IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 12, Issue 3, Ver. IV (May - June 2017), PP 01-08
www.iosrjournals.org

Energy Efficient Hierarchical Clustering for Dynamic and Heterogeneous Internet of things

Ashwala Mohan[1], Dr. Bhanu Bhaskara[2]
[1]*(Research Scholar, Department of ECE, Rayalaseema University, Kurnool, Andhra Pradesh, India)*
[2]*(Professor, College of Computer and Information Sciences, Majmaah University, Saudi Arabia)*

Abstract: *Distributed networks are formulated to create a large network in heterogeneous manner to provide higher service offering in internet of things. In the distributed network, devices are connected in a dynamic manner to exchange data with each other for controlling or exchange of data. In the communication approach, data are exchanged among each other at a random fashion between different devices. In the exchange of information energy dissipation are encountered at each node level. Wherein the conventional models clustering approach were suggested to achieve optimal resource utilization, the dynamic node behavior in the network gives a synchronized behavior in the network resulting in higher energy dissipation. To overcome this issue in this paper, a new energy conservation model for a randomly distributed network is developed, and a new scheduling approach is defined to have minimum energy dissipation in communication approach for internet of thing applications.*
Keywords: *Energy dissipation, scheduling scheme, energy consideration, MAC approach*.

I. Introduction

The Internet of Things (IoT) is an evolving area that is rapidly growing in future wireless communications. The basic approach of IoT is the pervasive presence of a variety of things or objects around us, such as radio-frequency identification (RFID) tags, sensors, actuators, mobile phones, and so forth. These things or objects are able to interact with each other and cooperate with their neighbors to achieve common goals through unique addressing schemes. However, the rapid growth of wireless communications and mobile internet services makes it necessary to improve the performance of current IoT technology to achieve requirements such as low cost, low complexity, coverage enhancement and so forth [1-5]. Techniques regarding IoT were well studied in current literatures. Specifically, in [4], the authors presented a systematical review about IoT which includes different definitions, key technologies, open issues and major challenges. The use of error control techniques can prevent retransmission, however at the cost of introducing transmission overhead, and thus increasing the sensors energy consumption. This leads to a tradeoff between the QoS and energy consumption. Hence, it can be seen that transmission errors, QoS constraints, and energy consumption are closely related, requiring advanced solutions to address these problems. To achieve the objective of higher QoS in wireless sensor network, in recent past a throughput enhancement is approach with power optimization was proposed in [6].The approaches of dynamic clustering [7, 8] operation scheduling [9, 10] and interference monitoring [11] were developed in past to achieve this objective. In [12] the cluster based scheme is developed to realign the network distribution for power saving. The clustering approach rearranges the node distribution, to achieve the power conservation. In [13] the node operation are scheduled with their operating cycles to achieve power saving. The nodes are scheduled for different operating phases such as sleep, wake, transmit and ideal to conserve the nodes power. As the power are heavily drained under high traffic condition, to control the power conservation under high interference MAC protocol is defined in [14]. The approach, of energy preservation using energy harvesting [15] approach is proposed. Energy harvesting is a upcoming approach in wireless sensor networks. Energy harvesting is a process of energy generation by the utilization of node interface. In the process of energy harvesting an on demand medium access protocol is proposed in [16]. This approach develops a scheduling approach of node operation to conserve energy and harvest energy based on movement from ideal listening time of receiver to transmitter unit. To conserve energy based on harvesting RF-MAC protocol was recently proposed in [17]. The approach proposed an energy transmission via RF media to recharge the distributed nodes over wide distributed nodes. However this method, does not concentrate on nodes interference and distribution simultaneously. There are proposed approaches of scheduling scheme [9, 10 and 12] for operational phases; however the proposed protocol does not shows the effect of scheduling scheme for MAC protocol. With this objective to an extension to the scheduling scheme, in this paper a new MAC protocol based on interference and operation scheduling is proposed. The proposed approach presents an inference margin to the request packets, with scheduling mechanism for power conservation. The clustering scheme is outlined in Section II and presents the conventional approach of energy conservation based on MAC protocol. The proposed scheduled MAC protocol is outlined in Section III. Section IV presents the experimental results for the developed approach. The conclusion to the paper is outlined in Section V.

