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MTEAR: Energy Efficiency Routing Protocol for Network Traffic Control in Wireless Sensor Network

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ABSTRACT

Energy-Efficiency of routing algorithm is crucial for improving the lifetime of battery constrained Wireless Sensor Networks (WSNs). Consideration of nodes heterogeneity in routing is essential for achieving optimal resource utilization. Sensor nodes with random initial energies and random disparities in data generation rate (traffic) to model a realistic clustering based WSN suited for heterogeneous sensing applications. An energy model for the scenario and proposes a Traffic and Energy Aware Routing (TEAR) scheme to improve the stability period. The simulation results indicate that TEAR outperforms other clustering based routing algorithms under the scenario.

1.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 multi-level energy heterogeneous WSN and prefers nodes with higher initial energy and residual energy for CH The authors are with the CSIR-Central Scientific Instruments Organisation, Chandigarh, India and the Academy of Scientific and Innovative Research, CSIR-CSIO campus, India (e-mail: deepakskc@yahoo.com). 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 level.

2. LITERATURE REVIEW

[1] S. Tanwar, N. Kumar, and J. J. Rodrigues, "A systematic review on heterogeneous routing protocols for wireless sensor network," Journal of network and computer applications, vol. 53, pp. 39-56, 2015.

We propose an empirical and custom model with clustering with optimal cost for wireless route implementation. Even though various models proposed by various authors from years of research, every model has its own advantages and disadvantages. We propose a proficient routing method with ideal parameters like sign quality, channel limit, line delay and in-out. In this model we wipe out the superfluous nodes or transitional nodes while transfer of data among source and destination. Cluster usage association the comparable kind of items dependent on the scopes and longitudes of the nodes. Our proposed model gives more efficient results than traditional models.

[2] G. Smaragdakis, I. Matta, and A. Bestavros, "SEP: A stable election protocol for clustered heterogeneous wireless sensor networks," in Second international workshop on sensor and actor network protocols and applications (SANPA 2004), 2004.

We study the impact of heterogeneity of nodes, in terms of their energy, in wireless sensor networks that are hierarchically clustered. In these networks some of the nodes become cluster heads, aggregate the data of their cluster members and transmit it to the sink. We assume that a percentage of the population of sensor nodes is equipped with additional energy resources—this is a source of heterogeneity which may result from the initial setting or as the operation of the network evolves. We also assume that the sensors are randomly (uniformly) distributed and are not mobile, the coordinates of the sink and the dimensions of the sensor field are known. We show that the behavior of such sensor networks becomes very unstable once the first node dies, especially in the presence of node heterogeneity. Classical clustering protocols assume that all the nodes are equipped with the same amount of energy and as a result, they can not take full advantage of the presence of node heterogeneity. We propose SEP, 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 where the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. We show by simulation that SEP always prolongs the stability period compared to (and that the average throughput is greater than) the one obtained using current clustering protocols. We conclude by studying the sensitivity of our SEP protocol to heterogeneity parameters capturing energy imbalance in the network. We found that SEP yields longer stability region for higher values of extra energy brought by more powerful nodes.

[3] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks,"

Wireless Communications, IEEE Transactions on, vol. 1, pp. 660-670, 2002.

Aiming at the problem that node load is rarely considered in existing clustering routing algorithm for Wireless Sensor Networks (WSNs), a dynamic clustering routing algorithm for WSN is presented in this paper called DCRCL (Dynamic Clustering Routing Considering Load). This algorithm is comprised of three phases including cluster head (CH) selection, cluster setup and inter-cluster routing. First, the CHs are selected based on residual energy and node load. Then the non-CH nodes choose a cluster by comparing the cost function of its neighbor CHs. At last, each CH communicates with base station by Evaluation of routing protocols that consider traffic patterns and characteristics in their routing decisions. Protocols such as CTP (Collection Tree Protocol) and RPL (Routing Protocol for Low-Power and Lossy Networks) may be discussed here for their approaches to handling network traffic.

using multi-hop communication. The simulation results show that comparing with the existing one, the techniques life cycle and date volume of the network are increased by 30.7 percent and 29.8 percent respectively by using the proposed algorithm DCRCL.

[4] L. Qing, Q. Zhu, and M. Wang, "Design of a distributed energyefficient clustering algorithm for heterogeneous wireless sensor networks," Computer communications, vol. 29, pp. 2230-2237, 2006.

