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Key Challenges of Military Tactical Networking and the Promise of MANET Technology

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Abstract: Generally, the tactical operation regions highly dynamic in nature, consisting of a variety of network elements, like sensors, wireless nodes on a variety of platforms including vehicular, soldier and 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 [Mobile Ad-Hoc Networks] technology is attractive, as it would enable the creation of wireless sensor network (WSN) on 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 and data forwarding).

Keywords: NCW, GIG, MANET, Wireless Sensor Network, Clustering, homogeneous and heterogeneous Networks, network lifetime, LEACH, SEP, ASEP.

I. Introduction

This paper addresses the question of what communications and networking technology breakthroughs are required to fully realize mobile ad hoc networking (MANET) and deliver on the promises of NCW at the tactical edge of our military forces. Information technology has altered the business and economic environment by providing ubiquitous communications, low-cost, high-power computer processing, cheap, high-volume data storage, a proliferation of sensors, and advanced software capabilities that collectively provide precise, readily available information on the operating environment. 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 energylevel).Sensors should be energy-efficient as possible; because of when a sensor node runs out of energy it is useless. Since the limited wireless channel bandwidth must be shared among all the sensors in the network, routing protocols for these networks should be able to perform local collaboration to reduce bandwidth requirements. So it is necessary to work on the energy efficiency and channel efficiency in wireless network.

II. Implementation of energy efficient scheme: LEACH

LEACH can be described as a combination of a cluster-based architecture and multi-hop routing. The term cluster-based can be explained by the fact that sensors using the LEACH protocol functions are based on cluster heads and cluster members. Multi-hop routing is used for inter-cluster communication with cluster heads and base stations. Simulation results show that multi-hop routing consumes less energy when compared to direct transmission. The operations that are carried out in the LEACH protocol are divided into two stages, the setup phase and the steady-state phase. The operation of LEACH is broken up into rounds, where each round begins with a set-up phase, when the clusters are organized, followed by a steady state phase, when data transfers to the base station occur.

In order to minimize overhead, the steady-state phase is long compared to the set up phase. First phase or initialization phase has two process; clustering and cluster head determining. Second phase mean steady-state, that this phase concentrate to gathering, accumulation and transmit data to sink.

Set-up phase

- Cluster-head Advertisement
- Cluster Set-Up
- Transmission schedule creation

Steady-state phase

- Data transmission to cluster heads
- Signal processing (Data fusion)
- Data transmission to the base station

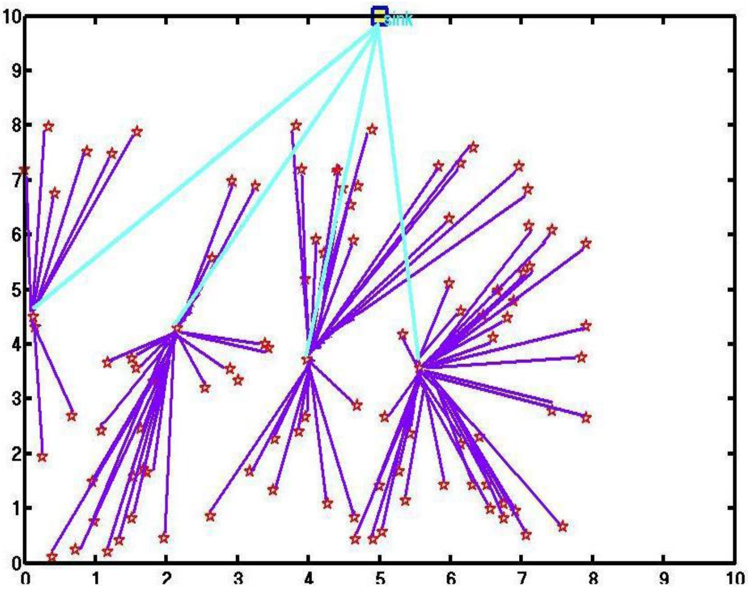


Figure 1: The LEACH Network model

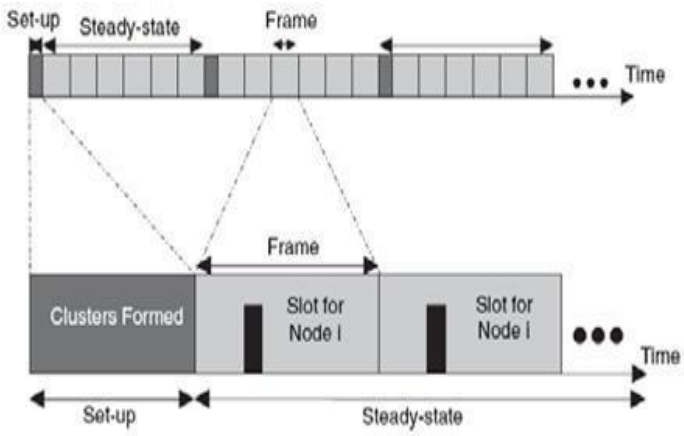


Figure 2: The LEACH protocol Phases.

