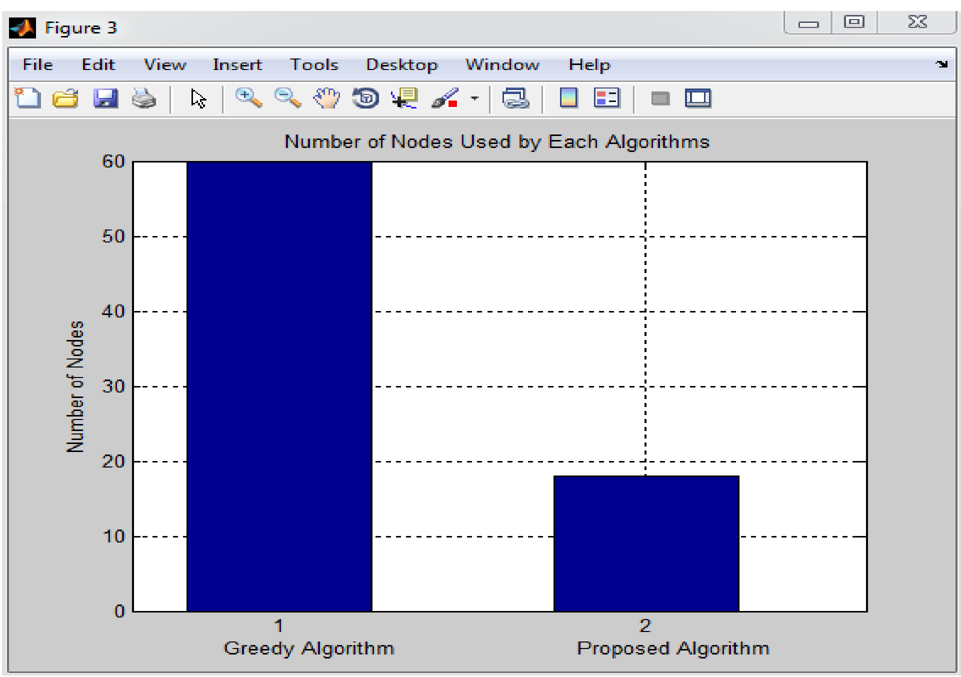

Fig 4.10.Number of Nodes Used by Different Algorithm When Targets=30

4.2.4 .Overall Cost of the Algorithms

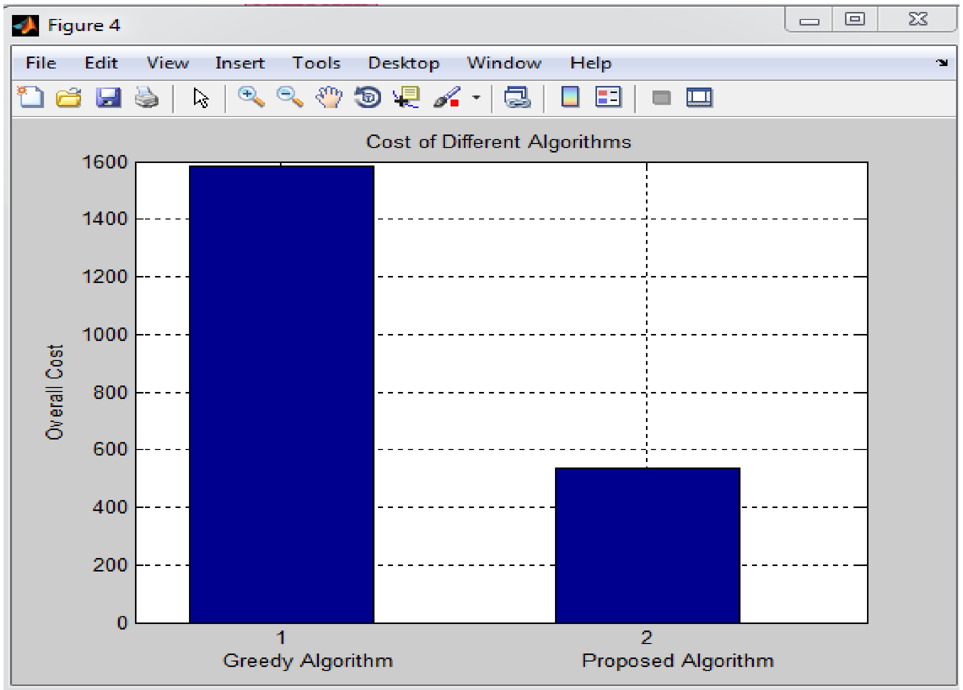

Fig 4.11.Overall Cost of Different Algorithms When Targets=30

4.2.5. Resultant Reduced Cost of the Algorithms

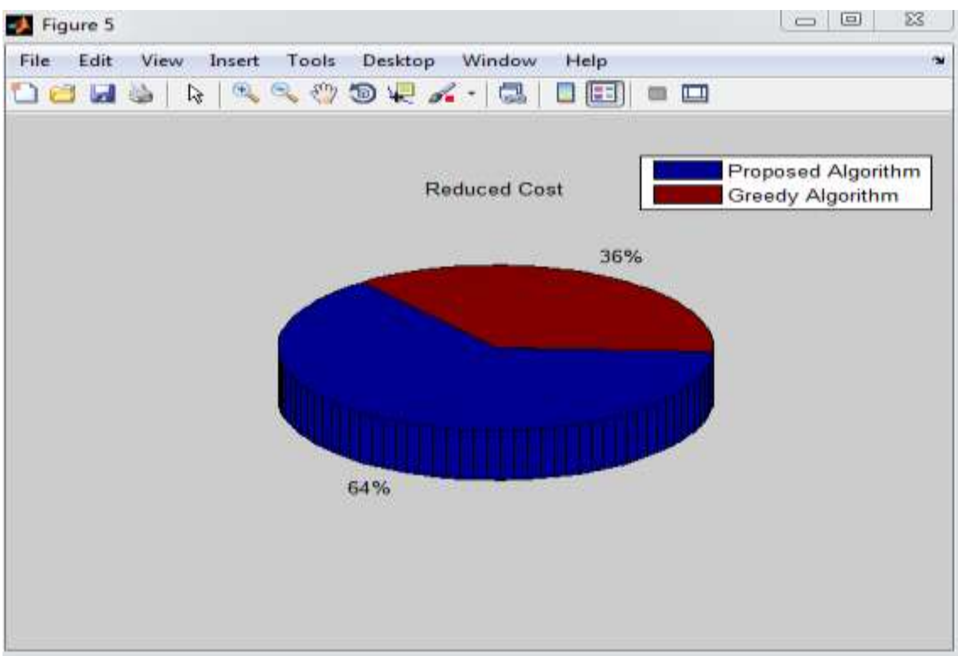

Fig 4.12 Reduced Cost of the Algorithms When Targets=30

4.3 DISCUSSIONS

The existing Greedy Algorithm and the Proposed modified algorithm are deployed for 10 targets and 30 targets. In the existing greedy algorithm, the sensors are deployed first, and then there is a generation of maximum set cover (MSC) which includes the entire sensor that can cover maximum number of uncovered targets. The problem here is that the set of target node that a particular sensor in the MSC is monitoring will have the same or some common targets with another sensor. Moreover if any one of the sensor inside the MSC fails then the entire MSC is discarded. The modified algorithm will solve these problems. In the proposed algorithm, the most critical target is assigned with the highest value of energy available and it does not discard any MSC but it checks to select which sensor is not working and replaces it.

4.3.1 Effect of Nodes When Target=10

The number of sensor nodes used by the Greedy Algorithm is 22 and that by the proposed algorithm is 12. The modified algorithm results in lesser number of nodes usages because in every iteration it searches for each target if the previously employed sensor for the critical target covers it too or not. The proposed algorithm will yield in better optimized value for the cost. It will result in a huge variation in the cost factor between the two algorithms.

4.3.2 Effect of Cost When Target=10

The overall cost obtained by the Heuristic Greedy algorithm is 1580 and the overall cost obtained by the proposed algorithm is 540. Hence, the objective of our work is accomplished and the proposed algorithm results in better cost optimization with proper coverage, connectivity, network lifetime with less number of sensor usages.