The clustering Algorithm is a kind of key technique used to reduce energy consumption. It can increase the scalability and lifetime of the network. Energy-efficient clustering protocols should be designed for the characteristic of heterogeneous wireless sensor networks. We propose and evaluate a new distributed energy-efficient clustering scheme for heterogeneous wireless sensor networks, which is called DEEC. In DEEC, the cluster-heads are elected by a probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster-heads for nodes are different according to their initial and residual energy. The nodes with high initial and residual energy will have more chances to be the cluster-heads than the nodes with low energy. Finally, the simulation results show that DEEC achieves longer lifetime and more effective messages than current important clustering protocols in heterogeneous environments.

[5] H. Zhou, Y. Wu, Y. Hu, and G. Xie, "A novel stable selection and reliable transmission protocol for clustered heterogeneous wireless sensor networks," Computer communications, vol. 33, pp. 1843- 1849, 2010.

In this paper, a new model with energy and computational heterogeneity is proposed for heterogeneous wireless sensor networks (HWSNs). The energy dissipation structure and the optimum number of clusters in HWSNs are also obtained under a mathematical model, providing the guidance for designing the clustering protocols. Moreover, a novel energy efficient protocol that can guarantee the reliable transmission for HWSNs is designed to improve the clustering scheme in low-energy adaptive clustering hierarchy (LEACH) and LEACH-type protocols, in which the cluster head selection algorithm is based on a method of energy dissipation forecast and clustering management (EDFCM). EDFCM considers the residual energy and energy consumption rate in all nodes. Simulation results show that EDFCM balances the energy consumption better than the conventional routing protocols and prolongs the lifetime of networks obviously.

3. PROPOSED METHOD

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

(αth = 2; αeh = 0) in DEEC environment. $Ei(r)$ is the residual energy of node i for the round r. It shows that the nodes with higher traffic load (i.e. higher αthi) 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).

$$T(i,r) = \begin{cases} \frac{p_i(r)}{1-p_i(r)(r \bmod \frac{1}{p_i(r)})} & if \quad node\ i \in G(r) \end{cases} \qquad (14)$$

$otherwise$ Where $pi(r)$ is the CH selection probability for node i during round r. $G(r)$ 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 $pi(r)$ 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

$$p_i(r) = \frac{p_{opt}.N(1+\alpha_{eh_i})\, N(1+\alpha_{th}-\alpha_{eh_i})E_i(r)}{(N+\sum_{i=1}^{N}\alpha_{eh_i})(N+N\alpha_{th}-\alpha_{Tot})E_{Avg}(r)} \qquad (15)$$

Where $EAvg(r)$ is average energy of the round and $popt$ is optimal probability of a node to become CH, given by $opt = kopt\ N$. 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 $Avg(r)$ is given by

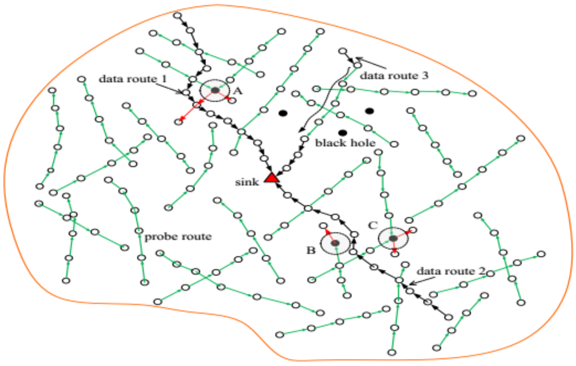
$$\bar{E}_{Avg}(r) = \frac{1}{N}\bar{E}_{Tot}\left(1-\frac{r}{R}\right); \ where \ R = \frac{E_{Tot}}{E_{Round}} \qquad (16)$$

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. Based on (16), when r approaches R, $EAvg(r)$ 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 $EAvg(r)$ 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.

TABLE I
SIMULATION PARAMETERS

Parameter	Value
Number of sensor nodes (N)	100
WSN Area ($R \times R$)	$100m$ x $100m$
Initial energy lower bound (E_0)	$0.5J$
Energy consumed in Tx/Rx electronics (E_{ele})	50 nJ/bit
Tx Amplifier energy dissipation in free space scenario (ϵ_{fs})	10 $pJ/bit/m^2$
Tx Amplifier energy dissipation in Multipath scenario (ϵ_{mp})	0.0013 $pJ/bit/m^4$
Energy consumed in Data Aggregation (E_{DA})	5 $nJ/bit/signal$
Packet length lower bound (m_0)	4000 $bits$