III. Proposed heterogeneous energy efficient scheme: ASEP

Most of the analytical results for LEACH-type schemes are obtained assuming that the nodes of the sensor network are equipped with the same amount of energy this is the case of homogeneous sensor networks. In this paper had presented a paradigm of heterogeneous wireless sensor network and discuss the impact of heterogeneous resources. To study the impact of heterogeneity in terms of node energy SEP has designed where it is assumed that a percentage of the node population is equipped with more energy than the rest of the nodes in the same network this is the case of heterogeneous sensor networks.

In this section we describe ASEP (Advance Stable Election Protocol), which improves the stable region of the clustering hierarchy process using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes (m) and the additional energy factor between advanced and normal nodes (α). In order to prolong the stable region, SEP attempts to maintain the constraint of well balanced energy consumption. Intuitively, advanced nodes have to become cluster heads more often than the normal nodes, which is equivalent to a fairness constraint on energy consumption.

Energy analysis for ASEP can be considered as let E_0 = Initial energy of each normal sensor node.

$E_0 (1 + \alpha) = E_0 + \alpha E_0$ = the energy of each advance node

Hence, the total initial energy of the new heterogeneous setting is equal to

$$[n (1- m)* E0] + [n* m* E0 *(1+ \alpha)] =n*E0 (1+ \alpha * m) \text{ ---- } (1)$$

So total initial energy of the new heterogeneous setting is,

$$Etot = nE0+ \alpha\, mnE0 \quad \text{-------------------------- } (2)$$

For advantage of ASEP over LEACH in heterogeneous case we need two Improvements in existing LEACH analysis

1) Total energy of the system should be increased which can be possible as shown by equation (1). Here from nE0 (1+ α) we can observe that energy has been increased by a factor of $(1 + \alpha\, m)$.

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

------------------------ (3)

Because system has (m) times more energy and it seems virtually (m) more nodes. So, stable region of the sensor network can be increased by (1 + m) if

i) Each normal node becomes a cluster head once every rounds per epoch.

ii) Each advanced node becomes a cluster head exactly (1 +) times every rounds per epoch.

iii) Average number of cluster heads per round per epoch = n* p_{opt}.

IV. Application areas of heterogeneous approach

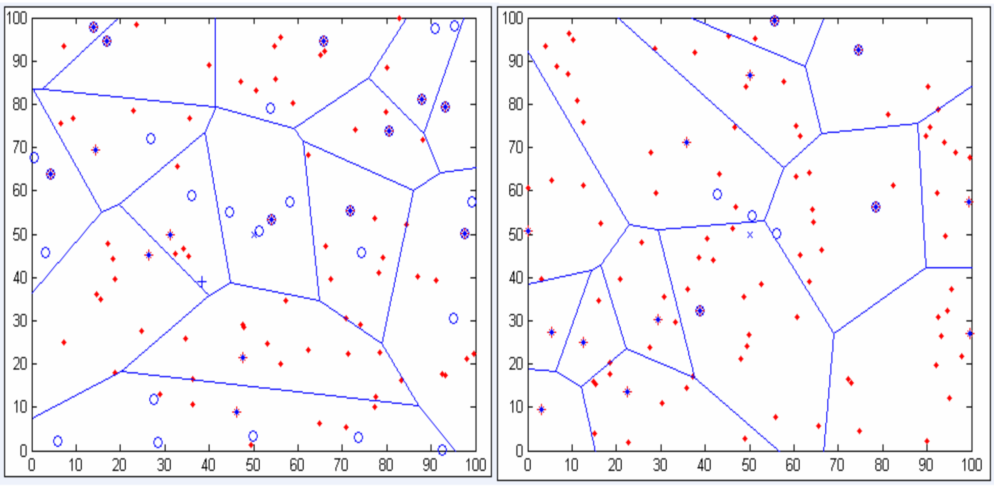
One of these applications could be the reenergization of sensor networks. As the lifetime of sensor networks is limited there is a need to re-energize the sensor network by adding more nodes. These nodes will be equipped with more energy than the nodes that are already in use which creates heterogeneity in terms of node energy. There are also applications where the spatial density of sensors is a constraint. Assuming that with the current technology the cost of a sensor is tens of times greater than the cost of embedded batteries, it will be valuable to examine whether the lifetime of the network could be increased by simply distributing extra energy to some existing nodes without introducing new nodes. In some applications, nodes could, over time, expend different amounts of energy due to the radio communication characteristics, random events such as short term link failures or morphological characteristics of the field (e.g. uneven terrain.)