II. Hierarchical Clustering Scheme

In the process of power saving approach in randomly distributed heterogeneous network, an operational scheduling scheme was proposed in [1]. This approach minimizes the power consumption by scheduling the operation phases into sub operational stages. A Beacon period for the node operation is divided into a sleep, wakeup, transmit and listen stage. Wherein this approach is a topology driven approach, the nodes are arranged as small intersecting sub clusters, and nodes in these clusters are declared as Master, or Link nodes based on the node power limits. A Node selection process and updating process for this approach is proposed. The process of Active_Masters along with Links, confirm a path in the virtual backbone, which is used for routing and there is demands for additional power for transmission, reception and processing of packets. In the process of upstream link selection, the nodes intersecting to the two clusters are defined. In this process the information is obtained from the broadcast packets from its one hop neighbors. Active_Master periodically sends broadcast request packet AWAKE to its Actives to put them in a listen mode for at least one link period. Active_Master finds out all the Active_Masters within two hops and Active_Master selects its Active as a Link which has maximum power level, for each Active_Master within two hops. Generally the Link is taken such that it has more number of neighbors to ensure less number of Links. The Active_Master determine the validity of the Link node i.e., power level periodically, if the power level is below the threshold level the Active_Master starts the selection procedure for new Link. In the process of wakeup scheduling approach Active_Masters and Links continuously AWAKE to forward packets of other nodes. Active nodes listen up a number of times in a link period T, and if they do not have to transmit or receive data, they goes to off again. There are number of Wakeup cycle periods (T_1, T_2), (T_2, T_3) … (T_n, T) in a link period. Active nodes listens up once in a Wakeup cycle. All nodes stays alisten during period $(0, T_1)$ called as broadcast window to exchange broadcast packets. Each node synchronizes its clock by using time stamp of broadcast message from Active_Master. During the process of communication the packets are transferred via Active_Master nodes and intermediate link nodes, the scheduling process keep the nodes scheduled for wake/Sleep in this beacon period. The data are buffered during the sleep off period at MAC layer and a time stamp is applied to control the packet forwarding process. This process of communication is defined to power saving and intern improves the node lifetime.

Towards improving the life time, power needs to be conserved for a longer time, or need to be refreshed periodically. Wherein it is observed that nodes in the network are dynamic in nature, power is a constraint resource and refreshing power under such environment is difficult. In such scenario, the node drains the power in a regular basis and collapse after certain time period. To overcome such issues, RF-MAC approach has recently been proposed as a upcoming solution. The process of RF-MAC is utilized to refresh the power level in nodes. The process of RF-MAC is a wireless charging through radio frequency (RF) waves. In such process the radio frequencies are used to operate a sensor node, which replenish the battery power. An optimal mode of such power refreshing scheme is presented in [15]. The approach present a new mode of communication and power charging by introducing a new channel accessing control in MAC layer, called RF-MAC. The method proposed focus on the problem of energy replenishment, and focus on the issues of, (i) how and when should the energy transfer occur, (ii) its priority over, and the resulting impact on the process of data communication, (iii) the challenges in aggregating the charging action of multiple transmitters, and (iv) impact of the choice of frequency. The proposed approach focus on the design of a CSMA/CA based MAC protocol [17], [18] for RF energy harvesting sensors. The MAC protocol proposed, works with RF energy harvesting, called as RF-MAC [20], allows a node to broadcast its request for energy (RFE) packet containing its ID, and then waits to hear from the energy transmitters (ETs) in the neighborhood. These responses from ETs are called cleared for energy (CFE) pulses, which are simple, time-separated energy beacons. These pulses maybe transmitted by more than one ET concurrently as overlapping CFEs and need not be distinguished. Rather, the concurrent emission of the CFEs increases the received energy level at the sensor, and this indicates a higher number of potential transmitters from the energy requesting sensor.The responding ETs are then classified into two sets, based on rough estimates of their separation distance from the energy requesting node to minimize the impact of destructive interference as much as possible. Each set of ETs is assigned a slightly different peak transmission frequency so that each set of ETs contributes constructively to the level of RF energy received at the node. The process focus on the interference monitoring and cancellation during simultaneous ET transmission. The energy transmitted during this process may be observed as a constructive or destructive in approach. This effect leads to variant in energy harvesting at the nodes. The constructive mode result in higher power generation than the reference level, whereas a destructive approach reduces the power generation at the node resulting in RF transmission wastage. To have an optimal ET transmission the energy generation process, frequency isolation and distance isolation is proposed. In such mechanism, a requesting of energy is made by the node when no data packets are transmitted when the node voltage falls below a pre-set threshold. Based on the received request packet at the receiver, the node computes the distance and generates energy based on the received signal strength (RSS) [13]. This approach proposed a clustering of ETs based on the approach constructive and destructive nature of the received signal strength. The distance between the ET and the sensor node directly results in a phase difference of the incoming wireless signals at the node. The ETs that identify themselves to lie in the band $[m\lambda-(\lambda/4), m\lambda+(\lambda/4)]$, are grouped together, where m = {1, 2, . . .}. We call this as Group I. Here, λ is the wavelength of the transmitted radiation. Similarly, the other ETs in the range $[(m + 1/2)\lambda-(\lambda/4), (m + 1/2)\lambda + (\lambda/4)]$ fall in the second group, called Group II. Thus, on receiving the RFE, each ET knows which concentric band it lies in centered around the requesting node, and the group in which it belongs [15]. The node that sent the initial RFE estimates the total energy that it will receive based on the signal strength and how much energy is contributed by the two groups of ETs separately.

