A Methodology for an Efficient and Relaible Routing Scheme for Internet Connected Devices

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***Abstract*—The internet connected devices (ICD) are more energy constrained technology as the data requires more energy to transmit. In this paper we considered the wireless sensor networks as the application domain of Internet connected Devices. In this paper we proposed an Energy Efficient(EE) and reliable Algorithm for wireless Sensor Networks .Most of the existing protocols works for the static nodes and base station instead we proposed the algorithm for Mobile nodes as well base station.**

The proposed algorithm is hierarchal and cluster based, each cluster contains one cluster head and one deputy cluster head. The data can be transferred from the cluster to the base station in single or multihop manner. In this paper we compared our algorithm with the existing algorithm used for the Mobile nodes and base station on the basis of Energy Efficiency, throughput and Life time of the nodes to prolong the sustainability of the algorithm.

Keywords—Wireless Sensor Networks (WSN), Energy-Efficient (EE) routing algorithm, Internet Connected Devices (ICD).

I. INTRODUCTION

Internet has revolutionized modern world by influencing every aspect of human life by providing seamless communication without geographical barriers. Gone are the days when communication was strictly limited to writing letters and waiting for postal services to deliver them. Technological advancements do not merely close the communication gap but also influences various other sectors such as healthcare, industrial automation, agriculture, transportation and education. The advent of wireless communication has made network connectivity slightly more ethereal. The presence of innovative technological devices in the Internet has not only broadened its scope but also provides an interoperable wireless connectivity anytime, anywhere and on any device in the world. This is something difficult to happen in any traditional wired infrastructure. The latest technological advances in Micro-Electro-Mechanical Systems (MEMS) have enabled the development of miniaturized sensor nodes [2]. These nodes are small in size, with limited computation and processing capabilities, and they operate on small batteries. Furthermore, they have limited storage and typically have a limitation on their transmission range. These tiny sensor nodes have brought a revolution in the world of wireless communication by operating in remote and human-inaccessible terrains. Wireless Sensor Network (WSN) is comprised of such tiny nodes which are deployed to monitor and gather data from the physical environment. The data is routed to a centralized base station for further processing to obtain valuable and meaningful information. WSNs possess some unique characteristics such as self-healing, self-organization, scalability and fault tolerance [3]. These networks are considered as the next wave in computing as they are typically deployed in environments which cannot be monitored with wired networks. As a result, they have found their applications in various domains such as automated irrigation system [4], tele monitoring system for healthcare [5], forest fire monitoring [6] and air pollution monitoring system [7].In WSNs, the nodes are either static or mobile depending on the nature of monitored application. Most applications rely on static deployment, which has several drawbacks [8]. First, static deployment cannot guarantee an optimal coverage of the sensor field. Even a large-scale deployment of nodes may not be sufficient to provide an optimal coverage. Static deployment may result in severe consequences if all the critical events occur outside the designated region of interest. Second, when static nodes die or malfunction, they create“holes” in the network which causes a communication gap among the sensor nodes. Thus, the network connectivity is affected, causing packet loss and degradation of the network quality. Another major drawback of static deployment is the role of gateway nodes, which are one-hop away from the base station. These nodes consume a considerable amount of energy because the whole of network traffic is routed toward the base station via them. By contrast, mobile nodes move around the field to produce different sets of gateway nodes in the entire span of network lifetime. As a result, the energy load is uniformly distributed among all the nodes in the network to act as gateway nodes [9]. Mobile nodes ensure complete coverage by capturing events and transmitting them to the base station. Mobile WSNs improve the coverage, connectivity, energy consumption and other Quality of Service (QoS) metrics [10]. In many applications, the sensor nodes do not need to be mobile. However, they require data mules [11] to gather their data and transmit to the base station. Data mules not only carry the data to a base station but also maintain high connectivity to ensure a robust data flow. In WSNs, the nodes are deployed and left unattended to monitor an application. These nodes need to operate with minimal human intervention. Furthermore, it is infeasible to replace their batteries especially when they are deployed in a hostile environment. Therefore, special considerations need to be in place in order to efficiently utilize the limited battery power of the nodes. In these networks, most of the energy is consumed in data transmission as compared to data processing. Therefore, energy-efficient routing protocols need to be carefully designed to maximize the lifetime of these networks. In these networks, routing is a challenging task because they possess several unique features which differentiate them from contemporary communication and wireless ad hoc networks [12]. First of all, it is very difficult to build a global addressing scheme due to the sheer number of deployed nodes. As a result, classical IP-based protocols are not suitable for such networks. Second, the source nodes in close vicinity capture identical data packets and as such, there is high redundancy in the gathered data. It is of utmost importance that such redundant data packets are eliminated by routing protocols to improve energy consumption, bandwidth utilization and quality of the data. Third, sensor nodes have strictly limited resources and any routing protocol must abide by such limitations. Fourth, sensor nodes operate in harsh environment and as such, they are prone to failure..

