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TRAFFIC AND ENERGY AWARE ROUTING FOR HETEROGENEOUS WIRELESS SENSOR NETWORKS

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Abstract:-An efficient routing protocol can make heterogeneous WSN better to provide a reliable and energy efficient connectivity between nodes and the sink. When designing a routing protocol for heterogeneous. For efficient switching clock rate and to increase network robustness the system introduces 802.11 standard protocols. A C-MAC is introduced; it may be a feasible approach to prolong the network lifetime, yet maintaining the network connectivity. CMAC first uses any cast to wake up forwarding nodes, and then converges gradually from route-suboptimal any cast with unsynchronized duty cycling to route-optimal unicast with synchronized scheduling. Energy-balanced routing protocol, forwards data packets toward the sink through dense energy areas so as to protect the nodes with relatively low residual energy. The protocol is optimized dynamically by a constrained optimization problem. The objective function is the total energy consumption for transmitting and receiving packets from the edge cluster to the sink. Proposed to use a set of sub-optimal paths occasionally to increase the lifetime of the network. Motivated by the limitations of current approaches, propose a new MAC layer protocol called Convergent MAC (CMAC) that supports low latency and high throughput as well as low duty cycle operation. Simulation result illustrates the efficiency of the proposed system compared to algorithm developed for sensor network.

Keywords:- Mobile Computing, CMAC, 802.11, MANET, MAC.

I.INTRODUCTION

Internet of Things (IoT) envisions interoperability of heterogeneous devices to support diverse applications, and the Wireless Sensor Network (WSN) technology is an important building block of IoT sphere. Consideration of heterogeneity (e.g., energy, link and computational heterogeneities) [1] can improve the performance of WSN routing algorithms in terms of network lifetime, stability, reliability, network delay, etc. The energy heterogeneity in WSN routing is pursued widely; however, the link and computation heterogeneities, which are generally used along with the energy heterogeneity, are relatively less explored areas. In the early work in WSN routing algorithms for energy heterogeneous scenarios, Stable Election Protocol (SEP) [2] considers two-level energy heterogeneity in Low-Energy Adaptive Clustering Hierarchy (LEACH) [3] like cluster-head (CH) role rotation environment. SEP proposes weighted election probabilities based on the initial energies of the nodes to give energy-rich nodes more chances of becoming CHs. The Distributed Energy-Efficient Clustering (DEEC) [4] considers multilevel energy heterogeneous WSN and prefers nodes with higher initial energy and residual energy for CH role. The heterogeneity in terms of disparities in data generation rate (traffic) is considered under computation heterogeneity [5]. Sharma et al. [6] analyzed the effect of traffic heterogeneity in homogeneous WSN routing (LEACH) algorithm. Energy Dissipation Forecast and Clustering Management (EDFCM) [5] considers traffic heterogeneity along with energy heterogeneity in a very specific two-level WSN. Further, EDFCM considers additional nodes (management nodes) to control the number of clusters, which makes its natural distributed localized decision-making behavior questionable. The consideration of traffic heterogeneity along with energy heterogeneity is crucial for modeling realistic WSNs with application heterogeneity and event-driven scenarios. This letter considers both, energy and traffic heterogeneities, with multiple random levels. An energy model is presented for the multi-heterogeneity scenario, where consideration of multi-level traffic heterogeneity is a novel concept. A novel routing algorithm named Traffic and Energy Aware Routing (TEAR) is presented, which considers node's traffic requirements along with its energy levels while making CH selection. TEAR shows improvements in terms of stability period (reliable lifespan of the WSN before the death of its first node) over existing algorithms (LEACH, SEP and DEEC) under the scenario. The rest of this letter is arranged as follows. Section II presents the system model, which includes the energy model for the multi-heterogeneous scenario. In Section III, the proposed routing algorithm is described. The simulation results have been discussed in Section IV. Finally, Section V concludes the letter.