This computed energies for each group is called cumulative energy as $EGroup\ I_{RX}$ and $EGroup\ II_{RX}$, respectively, which are calculated by the RFE issuing node from the received pulses. An optimization problem is then formulated which is defined to maximize the energy transfer, $EMax_{RX} = EGroup\ I_{RX} + EGroup\ II_{RX}$, [15] which at a given frequency point is the product of the power spectral density and the circuit frequency response. An optimal group is then selected satisfying the constraint of maximum energy generation. The approach is an optimal solution to energy harvesting in distributed wireless network. This approach improves the node life time, intern network lifetime in comparison to the conventional network model. This approach is hence incorporated in a cluster based communication for network performance improvement. The proposed approach of network harvesting overscheduled cluster topology is outlined in following section.

III. Proposed Energy Conserved Clustering Approach

In the proposed cluster based energy harvesting approach to improve network life time, the cluster based scheduling approach as outlined in our previous proposal [14], is integrated with the RF-MAC proposal to achieve node power enhancement and improving overall network life time. In the process of energy harvesting, each node is defined with a sensor device which is used for energy generation, such as a solar sensor unit, used for power generation. It is required to obtain the energy power scheduling and operation scheduling, which is outlined in this section. The RF-MAC approach outlined in previous section is used for the energy harvesting approach. In the process of cluster based communication [14], a beacon period is defined into sub operational stages, where the nodes are scheduled to sleep, data exchange or listening mode of operation. To achieve the objective of energy harvesting to the clustering approach, an energy harvesting factor 'E_m' is introduced. The Harvesting factor is the maximum energy factor 'E_{max}' as defined in the previous section. The maximum energy 'E_{max}' is the converged optimal factor of sum of constructive and destructive energy factors for each group. With these factors under consideration, a new clustering and scheduling approach is developed which optimizes the power conservation and refresh the node lifetime, intern increase the network life time. In this approach of clustering, the network is formed to sub- optimal clusters based on two factors, of Maximum energy level per node $P_{i,N}$ with optimize harvesting factor 'E_m'. As outlined in our previous proposed approach [14], the process of active_master selection is made based on the $Max(P_{i,N})$ constraint. This Node is defined as the main interlink between the member groups and the cluster links. The $Max(P_{i,N})$ constraint guarantees the nodes stability for maximum period and intern increases the reliability. As this nodes routes multiple traffics through it, the power draining in such node is more rapid than the member nodes. As this node is treated as the central point for a cluster, its reliability is more important. To avoid intermediate collapsing and to improve the node life time, the harvesting factor is hence introduced. Hence to the active_master selection process, the E_{max}constraint is introduced, which guarantee an optimal energy harvesting at the node level. To select an active_master in such case, the selection algorithm is as outlined below;