II. Network Architectural Model

In our proposed scheme, the sensor nodes are deployed in a (210 ×210) square meter geographical region. All nodes are dynamic and are randomly deployed. We make the following assumptions about the architectural model of our proposed scheme.

- Base station and sensor are mobile and located outside a sensor field.
- All nodes have the same initial residual energy at the time of deployment.
- Nodes have the ability to adjust their transmission power.
- Nodes sense the environment at a fixed rate and always have data to transmit.

In WSNs, the lifetime of sensor nodes depend on their communication patterns. In these networks, the energy consumption in communication is much higher than data processing and data sensing [13]. The distance among the neighboring nodes determines the type of communication model to be used. If the distance between a transmitter node and a receiver node is less than crossover distance (*dc*), free-space propagation model (*fs*) is used; otherwise, multipath ground propagation model (*mp*) is used [14]. In a free-space model, there is a line-of-sight connection between a transmitter and a receiver node. In a multipath model, a radio signal travels through multiple paths due to reflection, refraction and deflection through various obstacles. Irrespective of the type of model, the crossover distance between a transmitter and a receiver node is calculated using Equation (1).

$$d_c = \frac{4\pi h_t h_r \sqrt{L}}{\lambda} \quad (1)$$

Here, h_t, h_r are the heights of transmitter and receiver antennas, L is the system loss factor and λ is the wavelength of a radio signal. In general, L >1, but if there is no loss in system hardware, then L=1 [15].

In our scheme, the radio model of the transmitter and receiver node is similar to *first order* radio model [16]. The electronic component of a node is responsible for processing the data while the amplifier component performs the transmission of data over low-power loss links of WSNs. The radio communication among any transmitter node and a receiver node is shown in Fig. 1. A transmitter node processes a *k*-bits packet and transmits to a receiver over a distance *d*. The value of *d* determines the type of model to be used between any two sensor nodes. If $d < dc$, free-space propagation model is used, otherwise, multipath ground propagation model is used.

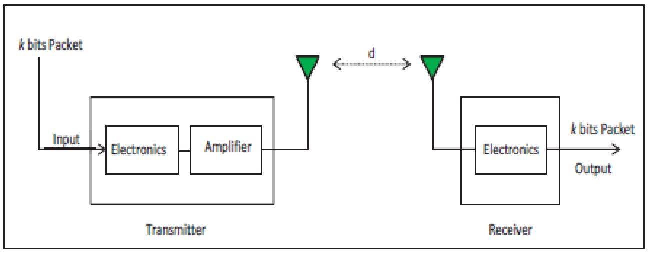


Fig: 1. Radio communication Model

The amount of energy consumed by a transmitter node (E_{Tx}) in transmitting a *k*-bits packet over a distance *d* in a free-space model is calculated using Equation (2).

