International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Efficient Energy Reduction using Dynamic Concentric Ring Infrastructure for Communication in Wireless Sensor Network

Ashvini A. Kadam
PG department
M. B. E. Society's College Of Engineering Ambajogai
Ambajogai, India

Prof. S. K. Sudhansu
PG Department
M. B. E. Society's College of Engineering Ambajogai
Ambajogai, India

***Abstract*— Wireless Sensor Network is very useful in number of applications such as home applications, military applications, industrial applications and hospitals. Here we proposed Ring Infrastructure Protocol (RIP) for efficient communication in WSN (Wireless Sensor Network), to form the infrastructure. RIP originate physical rings that already exist in a WSN and form an infrastructure having the same center of rings. One or more mobile agents are allocated to each ring in rings, which collect the data and observe the rings. At each ring access nodes are selected randomly and they visiting to their respective ring. Here we use both multi-hop and data-mule communication model for high reliability. Our goal is to create an infrastructure which is robust and reliable. With the help of that infrastructure provide a rough cost model. Infrastructure performance is evaluated with the help of upper layer processes. System output is compared with the multi-scale communication and results shows that ring infrastructure saves more energy compared with multi-scale communication. And results are shown via extensive numerical calculations in MATLAB.**

Keywords*— *Infrastructure, Ring, Sensor Network, Protocol

I. INTRODUCTION

For designing of wireless sensor network recently the multi-hop communication model is used. In most of the network deployment of node is random but network topology is arbitrary. Communication protocol controls the cooperation between all nodes. So that communication process is coupled to near to near topology. In contradiction upper layer protocol use basics of communication protocol, which gives cross layered design of wireless sensor network[2]. The degree of dependence is high between upper layer protocol and communication functionalities. The development of paper is depend on previous work [4]. Here we proposed ring infrastructure protocol. And wireless sensor network is covered with both stationary and mobile nodes. By using the mobility property in WSNs we achieve number of goals [5]. With the help of that we can move sensors in the field and arrange them newly in the network. In this paper some powerful entities are assigned to collect the data from rings, which are known as mobile agents. Each ring accredit by one or more mobile agent/sinks which behave like mobile probes. For the collection of data we assign two strategies i.e. Multi-hop and Data-mule communication strategies. For multi-hop strategies data is coming from all the intermediate nodes. But in the data-mule strategies mobile agents collect the data from each sensor node. Bunch of access points are selected for each ring. And mobile agents used these access points for the master and managing the network. In ring logical and physical sensors are neighboring nodes. For the construction of this system we require only location information depend on one-hop neighbor information. No need of any global information for RIP protocol. And we claim that our overlay construction is reusable, failure handling, efficient. The main goal of paper is overlay construction which is generic and minimizing the energy expenditure as compared to multi-scale communication in WSNs [6].

All related work is same as early described in paper [26]. Entire software stack architecture is proposed in early described paper [1] and [3]. In that author proposed a architecture and also describe rules for network services could be arranged over sensor network protocol and insertion of sensor protocol in between network layer and data link layer. Because Of unification process considerably increase overhead and gives decrease in performance [2]. For the construction of communication topology tree-based and cluster-based techniques are maximum used because topology usually constructed over a sensor network as an in-line communication structure that supports path finding (routing) and data collecting [7]. Flooding technique is commonly used operation for efficient network and maintaining the network [8]. General purpose overlay is not bind to any upper layer protocols. This overlay gives high efficiency [9]. It is not easy to modeling such type of overlay for the resource like WSNs which are rare resources. For modeling such overlay author of [10] describe coronas and wedges and here mainly used stationary sensor network. Training agent is allocated at center which is also known as special sink and it support transmission ranges. In that TA is act as master for all other node. Node position is given in the selected form (coronas and wedges), this protocol is centralized protocol and which require global information. But author did not specify effects of adding multiple sinks or TA and that whole paper gives the movement of training agent [11]. But there are some queries in [11] because author didn't answered how many coronas and wedges are allocated to each TA. But as compare to [11] in [12] author explain a ring overlay construction in which all nodes arranged in the format of ring around base station because base station is lies in a center and information is passing from outer to the inner ring and inner ring to the base station. In [13] author resulting a protocol which is a C3 protocol and it is depend on received signal strength indicator (RSSI), which is extended with the help of [14]. Both protocol constructed a ring which is depend on communication range. Rings are formed based on distance from the base station. In [13] which nodes are unaware of their location and also with the help of the C3 protocol cost of communication is reduced. In [10] for supporting the upper-layer processes author proposed multi-scale overlay in which nodes are arranged in cells or supper cells. In which a clustering based technique is used. Children nodes are passes the information to the parent means cluster heads and cluster heads passes the information to the base station. Also research is going on that is the construction of logical overlay i.e. the distributed hash table (DHT) on the top of the physical networks. [15] What changes are happened when considering the mobility is explain in this paper. And minimization of gap between the logical and physical overlay is explained in [16]. Author explained a routing protocol which is known as virtual ring routing (VRR). Which is explained based on a DHT schemes, in which above link layer logical rings are formed. But author of [17] assumed a circular field having a diameter D and then it is divided into number of circles a having a same center means concentric circle. Author of [18] explain a system based on a Gaussian ring deployment for security purpose at the edge of network. And also for managing the flood in the network author assume a ring topology for WSN.