V. Simulation and its parameters

A simulation is designed and implemented in MATLAB in order to investigate the energy efficiency with lifetime extension of the mentioned protocol. We simulated a wireless sensor network in a 100m*100m space and with an equal distribution of 100 sensors randomly by using MATLAB software. The primary energy of typical sensors is kept as 0.5J. Used radio characteristics in our simulations are as given in the table below:

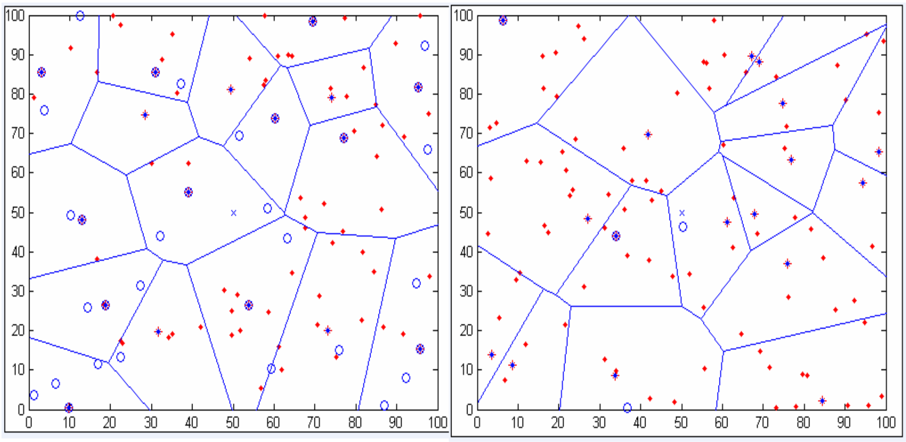
Sr.No.	Parameters	Specifications
1	Simulation Area (Xm * Ym)	100m * 100m
2	Sink Co-ordinates (sink.X * sink.Y)	(0.5Xm * 1.75Ym)
3	Number of nodes (n)	n = 100
4	Optimal election probability of a node to become a Cluster Head (p)	p = 0.1
5	Initial Energy (E0) of sensors	E0 = 0.5J
6	Eelec = ETx = ERx	50 nJ/bit
7	Transmitter amplifier energy dissipation a) Eamp ($d \leq d_0$) b) Eamp ($d > d_0$)	a) 10 pJ/bit/m2 b) 0.0013 pJ/bit/m4
8	Data Aggregation Energy (EDA)	EDA = 5 nJ/bit/signal
9	Maximum Rounds (rmax)	Variable (130;150;200)
10	Percentage of advance nodes (m)	Variable (10 ; 90)

Table 1: Radio characteristics / Simulation Parameters ASEP).



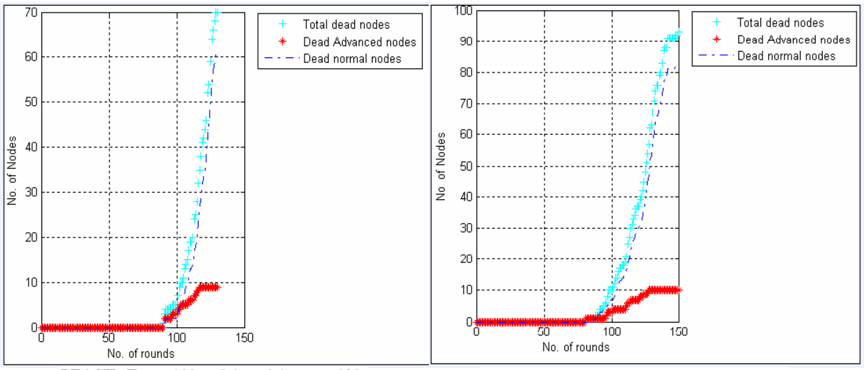
LEACH : For n=100;p=0.1;m=0.1;rmax=130 LEACH : For n=100;p=0.1;m=0.1;rmax=150

Figure 3: LEACH - N/W Status at end.