$$E_{Tx}(k,d) = kE_{elec} + ke_{fs}d^{2,} \quad d < d_c \quad (2)$$

Here, E_{elec} and f_s are the energy consumptions of the electronic and amplifier components of a transmitter node. The free-space assumption is being used to allow comparison with existing work which does use this assumption. For a multipath ground propagation model, the energy consumption of a transmitter node is calculated using Equation (3).

$$E_{Tx}(k,d) = kE_{dec} + ke_{fs}d^{2,} \quad d \geq d_c (3)$$

Here, m_p is the energy consumption of the amplifier component in a multipath model. Irrespective of the type of model, the energy consumption of a receiver node (E_{Rx}) stays the same and is calculated using Equation (4)

$$E_{Rx}(k,d) = KE_{elec} \quad (4)$$

$$E_{Tx}(k,d) = kE_{elec} + ke_{fs}d^{2,}$$

$$d < d_c$$

III. Network Operational Model

Here, we provide a brief overview of the underlying operational model of our proposed routing algorithm. The main objective is to improve the network lifetime and quality of the data delivered at the base station. Upon network deployment, each node *n* chooses a random number between 0 and 1 in each round. If the random number is less than threshold value (*T (n) proposed*) of Equation (5), the node is elected as cluster head for the current round. Unlike LEACH protocol [17], our proposed algorithm elects the cluster heads based on the consumed energy (*Econ*) of each node.

$$T(n)_{proposed} = \begin{cases} \dfrac{k_{opt}}{1 - k_{opt}\left(r \bmod \left(\frac{1}{k_{opt}}\right)\right)} \\ \times E_{con}, n \in G \end{cases} \quad (5)$$

The inclusion of *Econ* in Equation (5) reduces the likelihood of lower energy nodes being elected as cluster heads in each round. The unit of E*con* is joule. Our proposed cluster based routing algorithm has significant improvement over LEACH protocol in terms of cluster head selection. However, the probabilistic nature of Equation (5) cannot completely

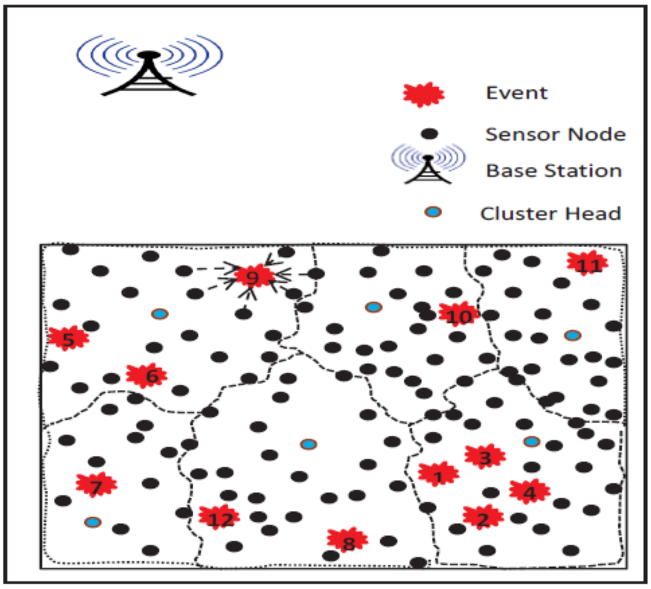


Fig: 2. Sensing Similar Events

rule out the possibility of lower energy nodes being elected as cluster heads. The use ofa random number generation approach in LEACH protocol elects *x* nodes as cluster heads for a network of *n* nodes in each round, where *x* _ *n*. However, the inclusion of *Econ* further reduces the number of cluster heads to *y* nodes, where *y* < *x* ⋀ *y* _ *n*.