4.3.3 Effect of the Reduced Cost of the Algorithms when Target=10

This is calculated in the percentage form out of 100. If there are two costs C1 for Greedy Algorithm and C2 for the proposed algorithm, then reduced cost is calculated as

For Greedy Algorithm=(C1*100/(C1+C2))

For Proposed Algorithm=(C2*100/(C1+C2))

Thus cost reduced by the proposed algorithm will be 75% and the cost reduced by the Greedy Algorithm is 25%. The Proposed algorithm reduced the cost more the existing algorithm.

4.3.4 Effect of Nodes When Target=30

The number of sensor nodes used by the Greedy Algorithm is 60 and that by the proposed algorithm is 18. The modified algorithm results in lesser number of nodes usages because for every iteration it searches for the target that if the previously employed sensor for the critical target covers it too. The proposed algorithm will yield in better optimized value for the cost. It will result in a huge variation in the cost factor between the two algorithms.

4.3.5 Effect of Cost When Target=30

The overall cost obtained by the Heuristic Greedy algorithm is 1740 and the overall cost obtained by the proposed algorithm is 980. Hence, the objective of our work is accomplished and the proposed algorithm results in better cost optimization with proper coverage, connectivity, network lifetime with less number of sensor usages.

4.3.6 Effect of the Reduced Cost of the Algorithms when Target=30

This is calculated in the percentage form out of 100. If there are two costs C1 for Greedy Algorithm and C2 for the proposed algorithm, then reduced cost is calculated as

For Greedy Algorithm=(C1*100/(C1+C2))

For Proposed Algorithm=(C2*100/(C1+C2))

Thus cost reduced by the proposed algorithm will be 64% and the cost reduced by the Greedy Algorithm is 36%. The Proposed algorithm reduced the cost more the existing algorithm.

