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Tactical Communication System using MANET and WSN

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Abstract: *Military community is redefining the way wars will be fought in the future, evolving towards a Network – Centric Warfare (NCW) paradigm, where force is increasingly realized through the communication network & information sharing, which should be provided to the centralized Global Information Grid. MANET [Mobile Ad-Hoc Networks] technology is attractive, as it would enable the creation of wireless sensor network (WSN) on demand as the need arises. Wireless sensor nodes have a limited amount of energy for its operation generally depends on the power of their own battery. MANET topology varies in time, depending on the position of the nodes, and their on or off status. Also it has a limited bandwidth with link of variable capacity. Here this paper deals with the limitations of the energy of nodes and describes different approaches to prolong the energy of the battery in wireless sensor networks that are hierarchically clustered. Also this paper compares the impact of homogeneity and heterogeneity of nodes, in terms of their energy for LEACH (Low Energy Adaptive Clustering Hierarchy) and SEP (Stable Election protocol). After comparison the paper suggest a new cluster based protocol- i,e ASEP-Advance SEP, to improve lifetime of wireless sensors in MANET.*

Keywords: *ASEP, Clustering, Homogeneous and Heterogeneous Networks, LEACH, MANET, NCW, Network Lifetime, SEP, Wireless Sensor Network.*

I. Introduction

Generally, the tactical operation region is highly dynamic in nature, consisting of a variety of network elements, like sensors, wireless nodes on a variety of platforms including vehicular, soldier & temporary fixed (but nomadic) sites. Ideally, all these platforms would interconnect in a robust, reliable network system.Because tactical network operations so often take place in locations where useable infrastructure is scarce, nonexistent, or unsuitable, MANET technology is attractive, as it would enable the creation of wireless sensor networkon demand as the need arises. A MANET consists of mobile platforms, which are free to move about arbitrarily. Each of these platforms, herein simply referred to as "nodes". Nodes of MANET must coordinate to perform the services typically provided by a network infrastructure (e.g., routing & data forwarding).This paper addresses the question of what communications and networking technology breakthroughs are required to fully realize mobile ad hoc networking and deliver on the promises of NCW at the tactical edge of our military forces.Ad hoc networks are well suited for sensor networks comprised of small wireless electronic devices that can measure and monitor events and physical properties such as temperature, movement, pressure, and location. These sensors can be used to provide visual and audio feedback in environments not easily accessible by humans. Micro sensor networks can contain hundreds of sensor nodes and such networks rely on large numbers to obtain high quality results. Nodes in network could be homogeneous (nodes with same energy-level) or heterogeneous (nodes with different energy-level). Sensors should be energy-efficient as possible, because when a sensor node runs out of energy it is useless.

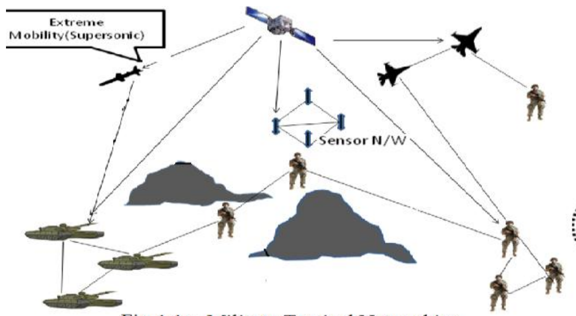


Fig.1.1: - Military Tactical Networking.

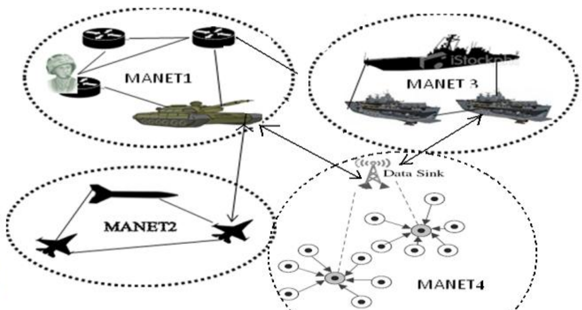


Fig.1.2: - MANET structure.