II.LITERATURE SURVEY

Heinzelman W. Chandrakasan A. Balakrishnan H. The simulations show that: (i) LEACH reduces communication energy by as much as 8x compared with direct transmission and minimum- transmission-energy routing. (ii) The first node death in LEACH occurs over 8 times later than the first node death in direct transmission, minimum-transmission-energy routing, and a static clustering protocol, and the last node death in LEACH occurs over 3 times later than the last node death in the other protocols. Providing such a low-energy, ad hoc, distributed protocol will help pave the way for future micro sensor networks. Meenakshi Sharma, Kalpana Sharma EEE LEACH or Energy Efficient Extended LEACH is an approach of multilevel clustering technique to increase energy efficiency by reducing its radio communication distance. In this multilevel clustering approach besides having a single layer of clusters formation between the nodes and Base station like LEACH, it involves two layers of clusters formation. In the first layer CHs are formed where the normal nodes transmit their own data to their respective CH and by using the fuse mechanism the CHs aggregate the received data. Arezoo Yektaparast, Betsy Mariam Varghese et al, International Journal of Computer Science and Mobile Computing, Vol.3 Issue.11, November- 2014, pg. 242-250 © 2014, IJCSMC All Rights Reserved 244 Fatemeh-Hoda Nabavi, Adel Sarmast, and Wireless sensor network is a wireless network consisting of independent sensor, communicating with each other in distributed fashion to monitor the environment. Sensors are usually attached to microcontroller and are powered by battery. The goal of Wireless sensor network is to have long life time and high reliability with maximum coverage. Routing techniques are the most important issue for networks where resources are limited. LEACH is one of the first hierarchical routing approaches for sensor networks. Most of the clustering algorithms are derived from this algorithm. In this paper we propose an improvement on the LEACH Protocol. In our proposed algorithm, every cluster divided into 7 subsections that are called cells. Also every cell has a cell-head. Cell-heads communicate with cluster-heads directly.

III.METHODOLOGY

CMAC Proposed a MAC layer protocol called Convergent MAC (CMAC) that supports low latency and high throughput as well as low duty cycle operation. CMAC has three main components: Aggressive RTS equipped with double channel check for channel assessment, any cast to quickly discover forwarder, and convergent packet forwarding to reduce the any cast overhead. In this section, firstly an overview on how CMAC works is given, and then the detailed design of CMAC follows.

CMAC Overview

When there is no traffic in the network, CMAC uses unsynchronized wake-up scheduling with a pre-defined idle duty cycle (i.e., the duty cycle followed by nodes when there is no traffic). In this wake-up scheduling scheme, the duration between successive wake-ups is fixed according to the duty cycle and active period. However, to make the following mechanisms work at expected performance, we evenly randomize the wake-up time of each node for the first times it goes back to sleep after receiving a packet. While transmitting packets, the transmitter uses aggressive RTS instead of a long preamble to activate the receiver. To detect aggressive RTS, nodes periodically wake up and

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"double check" the channel for activities. Unlike other unicast MAC layer protocols, CMAC initially uses any casts to transmit packets to a potential forwarder that wakes up first. Awake candidate receivers will contend to be the any cast receiver by prioritizing their CTS transmissions according to their routing metrics to the sink. After receiving a CTS, the data packet will be sent to the sender of the CTS immediately. Nodes will keep their radios "on" for a short duration anticipating more packets whenever they successfully receive data packets destined to them. This reduces the overhead of searching for awake forwarders in subsequent transmissions.

Motivated by the limitations of current approaches, we propose a new MAC layer protocol called Convergent MAC (CMAC) that supports low latency and high throughput as well as low duty cycle operation. An C-MAC may be a feasible approach to prolong the network lifetime, yet maintaining the network connectivity. Energy-balanced routing protocol, forwards data packets toward the sink through dense energy areas so as to protect the nodes with relatively low residual energy. The metric is measured as the percent of energy consumed by a node with respect to its initial energy. The initial energy and the final energy left in the node, at the end of the simulation run are measured. The percent energy consumed by a node is calculated as the energy consumed to the initial energy. And finally the percent energy consumed by all the nodes in a scenario is calculated as the average of their individual energy consumption of the nodes. The metric is measured as the percent of energy consumed by a node with respect to its initial energy. The initial energy and the final energy left in the node, at the end of the simulation run are measured. The percent energy consumed by a node is calculated as the energy consumed to the initial energy.