But our proposed approach described in paper is very simple and energy efficient. It does not need to form ring around base station but in contrast to this in that system sweeps the network from outermost to the innermost nodes. It also uses both multi-hop and mobility based communication. It gives easy data routing and collection of data.

Previous work [26] , we get the reduced energy expenditure but in that paper we again improve or reduced energy expenditure as compare to previous work by increasing bandwidth and proper synchronization between transmitter and receiver. And results are obtained using extensive numerical calculations in MATLAB .The further paper is arranged as follows. All the network entities in section II. All details about infrastructure design issues related to ring discovery in section III. And all summary for performance in section IV. And V consists of conclusion.

II. RING INFRASTRUCTURE PROTOCOL (RIP)

A. System Model

Now consider a deployment framework in which there are some stationary nodes and moving nodes. But as compare to stationary nodes mobile nodes are in a less quantity. And these moving node or mobile agent are powerful than stationary nodes.

- Mobile Agent: This moving agent is also any moving thing which collects data from the sensor nodes. These mobile agent could be robot, moving vehicles, human with portable devices, for simplicity we knows them mobile agents (MA). Based on the proposed strategies mobile agents are allocated to the field. It is not import allocation of mobile agent at set up time. And mobility of mobile agent is also controlled in [28] and they move based on various mobility pattern.
- Sensor Nodes: Here we assume that sensor nodes are uniformly distributed in the framework, and provided by a common transmission range and energy supply. For detection of their coordinates they use GPS.

B. Stages of RIP

RIP manages allotted nodes into a framework of rings having same center. In [4] brief explanation is provided of RIP. With the help of localized operation means using GPS (Global Positioning System) RIP forms a ring infrastructure. Only one hop neighbor information is given to the next node. At the time of set up RIP dynamically discovers the rings. And at the run time mobile agents are allocated. According to required operation mobile probes are allocated. Here the Fig. 1 gives the formation of physical rings in the network topology. And Fig. 2 gives theoretical view of Ring framework.

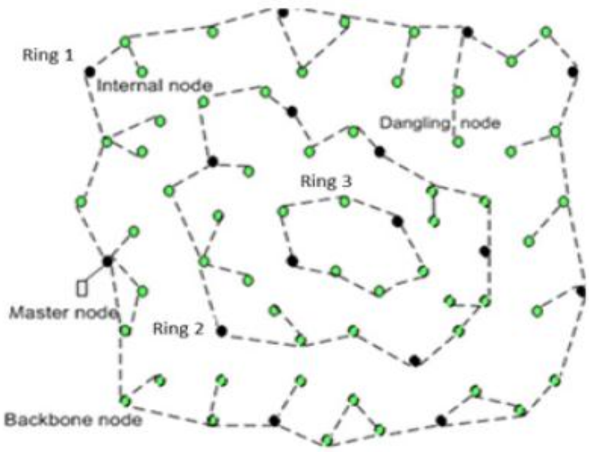


Fig.1. Outcome of RIP in WSN [26]