Future battlefield networks will consist of various heterogeneous networking systems and tiers with disparate capabilities and characteristics, ranging from ground ad hoc mobile and sensor networks to airborne-rich sky networks to satellite networks.

A. Problem Statement

In a MANET, the entire network infrastructure is moving along with the user nodes. As the nodes move, point-to-point links may be dropped due to terrain interference or simply because they move beyond range of other nodes. Network stability is continually stressed as nodes drop in and out of the mesh because of their limited Battery Lifetime. The sensor nodes can be mobile or static depending on the application. While wireless sensor network nodes are increasingly equipped to handle more complex functions, in-network processing may require these battery powered sensors to judiciously use their constrained energy to prolong the effective network life time especially in a homogeneous and heterogeneous settings.So to deliver the capabilities that NCW enabled forces require at the tactical edge, an objective MANET must possess four general characteristics: Strong Connectivity, Very High Bandwidth, Effective Security andSurvivability in terms of the lifetime of the nodes.

B. Objective of the Paper

So, the purpose of this paper is to find protocols that are energy efficient and support real-time traffic for environments like habitat monitoring or area surveillance. Stability period of the wireless sensor network means the number of rounds to which all the nodes become alive to collect meaningful information from every part of the sensing field.So another objective is to ensure greater stability of the WSN. We propose an efficient dynamic clustering algorithm to achieve a network-wide energy reduction in a multihop context. The proposed ASEP (Advance Stable Election Protocol), a heterogeneous-aware protocol to prolong the time interval before the death of the first node (we refer to as stability period), which is crucial for many applications. ASEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. Here in this project our objective is to implement and compare both of these protocols in MATLAB.

C. Previous Work

The cluster-based routing protocols are investigated in several research studies. For example, the work in [1] shows that a 2-tier architecture is more energy efficient when hierarchical clusters are deployed at specific locations. Bandyopadhyay and Coyle [2] describe a multi-level hierarchical clustering algorithm, where the parameters for minimum energy consumption are obtained using stochastic geometry.Rabia Noor Enam, Mumtazul Imam and RehanInamQureshi [3] describes overhead Energy Consumption in Random Cluster Head selection Phase of WSN, The basic model based on LEACH protocol is redeveloped to calculate the energy consumptions in the three phases of data transmissions from sensor nodes to the sink. It is shown through the extensive simulations of this model that the overhead energy is at least 20% of the networks total energy consumed in data transmissions. The optimum value of cluster heads, based on network lifetime has been calculated taking into consideration the energy consumed in the setup phase as well.Rajesh Patel, Sunil Pariyani, Vijay Ukani, [4] describes Energy and Throughput Analysis of Hierarchical Routing Protocol (LEACH) for Wireless Sensor Network by varying the different no. of clusters heads/clusters in the network the performance of network changed in terms of lifetime, throughput and average energy dissipation. SajidHussain and Abdul W. Matin [5] propose an energy efficient hierarchical cluster-based routing protocol for continuous stream queries in WSN. They introduce a set of cluster heads, head-set, for cluster-based routing. The head-set members are responsible for control and management of the network. On rotation basis, a head-set member receives data from the neighboring nodes and transmits the aggregated results to the distant base station. For a given number of data collecting sensor nodes, the number of control and management nodes can be systematically adjusted to reduce the energy consumption, which increases the network life.