Using Boston University source code1, LEACH protocol generates anything between 0 and 22 cluster heads in various rounds. When there are no cluster heads in a particular round, it means that LEACH protocol operates similar to data-centric and address-centric protocols [18]. In that case, the sensor nodes require long-haul, multi-hop transmissions to a base station. As a result, the protocol suffers from implosion and

Parameters	Value
A	100m X 100m
N	0
Rs	10m
Ra	15m
Rc	20m
Sc	10 bytes

flooding issues similar to data-centric and address-centric protocols.

In our proposed scheme, the number of elected cluster heads remains stable between 3 and 8 when the network has sufficient number of alive nodes. However, the percentage of elected cluster heads decreases towards the end of network lifetime which is logical as there are not sufficient nodes to form optimal number of clusters. The election of a near-optimal percentage of cluster heads in various rounds prolong the network lifetime. Unlike LEACH protocol, our proposed routing algorithm always elects cluster heads in each round. It means multiple clusters (anything from3 to 8) are formed in each round which enables the nodes to avoid long-haul transmission containing data observed by these nodes. The transmission of multiple copies of a single event to a base station depletes the battery of each node. Furthermore, the delivery of duplicate copies at the base station deteriorates the QoS of the network as well to a base station. The only exception is toward the end of network lifetime when there are not sufficient nodes to form clusters and they transmit their data directly to a base station. The election of near-optimal percentage of cluster heads coupled with the avoidance of long-haul transmission to a base station enhances the lifetime of our proposed algorithm over LEACH protocol. Once a near-optimal percentage of cluster heads are elected, they advertise themselves to the nearest neighboring nodes to form clusters. Similar to LEACH protocol, each cluster head allocates TDMA slots within its cluster for data transmission. The neighboring nodes within a cluster may sense and transmit highly redundant events containing similar data patterns as shown in Fig. 2. In this figure, multiple nodes capture a single event.

IV. Experimental Results and Analysis

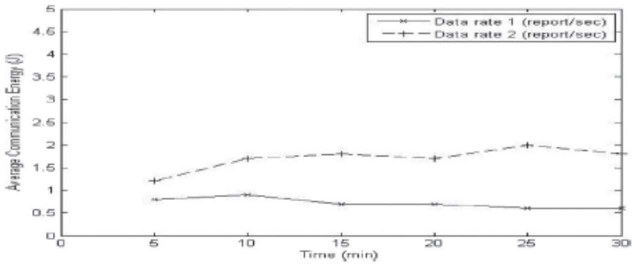
In this section we discussed about the simulation environment of the experiments. In our experiments we considered the 50 sensors are randomly deployed in the field with equal initial energy capacity of 10 J in the area of 210 X 210 m^2. We assumed the location of BS is in the left side of sensor field. The T_r-Transmission range of sensor node is set to 50 meter. .

Table: 4.2.1 Simulation setting

The result of the algorithm can be seen through the simulation of the experiments. In this section we discuss the many parameter matrices. In this phase we compare our proposed algorithm with the other implemented algorithm i.e. M-LEACH [40]. The reason behind to select the M-LEACH is that this protocol can handle mobility of the sensor nodes.

A. Performance Metrics

On the basis of the following parameters we compared our



protocol with the existing routing protocol M-LEACH.

Average Communication Energy: It is the rate of the total energy consumption and specific data used due to the communication in the networks over a particular time period.

Throughput: It represents the total number of packet lost during transmission. In this protocol the higher throughput is desirable to track the mobile target.

Lifetime: The span of time taken by node to die is called the lifetime.

B. Simulation Environment

We used the Network Simulator-2 [NS-2] to simulate our work.

The entire simulator is consisting of different modules such as deployment modules, Topology construction modules, mobility management protocol module.

D. Experimental Result

In this section we discussed the result of our proposed algorithm in terms of two parameters i.e. throughput and lifetime against different set of data rates. For the purpose of comparison we consider here the M-LEACH which is modified LEACH and based on the mobile sensor node instead of static sensor nodes and analyzed the performance of proposed protocol w.r.t. different data rate.