PRODUCT ARCHITECTURE



4. RESULT AND ANALYSIS

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

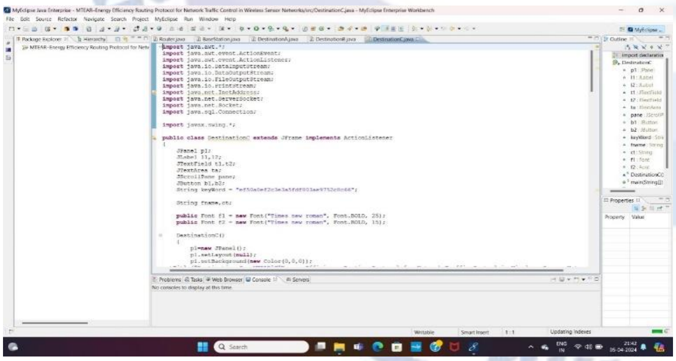


Figure1: router .java

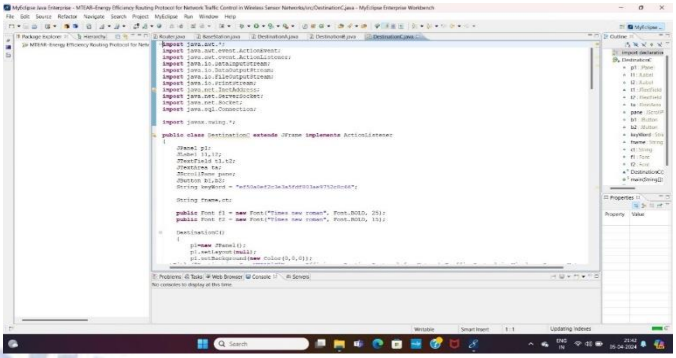


Figure2:basestation.java

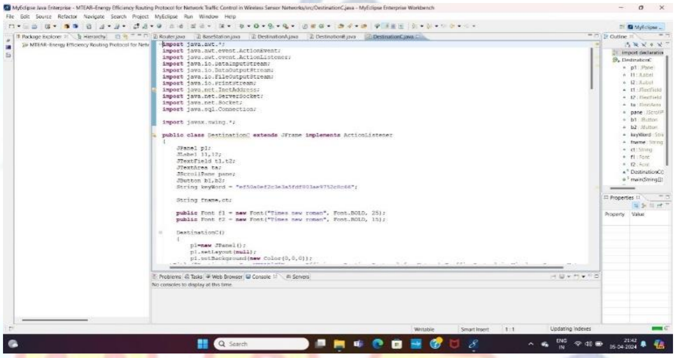


Figure3:destination.java

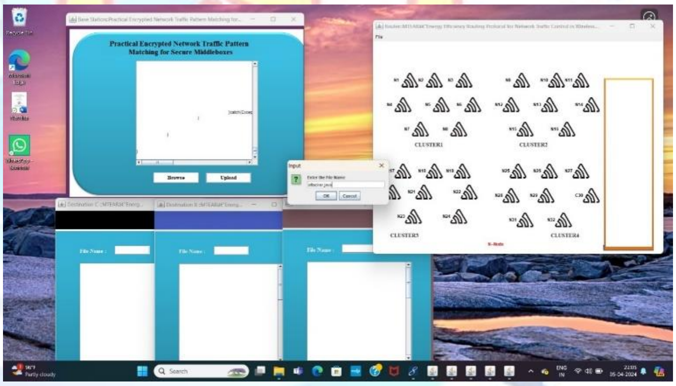


Figure4:Here three recieversis used to send the data sender to router is used to transmit the data

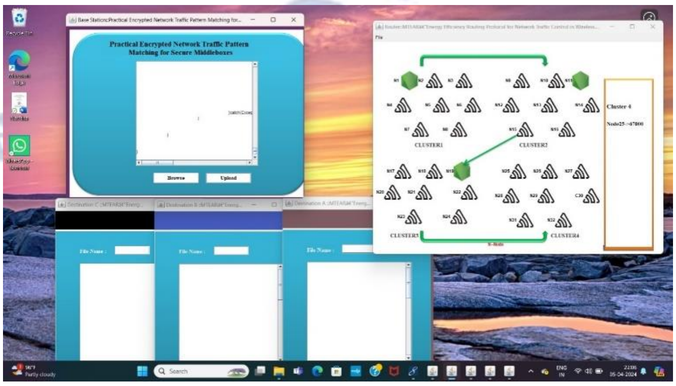


Figure5: finally the transmission is done it is used to transmit the data from one cluster to another cluster

5.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 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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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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