II. Wireless Sensor Network

With rapid advancement in electronics industry, small inexpensive lightweight battery-powered wireless sensors have already started to make an impact on the communication. The wireless sensor networks can be deployed in a wide geographical space to monitor physical phenomenon with acceptable accuracy and reliability.The sensors can monitor various entities such as: temperature, pressure, humidity, salinity, metallic objects, and mobility; this monitoring capability can be effectively used in commercial, military, and environmental applications.If they are properly networked and programmed, these sensor nodes can cooperate in order to perform complex signal processing functions.Since WSNs consist of numerous battery-powered devices, the energy efficient network protocols must be designed.The redundant, inaccurate or uncertain sensor data is filtered.The core operation of wireless sensor network is to collect and process data at the network nodes, and transmit the necessary data to the base station (sink) for further analysis and processing. Clustering in wireless sensor networks is one of the crucial methods for increasing of network lifetime. A cluster head is responsible for conveying any information gathered by the nodes in its cluster and may aggregate and compress the data before transmitting it to the sink. However, this added responsibility results in a higher rate of energy drain at the cluster heads. Currently there are several energy efficient communication models and protocols that are designed for specific applications, queries, topologies and specific type of Network i.e, homogeneous or heterogeneous depending on the amount of energy equipped with every node, namely –Direct communication protocol, Minimum-transmission-energy routing protocol and LEACH

A. Energy Analysis of routing protocols

We examine three such protocols, namely direct communication with the base station (DTE), LEACH and SEP using sensor network and radio models. Using a direct communication protocol (DTE), each sensor sends its data directly to the base station. If the base station is far away from the nodes, direct communication will require a large amount of transmit power from each node. This will quickly drain the battery of the nodes and reduce the system lifetime.Practically this approach is less efficient and has very less network stability in terms of energy of the nodes. LEACH and SEP have been discussed further in detail.

B. Energy efficient scheme for homogeneous structures: LEACH

LEACH is the most aspiring and widely used protocol. Heinzelman et al. [6] describes the LEACH protocol, which is a hierarchical self-organized cluster-based approach for monitoring applications.

Key features of LEACH are: Localized coordination and control for cluster set-up and operation, Randomized rotation of the cluster “base stations” or “cluster-heads” and the corresponding clusters, Local compression to reduce global communication, which avoid information overload.

The operation of LEACH is broken up into rounds, where each round begins with a set-up phasefollowed by a steady-state phase. Set-up phase has two process; clustering and cluster head determining and steady-state phase concentrate to gathering, accumulation and transmit data to sink.

C. Stable Election Protocol: SEP

SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. SEP always prolongs the stability period compared to (and that the average throughput is greater than) the one obtained using current clustering protocols. Our SEP protocol successfully extends the stable region by being aware of heterogeneity through assigning probabilities of cluster-head election weighted by the relative initial energy of nodes. The performance of SEP is observed to be close to that of an ideal upper bound obtained by distributing the additional energy of advanced nodes uniformly over all nodes in the sensor field.

III. Implementation of Energy Efficient Scheme

Energy Dissipation Models are very important in WSNs, as they can be utilized to compare the performance of different communication protocols. We assumed the same model, where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics at receiver side.

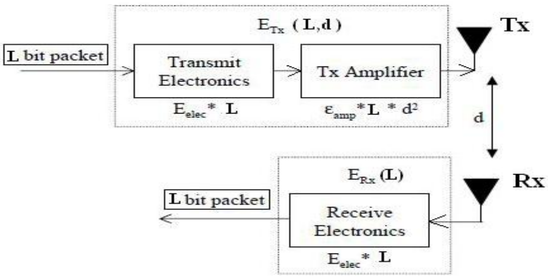


Fig. 1.3 Radio Energy dissipation Model

Using this radio model, to transmit L-bit message at distance d, radio expends –

$$E_{Tx}(L,d) = (L * E_{elec}) + (L * E_{amp} * d^2) \quad \text{---- (1)}$$

And to receive the message radio expends –

$$E_{Rx}(L,d) = L * E_{elec} \quad \text{--- (2)}$$

Now, assuming $d \leq d0$, Energy dissipated in CH during a round is,

$$E_{CH} = [(\frac{n}{k} - 1)L * E_{elec}] + [\frac{n}{k} * L * E_{DA}] + [L * E_{elec}] + [L * E_{amp} * d^2_{sink}] \quad \text{--- (3)}$$

Where,

n = number of nodes.

K = number of clusters.

E_{DA} = Processing or data aggregation cost.

d_{sink} = distance of CH to sink.

Energy dissipated in nonCH node during a round is,

$$E_{nonCH} = [L * E_{elec}] + [L * E_{amp} * d_{CH}^2] \quad \text{--- (4)}$$

Where d_{CH} = distance of non-CH node to CH.