On the basis of geographic location information, residual energy level and velocity of the target or nodes the base station select the CH and DCH node for each cluster.

As the simulation environment we have assumed the setup of 200 nodes. The node selected is described in table1.

Fig 4: In this figure it is shown that the expenditure of average communication energy w.r.t. data rate of 1 and 2 reports per second respectively. The average communication energy expenditure is directly proportional to data rate when the data rate is to report then the average communication expenditure is high and it reduces gradually after the 25 section of the completion of simulation.

The reduction is due to the death of the node after the simulation which actually leads to lesser traffic.

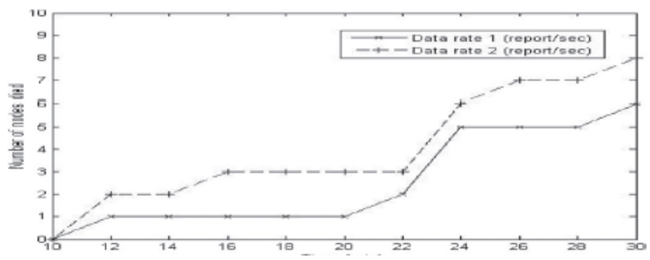


Fig 5: In this figure we can see that number of nodes that died after different interval of time. The node death rate depends on the data rate as data rate increases the death rate also increases. The reason behind it is that when the data rate increases the node needs to communicate more data packets which leads to more energy expenditure.

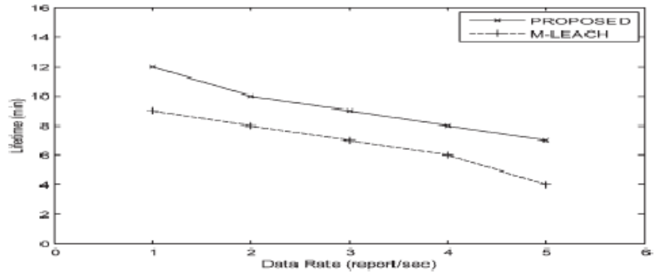


Fig 6: Depicts the comparison graph of communication will increase more data packets to handle it requires more energy as well and due to that lifetime is reduced.

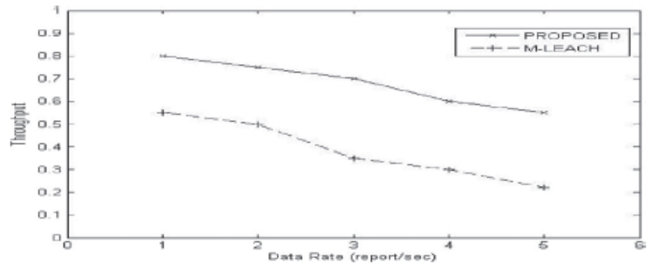
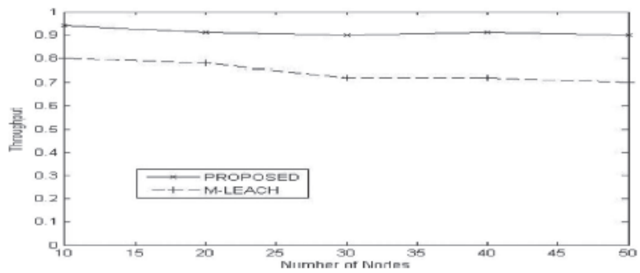


Fig 7: With the increase of data rates the throughput is decreases for both of the proposed and existing algorithm. However our protocol performs the existing protocol in terms of throughput also. Even for the proposed protocol the throughput decreases significantly.