Algorithm:

Each Node in the group, broadcast a request packet 'P_{req}', to all its in-range nodes and exchange their power levels to make a decision, with the power level, the distance between each node is also exchanged, which is used for the computation of RSS. The constraint Active_Master selection process is outlined as;

For each node in-range,
Broadcase the Request packet 'P_{req}'
Record the power level $P_{i,N}$
Record the node distance $D_{i,N}$
Compute the received signal strength (RSS),
$RSS_{i,N} = P_{i,N} / D_{i,N}$,
Wherein with the increase in distance between the two nodes the received signal strength decrease;
The Active_master selection is then defined as,
$MP_i = max(P_i)$,
$MR_i = max(RSS_i)$,

for Each neighbor node N_i, do,
if (power of node N_i, P_i<MP_i) and (RSS_i<MR_i) then
Node_Mode = member;
elseif (P_i>MP_i) and (RSS_i<MR_i), then
$MP_i = P_i$
Node_Mode = member;
Else
if (P_i>MP_i) and (RSS_i>MR_i), then
$MP_i = P_i$
$MR_i = RSS_i$,
Node_Mode = Active_Master;
End

The active_master are here selected based on the maximization criteria of power level and received signal strength. These nodes are hence optimal for data exchange. These nodes are incorporated with the proposed Harvesting approach and for a scheduled time interval, these nodes refresh their power level by energy harvesting so as to be in highest power level and provide a reliable link for data exchange.

The upstream links and the member nodes are however not operated with harvesting approach to avoid additional computation overhead, and as the operational scheduling scheme is defined to control the power utilization, these nodes will have longer life time.

The incorporation of the proposed Harvesting approach, to the active master node results in the following improvements,

1) The Active_master node will never be drained out.
2) The Computation overhead per node is not increased; as well the reliability of the network stability is increased.
3) The member nodes are kept under operational scheduling scheme to minimize power utilization; hence the probability of node going towards active_member selection is less, which further reduces the repetitive setup overhead.
4) With the proposed approach, as the stability of network and each node is increased, the network is hence optimal for higher level of service compatibilities.

The selected Master nodes are scheduled for data and energy conservation time schedule in this case. The nodes are scheduled for a very short period of energy charging on the value reaching to a set lower limit. In this case the Active Master nodes halt the wake up period to 'Ts' period defined as the energy charging period. During this period the sensors are enabling and certain values of charge are added to the existing energy of this node. The Halt period is set to be 10µs period for energy charging as defined by IEEE 802.11 standard [17]. Once the Halt period is elapsed the Nodes are triggered back to their current state and the nodes are then engaged for data exchange process. The Nodes are energized to $3E_{max}$ as referred to the Bernoulli energy Model [18]. This energy harvesting leads to longer life to active Master nodes and hence the network life time is increased. To evaluate the proposed approach a simulative approach is made, and the results obtained are outlined in following section.

IV. Simulation Results

For the simulation of the suggested approach a randomly distributed network simulated as given in figure 1. The Network is defined for a randomly distributed node, comprising of nodes with a power harvesting unit. The devices are incorporated with solar radiation energy generation units. Each node is defined for an average radiation reception of about 0.2 KWh/m^2 [16]. The minimum power required for a node to drive is taken as 0.5mW. The charging energy level is taken as E_{max} is taken as 10E, where E is taken as 100mW over a time slot period for communication. The harvesting approach when induced to a cluster based network, with optimal scheduling the overall network performances are improved. The observations made for the proposed approaches are as illustrated below. The randomly scattered network topology, for simulation is shown in figure 1. Each of the nodes is randomly placed in a network area of 30x30, with number of nodes as 30. Each node in the network is defined by its ID, geographical coordinates, defined by x and y coordinates, and a randomly defined power level at each node. These nodes process the routing protocol and select the optimal route for data communication using Multi hoping approach. At each of the hop, the node dissipates power based on the IEEE 802.11 standards for receiving, transmitting, and ideal condition. For the developed communication, the obtained parametric observations are as illustrated in following figures.