Percent Energy consumed =[(Initial Energy –Final Energy)/Initial Energy]*100

Average_Energy_consumed=Num_of_precent_Energy_consumed_by_All_Nodes/Num_of_Nodes

Residual_Energy=total_energy_given_to_all_nodes-Sum_of_energy_consumed_by_all_nodes To allow nodes to work at a very low duty cycle, nodes must assess the channel very quickly each time they wake up. However, if the receiver wakes up during the gap between two RTS transmissions, it may miss this RTS burst. So we propose to use double channel check which works by assessing the channel twice with a fix short separation between them each time a node wakes up. For each channel check, nodes sample the channel for up to 5 times. Between these two channel checks, the radio could be put to sleep mode to save energy. If the first check detects a busy channel, the second check will be canceled. Otherwise, the second check is performed. The positive conclusion on busy channel from either check will keep the node awake anticipating an RTS.

III.PROPOSEDROUTINGALGORITHM

This section first discusses in brief the effects of energy and traffic heterogeneities, which provides insight for an effective CH selection in multi-heterogeneity scenario. Then, the proposed routing protocol is presented, which considers nodes' initial energy, residual energy and traffic load along with the average energy of the round during CH selection. A. Traffic and Energy Heterogeneities in WSN An increase in traffic heterogeneity, by increasing nodes' packet lengths, increases the effective number of bits per round for communication. This increases the WSN energy consumption per round and reduces the WSN lifetime (and the stability period). The effect is discussed further in Section IV based on simulation results.

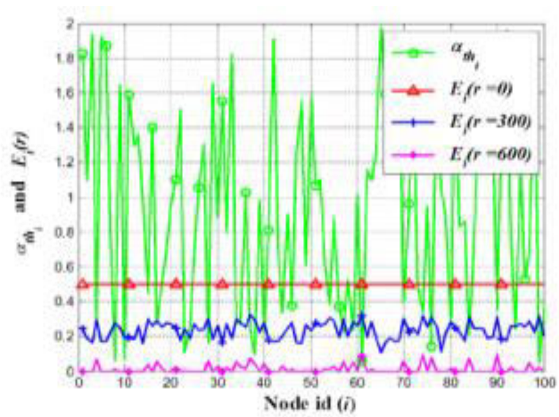

Fig.1.Energy consumption pattern of traffic heterogeneous node

The nodes residual energies are analyzed over the WSN lifetime for different traffic heterogeneous scenarios (i.e. for different $\alpha th$with αeh = 0). Fig. 1 shows the energy consumption pattern over the

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rounds of operation for a traffic heterogeneous scenario (αth = 2; αeh = 0) in DEEC environment. $E(r)$ is the residual energy of node i for the round r. It shows that the nodes with higher traffic load (i.e. higher αth) lose their energies faster in comparison to the nodes with lower traffic loads over the rounds of operation. Under two-level energy heterogeneous WSN, SEP performs better than LEACH by preferring nodes with higher initial energy for CH role. DEEC performs better than LEACH and SEP under multi-level energy heterogeneous WSN by preferring nodes (for CH role) with higher initial and residual energies over the average energy of the round.

B. Traffic and Energy Aware Routing (TEAR)

The CH selection in TEAR is based on the CH role rotation approach [2-4], where the node i becomes a CH in the current round r, if the random number selected by the node i is less than the threshold T(i, r)

$$T(i,r) = \begin{cases} \frac{p_i(r)}{1-p_i(r)(r \bmod \frac{1}{p_i(r)})} & if \quad node\ i \in G(r) \\ 0 & otherwise \end{cases}$$