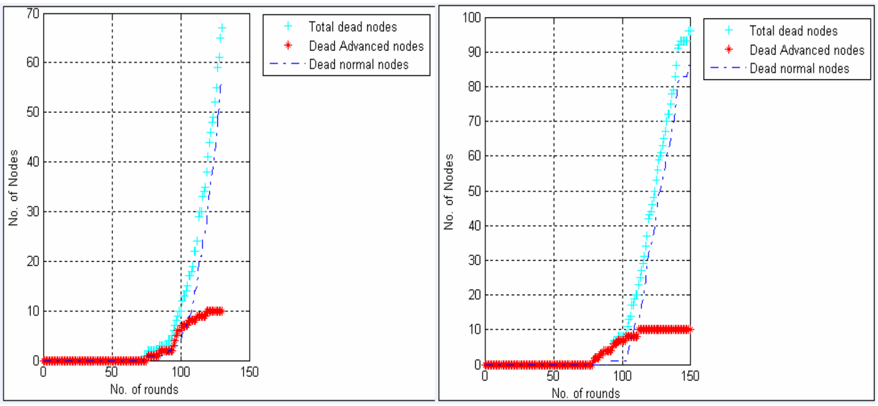
SEP: For n=100;p=0.1;m=0.1; rmax = 130 SEP: For n=100;p=0.1;m=0.1; rmax = 150

Figure 4: SEP - N/W Status at end



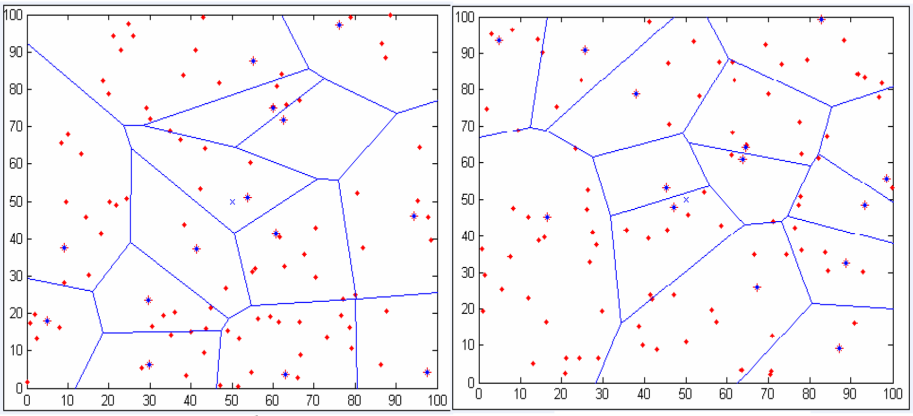
LEACH : For n=100;p=0.1;m=0.1; rmax=130 LEACH : For n=100;p=0.1;m=0.1; rmax=150

Figure 5: LEACH - Dead Nodes/round



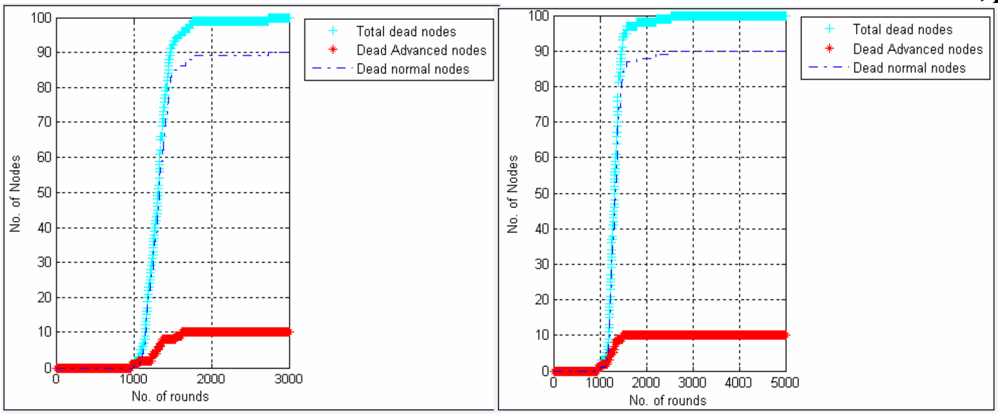
SEP : For n=100;p=0.1;m=0.1; rmax=130 SEP : For n=100;p=0.1;m=0.1; rmax= 150

Figure 6: SEP - Dead Nodes/round.



ASEP-NWstatus at end rmax=3000 ASEP-NWstatus at end rmax=5000

Figure 7: ASEP - N/W Status at end



ASEP-For n=100; p=0.1; m=0.1 rmax=3000 ASEP-For n=100; p=0.1; m=0.1 rmax=5000

Figure 8: ASEP - Dead Nodes/round.

VI. Conclusion

LEACH is heterogeneous-oblivious protocol where as SEP and ASEP are heterogeneous aware. SEP and ASEP is scalable and dynamic, as even normal node can be elected, no global knowledge required at every round. We show by simulation that ASEP always prolongs the stability period compared to (and that the average throughput is greater than) the one obtained using current clustering protocols. MANETs offer several significant advantages to a military force. A MANETs have an ability to self-form and self-manage, so if MANET sensor network is implemented with ASEP then it will eliminates the need for intensive central management of wireless sensor network

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