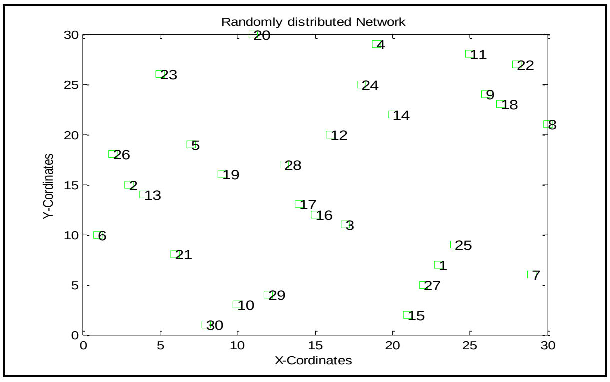

Figure 1: Random scattered Network topology

The average throughput for the developed system is shown in figure 2. The average throughput for the proposed approach of energy harvesting at master nodes result in higher throughput as, they are operable for more period. It is observed that the throughput for the linear network with energy harvesting is also improved. However as with the increase in number of communication iterations, it is observed that throughput decrease due to the power dissipation per node and time taken to harvest energy. However, the throughput is comparatively observed to be improved in case of proposed Topology driven power saving scheme with scheduling and conservation.

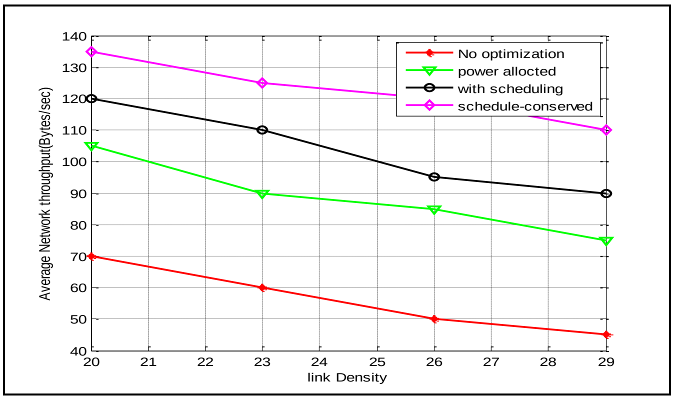

Figure 2: Average throughput with E=100mW and harvesting time set to 10µs

The observed network life time for the simulated network is observed to be improved with the increase in communication iteration, using the approach of proposed scheduling and conservation approach. The lifetime is computed as the number of nodes retained in the network in active path for data exchange. It is observed that, the network life time is increased by the incorporation of energy harvesting at the node level as shown in figure 3.

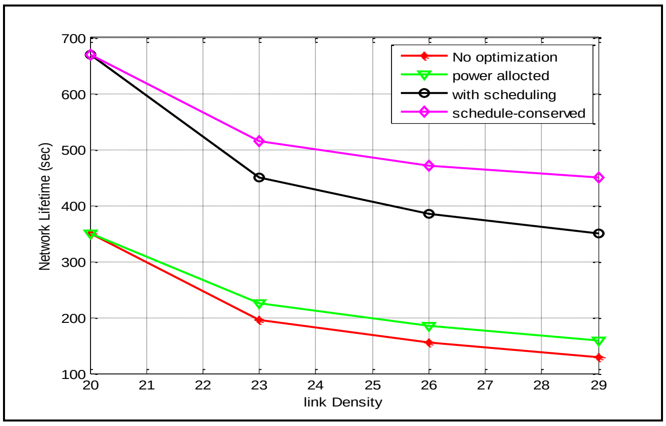

Figure 3: Network lifetime over communication period

Power at each node is measured and it is observed that, with the increase in the communication time period, the power level at each node is minimized, due to energy dissipation during transmission and reception operation. However, due to the incorporation of harvesting approach to the developed network, it is observed that, the power level for active nodes is increased. This improvement is higher in the proposed scheduling and conservation approach. As each node in such network remain in sleep mode, and master nodes are periodically been improved with energy harvesting is shown in figure 4.