Where $p(r)$ is the CH selection probability for node i during round r. (r) is a set of eligible nodes for the round r, where the rotating epoch for node i to become eligible again is $1/pi(r)$. DEEC considers randomly distributed energy heterogeneity and prefers nodes with higher initial and residual energies for CH role, i.e. an energy-rich node has higher $p(r)$ and higher chances of becoming CH. As the operations of a CH are energy intensive, preferring nodes with higher initial energies and higher residual energies improves the life of energy weaker nodes and hence it improves the WSN stability period. Section IIIA discusses that an increase in traffic loads increases the effective number of bits to be communicated to the BS and hence increases network energy consumption. In traffic heterogeneous scenario, the rate of energy consumption is higher for the nodes with higher traffic loads. So, it is logical that such nodes should be avoided for energy intensive operation, e.g., CH role. For a realistic WSN model, with the nodes having heterogeneous initial energies and data traffic requirements, the proposed algorithm (TEAR) prefers the nodes with higher energies (initial and residual) and avoids the nodes with higher traffic loads for CH role. In TEAR, the probability of becoming CH for node i during round r is defined as

$$p_i(r) = \frac{p_{opt}.N(1+\alpha_{eh_i})\,N(1+\alpha_{th}-\alpha_{eh_i})E_i(r)}{(N+\sum_{i=1}^{N}\alpha_{eh_i})(N+N\alpha_{th}-\alpha_{Tot})E_{Avg}(r)}$$

Where $EAv(r)$ is average energy of the round and $popt$ is optimal probability of a node to become CH, given by $popt = kopt\ N$. The remaining functionality of TEAR is similar to DEEC. Further, in the absence of traffic heterogeneity, TEAR falls back to DEEC behaviour. Based on DEEC, the $EAv(r)$ is given by

$$E_{Avg}(r) = \frac{1}{N} E_{Tot}\left(1-\frac{r}{R}\right); \quad where \ \ R = \frac{E_{Tot}}{E_{Round}}$$

Where R is the estimated value of network lifetime in terms of the number of rounds based on uniform energy drainage in each round. In actual scenario, the network energy may not drain in a uniform manner and few nodes remain alive for $r > R$. Based on (16), when r approaches R, $EAv(r)$ becomes a very small quantity and for $r > R$ it becomes a negative quantity. In DEEC, R is considered 1.5 times of the estimated value to avoid the situation where the last few remaining nodes stay alive and do not form clusters. Many approaches have been proposed in the literature to improve the accuracy of estimated energy per round, e.g., SEARCH [7] considers a semi-centralized approach, where BS keeps track of alive nodes and their residual energies to estimate the average residual energy of the network over the rounds of operation. This letter focuses on heterogeneity aspects and a simple approach is applied to handle the scenario. The $EAv(r)$ is considered as the value $EAvg(0.9R)$ for the rounds r > $0.9R$ to ensure active participation of remaining nodes in cluster formation for the remaining rounds. This is a better approach for distributed decision-making as nodes are aware of R and it can handle the scenarios, where r is much greater than R. The values of $ETot$ and R are calculated and supplied (through BS broadcast message or node's initial settings) to the nodes before the beginning of WSN operations.

IV. RESULTS AND DISCUSSION

The simulation setup considers 100 nodes (N), with randomness in energy and traffic levels,

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deployed uniformly in a 100m x 100m (R × R) area with BS located at the centre of the region. The system model for the multi-heterogeneity approach is based on Section II. All the scenarios have been simulated in MATLAB and the simulation parameters are detailed in TABLE I. LEACH and SEP have been modified to support multi-level energy heterogeneity based on [4]. Further, the algorithms are customized to support energy consumption in multi-level traffic heterogeneity, where nodes consider their specific traffic and the aggregated message sent from CH to BS is $mmax$ bits long. To handle the traffic heterogeneity in DEEC, it has been extended based on the above sections (except the proposed probability function for TEAR). Fig. 2 shows the effect of multi-level traffic heterogeneity on LEACH, SEP and DEEC algorithms in the multi-level energy heterogeneous scenario. An increase in node packet size (from αth = 0 to αth = 2), while maintaining the energy heterogeneity (αeh = 3), deteriorates the stable region of all the three algorithms.