RIP arranges the framework in a very simple way. Nodes are arranged in a sets like, framework ring R, the framework backbones B, the internal network nodes I, the framework access point AP and mobile agent MA. Ring R_i include backbone B_i and the associated internal nodes I_i. Closed sequence of nodes is known as backbone. One-hop neighbors of backbone nodes are internal nodes. A backbone ring is start from one node and at the same node or node belongs to the same backbone.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

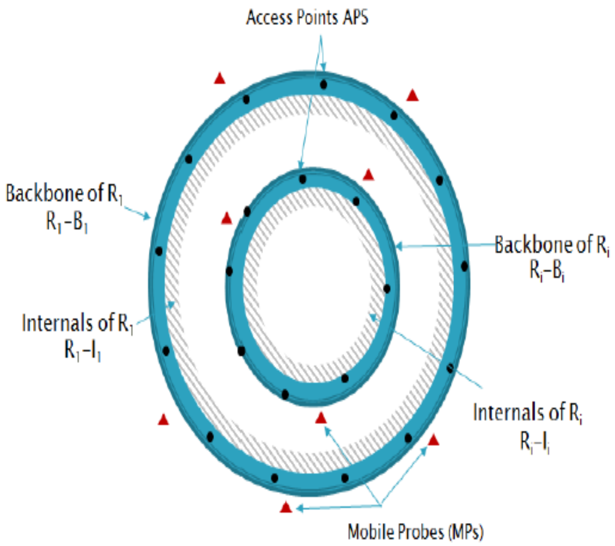


Fig 2. Theoretical view of ring structure

The network is divided by number of nodes such as Access points AP_i and MAs. AP is master for the mobile probes because they guide the mobile agents. Mobile agents directly pick up the data from access points in the data-mule communication, otherwise through multi-hop communication. RIP forms the ring framework three sections i.e. ring organization, AP selection and MA allocation.

1. Ring Organization

The closed sequence of nodes and their one-hop neighbors is known as ring. Iteratively rings are arranged. The outer ring R_1, consist of outer boundary of network and their one-hop nodes. Outer boundary is come to know by any boundary recognition algorithm which given in a [21] and [22]. Backbone nodes are those nodes which form the outer boundary and their one-hop neighbors are known as internal nodes of ring. As recognized, all nodes within the outermost ring are enters in sleep mode. Then this ring is out of operation, and then new boundary is considered as backbone of next ring R_2. Till the end of phase all rings are iteratively covered. A framework is divided into set of rings R= (R_1, R_2, R_n). Each ring consists of set of backbone nodes and internal node. One of the nodes from the backbone sequence is known as leader node of that ring. To find out the current ring number backbone discovery massage is transmitted by master node to recognize the outer boundary of node send a signature packet data. The position of each node is depending on leader node and it is a one-hop count from leader node of that ring. Set is form (ring number, node position) used to know the nodes in B_i. Each internal node gives the same ID as parent node. Bound hole algorithm is used by RIP [21] and [22].

2. AP(Access Point) selection

Many nodes are selected as access points for each ring. Access points are subset of backbone nodes B_i. Access points are chosen according to distance or hop count from the leader node in the ring as example, nodes at distance kh (k=1, 2, 3 etc or h is the given parameter). Piggy backed technique is used for the access point selection (because the parameter h denotes number of hops between successive access points could be conveying by same packet as boundary recognize information). As access pints are selected the nodes change their topological condition. Nodes with fellowship are known as dangling node. These nodes connect themselves to any attached internal neighbor. MA uses as access points as a guide. As the number of access point increases the accessibility of network increases. Where h parameter is tunable parameter and any node can change their status if necessary.

3. MA (Mobile Agent) allocation

For managing the load RIP allocate mobile agent. MA used for the collection of data and network management. Mobile agent for respective ring or home ring is known as mobile agent of that ring otherwise it assistant MA for other ring which is application dependent. Access points are guides for the MAs they guide the mobile agent for network navigation which is periodic or upon demand. Each MA know its periodic visiting time t, in periodic. Which is an application oriented parameter. We are described two main types passive allocation and active allocation. Passive allocation is depending on number of discovered rings. If m is Mobile agent and g is the number of rings then number of mobile agent to each ring is (m/g). Greater results is achieved when m=ag and $a \geq 1$. Active allocation is depending on application, for example a large number of mobile probes are given to critical areas. According to ring discovery, access point selection and mobile agent allocation we derive one simple algorithm.