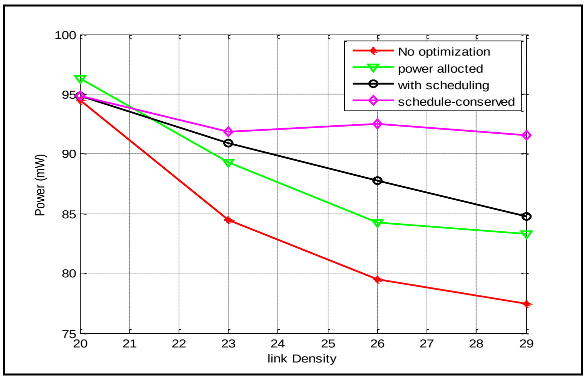

Figure 4: Power level with communication iteration with E=100mW and harvesting time set to 10µs

The Network overhead is observed to be minimized in case of the topology preserved with energy harvesting. The concept of energy harvesting makes more number of nodes available in the network, which results in higher throughput. Due to more traffic clearance the overhead is observed to be less in proposed approach as shown in figure 5.

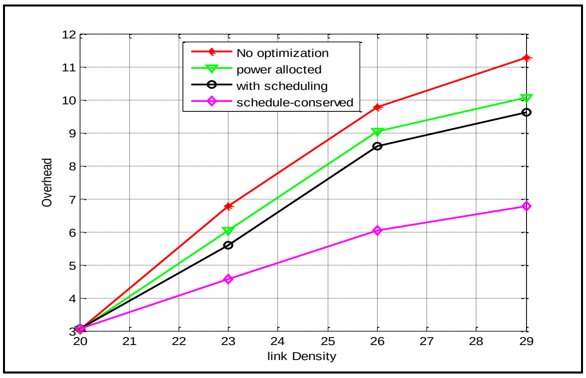

Figure 5: Network overhead over communication iteration

The effect of node density on the network performance is also evaluated for the simulation model. With the variation of node density from Number of nodes varying from 10 to 50 in the network is evaluated. For the evaluation of variation in node density and its impact over network parameter, node density is varied from 10 to 50. The evaluative parameters observed for the simulated network is presented below. For the simulation a network with node density of 50 nodes is shown in figure 6. The scattering of nodes in such network can be seen in figure 6. Due to higher density the nodes are very near to each other. This leads to more route probability and more reliability. However, as numbers of nodes are more, probability of node participation in data forwarding also increases, resulting in faster power drain.

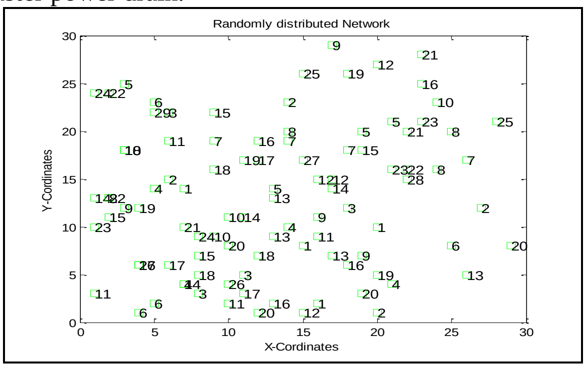

Figure 6: A randomly scattered network topology with Node density of 50 nodes

The average throughput with respect to variation in node density is observed and it is shown in figure 7. It is seen that, throughput for the developed approach is improvised with increase in node density. The average node density available for the routing in such case increases, and due to faster processing and rescheduled harvesting the nodes are processed for higher data transfer. As the data transfer is higher in such network the observing quality and intern the network reliability for Quality oriented service increases.

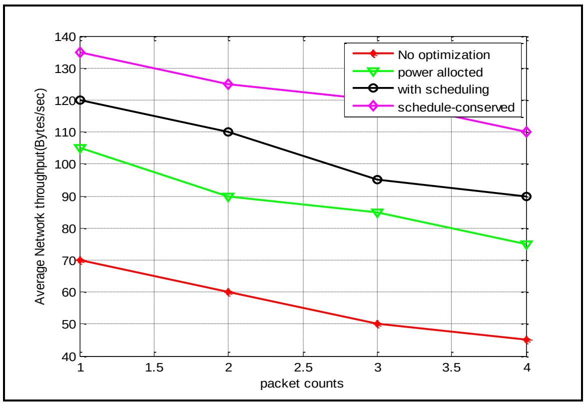

Figure 7: Average throughput with variant in node density

The network life time is observed to be improved in such case. As the number of nodes are high, the network sustaining increases. In addition due to energy harvesting, power are refreshed in a particular interval. These features increase the power per node in the network, hence resulting in longer life time. In comparison to the observation for network life time for a fixed node density as shown in figure 8, this network life time get increased; due to large number of node remain at higher energy level.