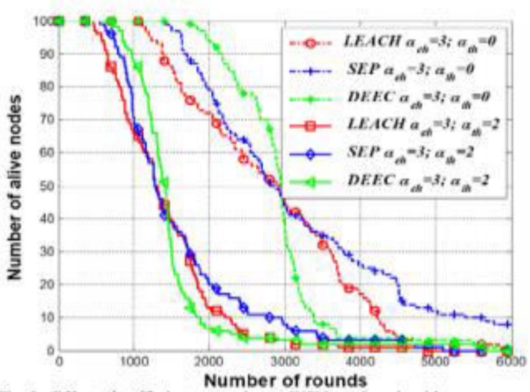

Fig. 2. Effect of traffic heterogeneity on WSN routing algorithms

The performance of proposed algorithm (TEAR) under multi-heterogeneity scenario is depicted in Fig. 3 for (αth = 4; αeh = 1), where the stability periods are 285, 280, 291 and 379 for LEACH, SEP, DEEC and TEAR respectively. Fig. 4 shows a similar scenario for (αth = 2; αeh = 1), where the stability periods are 521, 448, 567 and 614 for LEACH, SEP, DEEC and TEAR respectively. TEAR shows improvement in the stability period over LEACH, SEP and DEEC algorithms under the multi-heterogeneity scenario. The detailed results of TEAR under different heterogeneity parameter (αth and αeh) are shown in TABLE II, where each instance (mean and standard deviation) is based on analyzing the algorithm on a set of ten random WSN deployments

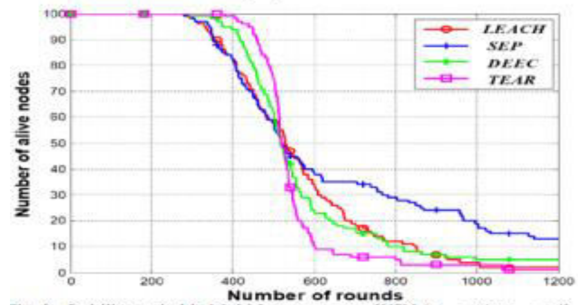

Fig. 3. Stability period in Multi-heterogeneous WSN (α_{th} = 4; α_{eh} = 1)

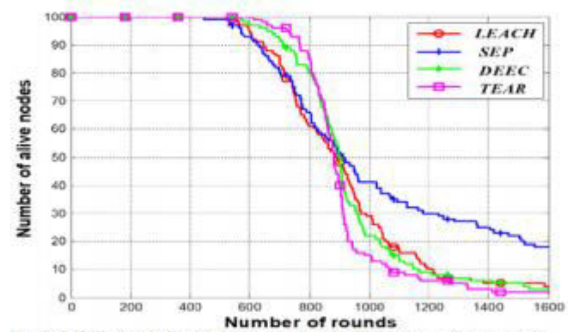

Fig. 4. Stability period in Multi-heterogeneous WSN (α_{th} = 2; α_{eh} = 1)

The results show that the extended version of SEP (based on [4]) do not perform well under traffic heterogeneity scenarios. As SEP considers initial energies in CH selection, it does not perform well with increase in traffic loads. DEEC better handles (over SEP) the increase in traffic heterogeneity, as it also considers node's residual energy. TEAR shows improved performance with increased traffic as it additionally considers the traffic loads while making CH decision. In the absence of traffic heterogeneity, TEAR performs like DEEC. However, TEAR performs better than all the three algorithms in the presence of traffic heterogeneity.

V. CONCLUSION

Consideration of multi-heterogeneity in WSN routing algorithms can help in achieving optimal resource utilization in realistic scenarios. This letter considers WSN nodes with random levels of energy and traffic heterogeneities. It devises a traffic and energy aware routing (TEAR) technique with an improved CH selection method, which considers node's traffic along with its initial energy

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and residual energy. TEAR performs better, in terms of stability period, over legacy algorithms (LEACH, SEP and DEEC) in the multiheterogeneous scenario. Further, the multi-heterogeneity concept (especially the traffic heterogeneity consideration) could be helpful in developing more effective routing algorithms for realistic WSNs and Internet of Things applications with heterogeneous sensing requirements.

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