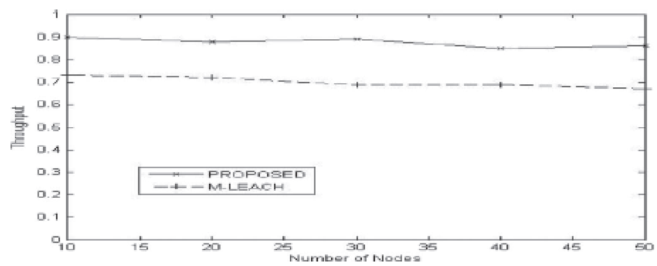


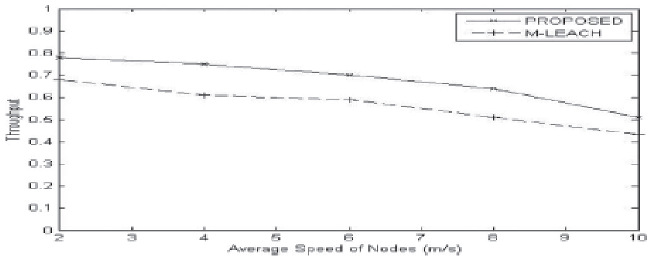
Fig 8: and Fig 9: Shows the throughput result of our proposed algorithm and M-LEACH protocol w.r.t. network size variation. For this proposed we perform this simulation in two

stage i.e. analysis I and analysis II. In both the analysis all the parameter is fixed with data rate is 16 B/S and the network size is increased by 10.

We analyzed that the random error (for link and node) of 2 to 4 percentage and of 5 to 7 percentage are considered for the throughput analysis I and throughput analysis II respectively.

With the help of this analysis we can say that proposed protocol improves the throughput level at the base station in comparison with the existing protocol.

The proposed algorithm improved the throughput level of 15 percentages. This could happen due to the introduction of DCH.



The performance of the throughput w.r.t. different mobility rate is shown in fig.10. Figure shows that the throughput degraded as the velocity of the nodes increases. This may be due to the fact that the more number of links breaks at higher speed.

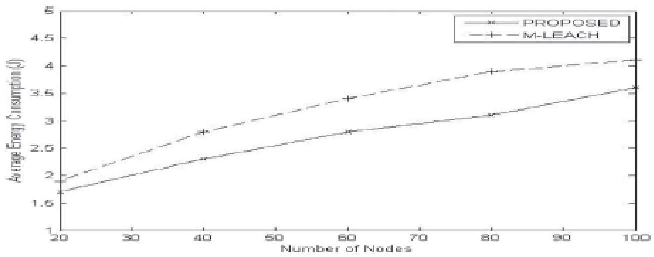


Fig. 11. Average energy consumption versus number of nodes at low mobility

level (0–5 m/s).Fig 11: depicts the average energy expenditure of the nodes under the influence of the proposed protocol and M- LEACH with the low mobility environment .In low mobility environment the speed of nodes will be 0-5 m/s. Through the figure 11 we can say that our proposed algorithm out performs

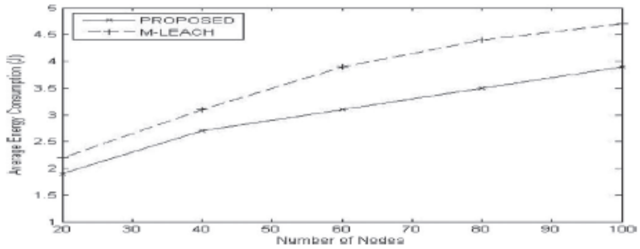


Fig. 13. Average energy consumption versus number of nodes at high

mobility level (5–15 m/s).the existing algorithm. The average energy expenditure of the nodes under the influence of high mobility node is depicts in the fig 12. The range of 5-15m/s speed is considered as high mobility

REFERENCES

[1] M. A. Jan, P. Nanda, X. He, and R. P. Liu, "Enhancing lifetime and quality of data in cluster-based hierarchical routing protocol for wireless sensor network," in *2013IEEE International Conference on High Performance Computing and Communications& 2013*

[2] *IEEE 10th International Conference on Embedded and UbiquitousComputing (HPCC EUC)*, pp. 1400–1407, IEEE, 2013.M. A. Jan, P. Nanda, and X. He, "Energy evaluation model for an improved centralized clustering hierarchical algorithm in wsn," in *Wired/Wireless Internet Communication*, pp. 154–167, Springer, 2013.