Energy dissipated in a cluster per round is given by,

$$E_{cluster} = E_{CH} + \frac{n}{k} E_{nonCH} \quad \text{--- (5)}$$

Total energy dissipated in the network equals,

$$E_{tot} = L[2nE_{elec} + nE_{DA} + E_{amp}(Kd_{sink}^2 + nd_{CH}^2)] \quad \text{--- (6)}$$

ENERGY ANALYSIS OF PROPOSED ENERGY EFFICIENT SCHEME: ASEP

Let E0 = Initial energy of each normal node. Then Energy of each advance node is –

$$E_0 (1 + \propto) = E_0 + \propto E_0 \quad \text{--- (7)}$$

Hence Total initial energy of new heterogeneous setting is,

$$[n(1-m) * E_0] + [n * m * E_0 * (1+ \propto)] = n^* E_0(1+ \propto^* m) \quad \text{--- (8)}$$

So, total initial energy of new heterogeneous setting is,

$$E_{tot} = nE_0 + \propto mnE_0 \quad \text{--- (9)}$$

To maintain or retain stable region of system, new epoch must become as,

$$\frac{1}{P_{opt}}(1+ \propto m) \quad \text{--- (10)}$$

So stable region of system can be increased by (1 + αm) if:

1) Each normal node becomes a CH once every

$$\frac{1}{P_{opt}}(1+ \propto m)$$ Rounds per epoch

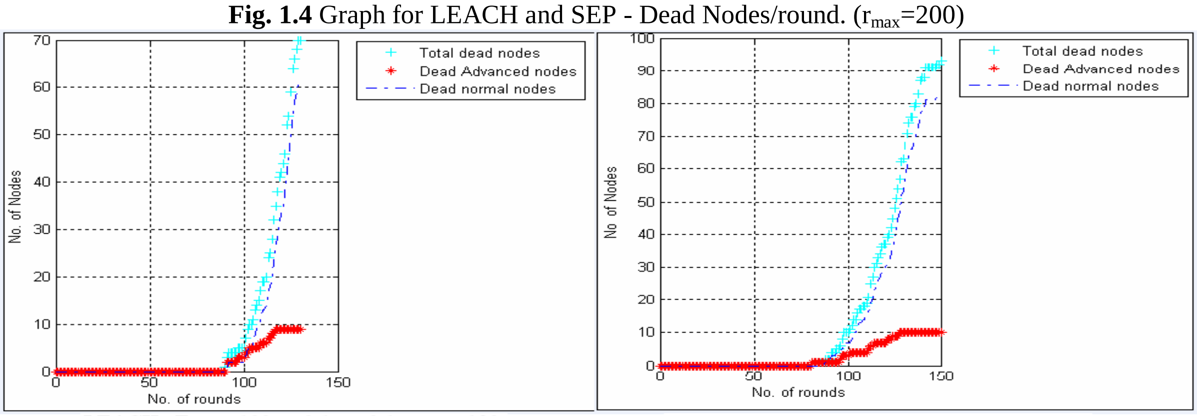
2) Each advanced node becomes a CH exactly (1 + αm) times every

$$\frac{1}{P_{opt}}(1+ \propto m)$$ Rounds per epoch

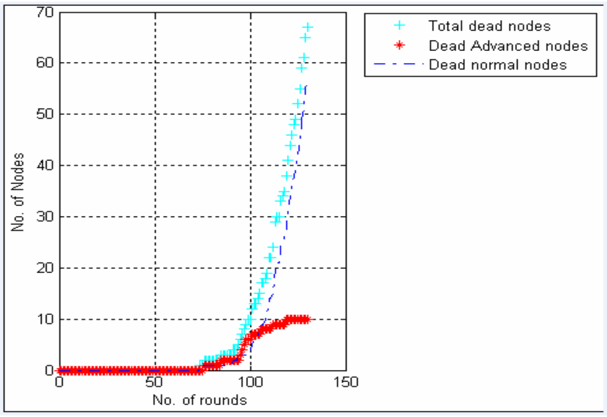
3) Average number of CH per round per epoch is = $\eta^* P_{opt}$