Table 4.Comparison of the results for target=10,30,50

		No of Nodes Utilized	Overall Cost	Reduced Cost
Targets=10	Existing Algorithm	22	1580	25%
	Proposed Algorithm	12	540	75%
Targets=30	Existing Algorithm	60	1740	36%
	Proposed Algorithm	18	980	64%
Targets=50	Existing Algorithm	100	2585	39%
	Existing Algorithm	20	1540	61%

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

Wireless Multimedia Sensor Network is used in tremendous application in different fields for the last decade. There has been so many research works done for the increasing demand of the multimedia sensor application. Its main function is to monitor an area or to monitor some target. With this, there comes a challenge of coverage and connectivity. Since sensors are equipped with low battery, maintaining energy with longer network lifetime is also a challenge. In the existing algorithm, it employs a lot of sensor to give an optimal node placement but some of the sensors are utilized only for some period of time and does a little work. After that, those sensors stop working and the entire MSC consisting of sensors which covers maximum number of uncovered targets has to be discarded. There might be some sensors left with energy that can operate but cannot actually form a set cover. With this, those sensors which haven't stopped working also have to be discarded. This algorithm may maximize the network lifetime but the cost of large number of sensor utilized will result in rise of cost and hence reducing the profit.

Based on the observation of the base paper technique, a new algorithm was formed. The new algorithm proves to be more computationally efficient and out performs the existing algorithm. It is computationally efficient because it doesn't discard the maximum set cover that gets exhausted but rather it replaces the sensor which has stopped working with a new one.

Although we consider the network in single-tier heterogeneous centralized network architecture, it can be used in any kind of network architecture. There are still many challenges that need to work on placement of nodes. More research work will provide a much better optimization of the cost with good quality of service and coverage.

Future Scope

Many researchers have studied and introduced new techniques for the cost optimization deployment of nodes but still there are many challenges to be worked upon. There are many issues related to sensor placement strategies and in future better performance studies can be done under more practical scenario such as in presence of obstacles or in different terrain specifications under a given deployment cost.

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[2] Imtisenla Imchen, Rajeev Kumar Patial, Dilip Kumar, "Efficient Node Placement For Reducing Cost in Wireless Multimedia Sensor Network " Accepted for publication in the proceedings of Advances in Applied Engineering and Technology-2015, International Journal of Applied Engineering Research, IJAER.

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APPENDIX

Glossary

Base Station	It is a transceiver connecting a number of other devices to one another and/or to a wider area.
F.o.V	It is a solid angle through which a detector is sensitive to electromagnetic radiation.
Heterogeneous WSN	It consists of sensor nodes with different ability, such as different computing power and sensing range.
Heuristic	It is a technique designed for solving a problem more quickly when classic methods are too slow, or for finding an approximate solution when classic methods fail to find any exact solution.
Homogeneous WSN	It consists of a sensor node that has the same storage, processing, battery power, sensing, and communication capabilities.
Lite nodes	Lite nodes are those nodes that with limited communication, storage, energy and computation power.
Multi-Tier Architecture	It exploits the higher processing and communication capabilities of high end nodes and yield a hierarchical network operation.
Node	It is a connection point, a redistribution point or a communication endpoint. It is attached to a network, and is capable of creating, receiving, or transmitting information over a communications channel.
Omnidirectional Camera Sensors	It is a sensor that can take picture in 360 degree. By utilizing omni directional camera instead of directional camera helps in covering portion of area of concerned occurring event.
Quality of Service	It is the overall performance of a WSN particularly the performance seen by the users of the network. It is often considered as error rates, bandwidth, throughput, transmission delay, availability, jitter, etc
Single-Tier Architecture	The network that are composed of either homogeneous or heterogeneous components.

Sophisticated Node	Those nodes that possess high communication, storage, energy and computation power capability.
WSN	It is a spatially distributed autonomous sensor to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to the main location.
Voronoi Diagram	It is the partitioning of a plane into regions based on distance to points in a specific subset of the plane

List of abbreviation

CCTV	Closed Circuit Television
CH	Cluster Head
CMOS	Complementary Metal-Oxide Semiconductor
D.o.C	Degree of Coverage
ECG	Electrocardiography
GUI	Graphical Use Interface
GUIDE	Graphical User Interface Design Environment
ILP	Integer Linear Programming
LN	Litenodes
MATLAB	Matrix Laboratory
MDC	Minimum Deployment Cost
SN	Sophisticated Nodes
SPA	Shortest Path Algorithm
VFCPSO	Virtual Force Directed Co-evolutionary Particle Swarm Optimization
WMSN	Wireless Multimedia Sensor Networks
WSN	Wireless Sensor Network