[3] G. Anastasi, M. Conti, M. Di Francesco, and A. Passarella, "Energy conservation in wireless sensor networks: A survey," *Ad hoc networks*, vol. 7, no. 3, pp. 537–568, 2009.

[4] J. Yick, B. Mukherjee, and D. Ghosal, "Wireless sensor network survey," *Computer networks*, vol. 52, no. 12, pp. 2292–2330, 2008.

[5] W.W. Dargie and C. Poellabauer, *Fundamentals of wireless sensor networks: theory and practice*. John Wiley & Sons, 2010.

[6] J. Gutierrez, J. F. Villa-Medina, A. Nieto-Garibay, andM. A´ . Porta-Ga´ndara, "Automated irrigation system using a wireless sensor network and gprs module," *Instrumentationand Measurement, IEEE Transactions on*, vol. 63, no. 1, pp. 166–176, 2014.

[7] J. M. Corchado, J. Bajo, D. Tapia, A. Abraham, *et al.*, "Using heterogeneous wirelesssensor networks in a telemonitoring system for healthcare," *Information Technologyin Biomedicine, IEEE Transactions on*, vol. 14, no. 2, pp. 234–240, 2010.

[8] Y. E. Aslan, I. Korpeoglu, and O¨ . Ulusoy, "A framework for use of wireless sensor networks in forest fire detection and monitoring," *Computers, Environment andUrban Systems*, vol. 36, no. 6, pp. 614–625, 2012.

[9] K. K. Khedo, R. Perseedoss, A. Mungur, *et al.*, "A wireless sensor network air pollution monitoring system," *arXiv preprint arXiv:1005.1737*, 2010.

[10] J. Rezazadeh, "Mobile wireless sensor networks overview," *International Journal of Computer Communications and Networks*, vol. 2, no. 1, pp. 17–22, 2012.

[11] S. A. Munir, B. Ren, W. Jiao, B. Wang, D. Xie, and J. Ma, "Mobile wireless sensor network: Architecture and enabling technologies for

ubiquitous computing," in *21st International Conference on Advanced Information Networking and ApplicationsWorkshops, AINAW'07*, pp. 113–120, IEEE, 2007.

[12] I. Amundson and X. D. Koutsoukos, "A survey on localization for mobile wireless sensor networks," in *Proceedings of the Second International Conference on MobileEntity Localization and Tracking in GPS-less Environments*, (Berlin, Heidelberg), pp. 235–254, Springer-Verlag, 2009.

[13] R. C. Shah, S. Roy, S. Jain, and W. Brunette, "Data mules: Modeling and analysis of a three-tier architecture for sparse sensor networks," *Ad Hoc Networks*, vol. 1,no. 2, pp. 215–233, 2003.

[14] K. Akkaya and M. Younis, "A survey on routing protocols for wireless sensor networks,"*Ad hoc networks*, vol. 3, no. 3, pp. 325–349, 2005.

[15] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," *Computer networks*, vol. 38, no. 4, pp. 393–422, 2002.

[16] W. B. Heinzelman, *Application-specific protocol architectures for wireless networks*. PhD thesis, Massachusetts Institute of Technology, 2000.

[17] Y. S. Cho, J. Kim, W. Y. Yang, and C. G. Kang, *MIMO-OFDM wireless communicationswith MATLAB*. John Wiley & Sons, 2010.

[18] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in *Proceedings of the 33rd annual Hawaii international conference on System sciences, 2000*, pp. 10–pp, IEEE, 2000.

[19] R. P. Liu, G. J. Sutton, and I. B. Collings, "Power save with offset listen interval forieee 802.11 ah smart grid communications," in *Communications (ICC), 2013*