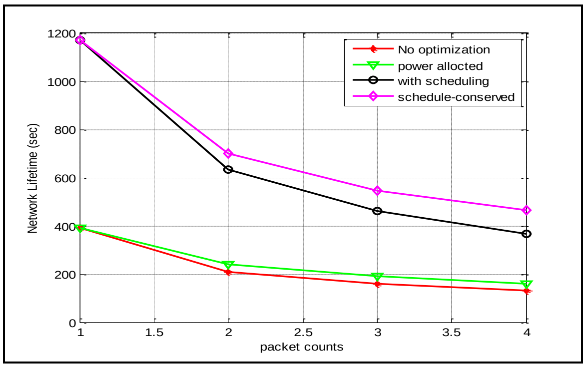

Figure 8: Network Lifetime over node density

The power consumption for such network will be lowered and hence the power conserved per node gets improved. In the case of topology driven power scheduling approach with scheduling and conservation approach, the nodes are scheduled for sleep and wakeup period, as well the master node keep the energy refreshment, this result in higher power in the network, as observed in figure 9.

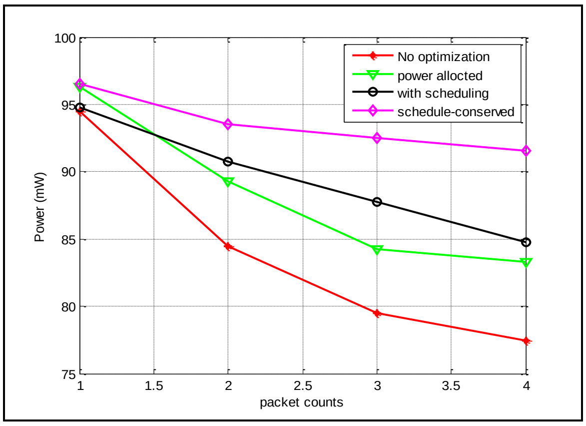

Figure 9: Power in the network over Node density

The Network overhead in such case is observed to be optimized in case of the topology preserved with energy harvesting. The overhead in such case is reduced, due to faster release of data, as due to availability of more nodes for data exchange as compared to its conventional counterparts as shown in figure 10.

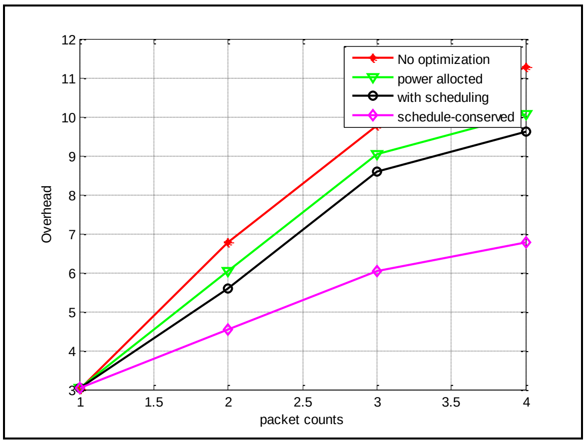

Figure 10: Network overhead with variation in Node density

V. Conclusion

The presented work, defines a new approach to energy conservation in distributed random network based on energy conservation model. A new scheduling model based on clustering and scheduling mode and energy allocation is developed. This approach gives the significance of longer time network sustaining property in a random distribution. This energy conservation gives the feature of higher node integration feasibility for internet of thing application.

References

[1] Sathish Kumar, Mukesh A Zaveri, "Hierarchical Clustering for Dynamic and Heterogeneous Internet of Things", Procedia Computer Science 93 (2016) 276 – 282.