IV. Simulation and Simulation Results

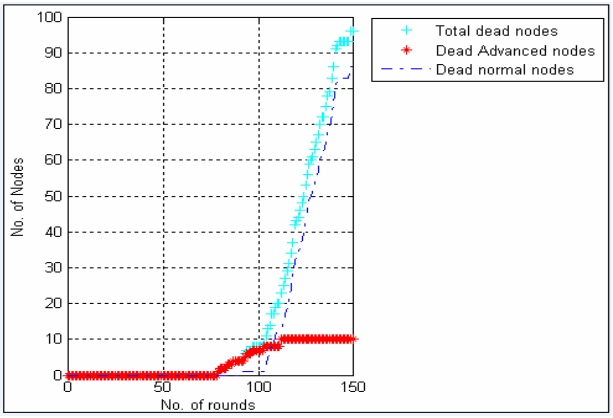
Fig. 1.4 Graph for LEACH and SEP - Dead Nodes/round. (r_{max}=200)



LEACH : For n=100;p=0.1;m=0.1; rmax=130 LEACH : For n=100;p=0.1;m=0.1; rmax=150

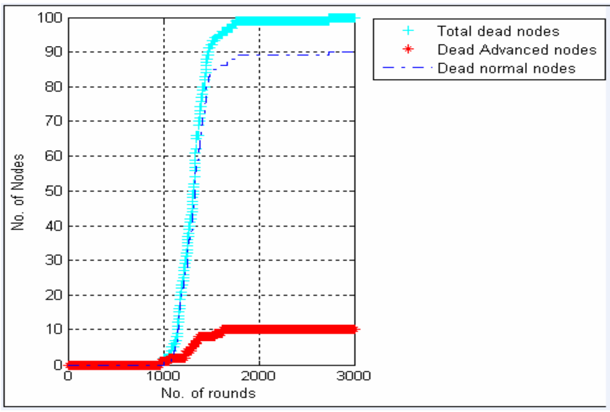


SEP : For n=100;p=0.1;m=0.1; rmax=130

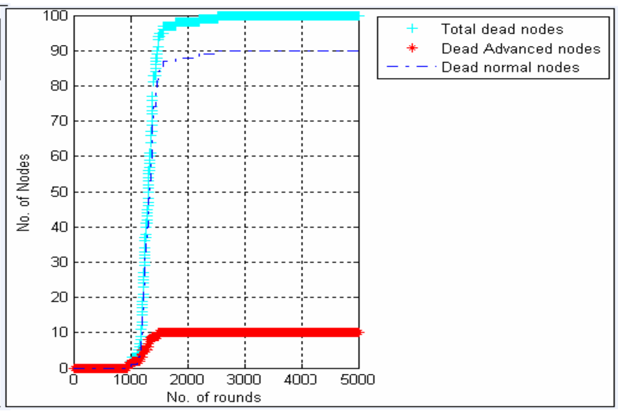


SEP : For n=100;p=0.1;m=0.1; rmax= 150

Fig. 1.5 Graph for ASEP – Dead Nodes/round.(r_{max}=3000 &r_{max}=5000)



ASEP-For n=100; p=0.1; m=0.1 rmax=3000



ASEP-For n=100; p=0.1; m=0.1 rmax=5000

V. Conclusion

LEACH is heterogeneous-oblivious protocol.SEP and ASEP are heterogeneous-aware, scalable and dynamic, as even normal node can be elected as a CH.No global knowledge required at every round. Simulation shows that ASEP always prolongs the stability period compared toother protocols. The average throughput is also greater in ASEP.Using CHs the channel BW has been efficiently utilized. So WSN can be implemented in MANET.

Future Scope and Extension

In MANET, entire network infrastructure is moving. Point-to-point links may be dropped due to terrain interference or beyond coverage range of other nodes. So Network stability is continually stressed. Hence further work can be expected on implementation of ASEP in MANET with this mobility concern.

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