[2] C. Wang , C. Jiang , Y. Liu , X.Y. Li , S. Tang , Aggregation capacity of wireless sensor networks: Extended network case, IEEE Trans. Comput. 63 (6) (2014) 1351–1364 .

[3] V.C. Gungor , G.P. Hancke , Industrial wireless sensor networks: Challenges, design principles, and technical approaches, IEEE Trans. Ind. Electr. 56 (10) (2009) 4258–4265 .

[4] J. Niu , L. Cheng , Y. Gu , L. Shu , S.K. Das , R3e: Reliable reactive routing enhancement for wireless sensor networks, IEEE Trans. Ind. Inform. 10 (1) (2014) 784–794 .

[5] R. Roman , J. Lopez , Integrating wireless sensor networks and the internet: A security analysis, Internet Res. 19 (2) (2009) 246–259 .

[6] X.H. Le , S. Lee , I. Butun , M. Khalid , R. Sankar , M. Kim , M. Han , Y.K. Lee , H. Lee , An energy-efficient access control scheme forwireless sensor networks based on elliptic curve cryptography, J. Commun. Netw. 11 (6) (2009) 599–606 .

[7] A. B. M. Alim Al Islam, ChowdhurySayeedHyder, HumayunKabir, MahmudaNaznin, "Stable Sensor Network (SSN): A Dynamic Clustering Technique for Maximizing Stability in Wireless Sensor Networks", scientific research wireless sensor network, 2010.

[8] Sandra Sendra, Jaime Lloret, Miguel García and José F. Toledo, "Power saving and energy optimization techniques for Wireless Sensor Networks", Journal of Communications, Sep 2011.

[9] Subhash Dhar Dwivedi, Praveen Kaushik, "Energy Efficient Routing Algorithm with sleep scheduling in Wireless Sensor Network", International Journal of Computer Science and Information Technologies, 2012.

[10] Zilong Liao, Deshi Li, and Jian Chen, "A Handshake Based Ordered Scheduling MAC Protocol for Underwater Acoustic Local Area Networks", HINDAWI International Journal of Distributed Sensor Networks, 2015.

[11] S. M. Kamruzzaman, "An Energy Efficient Multichannel MAC Protocol for Cognitive Radio Ad Hoc Networks", International Journal of Communication Networks and Information Security, Aug 2010.

[12] Guodong Sun, GuofuQiao and Lin Zhao, "Efficient link scheduling for rechargeable wireless ad hoc and sensor networks", EURASIP Journal on Wireless Communications and Networking 2013.

[13] XenofonFafoutis, XenofonFafoutis, "ODMAC: An On-Demand MAC Protocol for Energy Harvesting - Wireless Sensor Networks", PE-WASUN'11, November, 2011.

[14] ZhiAngEu, Hwee-Pink Tan, Winston K.G. Seah, "Design and performance analysis of MAC schemes for Wireless Sensor Networks Powered by Ambient Energy Harvesting", ELSEVIER, 6 Aug 2010.

[15] SantashilPalChaudhuri and David B. Johnson, "Power Mode Scheduling for Ad Hoc Networks", IEEE 2002.

[16] Alvin C. Valera, "Survey on wakeup scheduling for environmentally-powered wireless sensor networks", Elsevier, 2014.

[17] PrusayonNintanavongsa, M. YousofNaderi, and Kaushik R. Chowdhury, "Medium Access Control Protocol Design for Sensors Powered by Wireless Energy Transfer", IEEE, INFOCOM, 2013.

[18] Xiao Lu, Ping Wang, DusitNiyato, and Zhu Han, "Resource Allocation in Wireless Networks with RF Energy Harvesting and Transfer", IEEE Network.

[19] SharmilaSankar and V. Sankaranarayanan, "A Predictive Route Maintenance Protocol Based on Signal Strength for Dense Ad Hoc Networks", International Journal of Computer Theory and Engineering, August 2012.

[20] M. YousofNaderi, PrusayonNintanavongsa, and Kaushik R. Chowdhury, "RF-MAC: A Medium Access Control Protocol for Re-Chargeable Sensor Networks Powered by Wireless Energy Harvesting", IEEE transactions on wireless communications, July 2014.