- *RIP algorithm*

RIP phase I: Ring Discovery

1. Initialization mp0 at the edge of the network, i= 0, B, R
2. B_i= backbone of R_i
3. If i= 1, c = centroid (B_i)
4. Leader of R_i = Elect leader out of B_i
5. Internals of R_i = one hop count from B_i
6. Set membership of all internals and go sleep
7. MP next position= MP current position // move one step in the MP-to-c direction
8. i= i+1

Phase II: Set Access Point

1. Initialize k=1, for each B_i in backbone of R_i
2. Access point selection =hop count from leader node
3. If node count = kh then select access point
k= 1, 2, 3 etc ad h= No of hops between successive Aps
4. Exchange topological status among Aps
5. If no ring membership then // dangling node attach to any connected neighbor.

Phase III: Allocate MP

1. Input MP, R
2. Mpi initial location= Determine current probe location based on leader of R_i
3. Allocate for load balancing and collection of data from nodes

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

III. IMPLEMENTATION ISSUES IN RIP FRAMEWORK

Topological status of all nodes is also given in the following table according to ring overlay. Each node is classified according to (ring #, role). The role contains parent, backbone, internal, foreign-internal and dangling .the table describe information of all nodes and their role based on connectivity shown in fig 3.

TABLE I Neighbor's information of a) node R_1- i_3 and b) node R_1- b_4

Node	Ring	Function	Node	Ring	Function
i_3	R_1	Internal - self	b_4	R_1	AP-self
b_3	R_1	Backbone-parent	b_3	R_1	Backbone-parent
i_2	R_1	Internal	b_5	R_1	Backbone-next
b_2	R_2	Backbone	i_3	R_1	Internal exit toR_2
b_4	R_1	Backbone- AP	i_4	R_1	Internal exit to R_2

As $R_1$is the outermost ring so that it does not have any FINs. Default parent node is marked as within a ring R_i, for any internal node with more than backbone node.

We should note that internal nodes of R_i do not have backbone neighbor in R_i-1,internal nodes of R_i that are physical neighbor of R_i+1 are known as foreign internal neighbor(FINs) of R_i+1 (as example the node R_1- i_3 is a foreign internal neighbor of R_2- b_3)

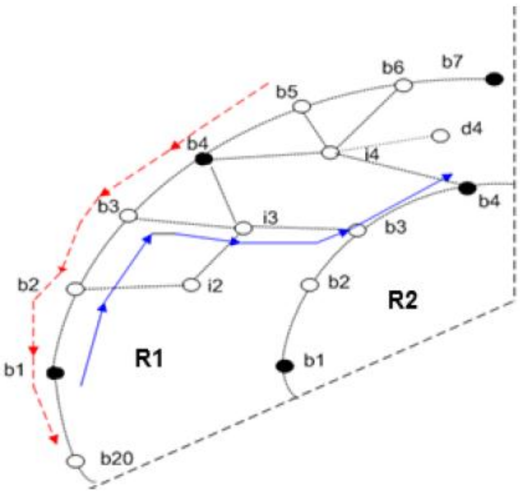


Fig. 3. Ring connectivity in RIP

A. *Framework Communications*

RIP gives two communication patterns: primitive pattern and composite pattern. In this paper only primitive pattern is described [26]. Composite pattern is very hard and complex and it is out of scope for this system still work on that in progress. F. According to location of source and destination in-ring and inter-ring primitives pattern is described. The destination could be any other node or mobile probe. RIP provides home only, Plan-based and cross ring communication for MAs. MAs collect data in home ring only and cannot participate in other ring for home only pattern, any data from other ring will reach by multi-hop communication. In cross ring, a MAs cross the ring for collection of data. In plan based mode they collect data according to plan which is application specific. MAs also communicate in data mule communication also they cannot collect data from the node but also carry data from one place to other in the framework. This is very flexible ring infrastructure which is used for number of applications.

According to fig. 4. Dashed line indicates in-ring communication between backbone nodes R_1- b_5 and R_1- b_{20}. Also solid or continue line indicate inter-ring communication between R_1- b_1 and R_2- b_4. Data are disseminated in the clockwise direction until they reach R_1- b_3, which sends the data to R_2 - b_3 via R_1 - i_3. In R_2 the data travel clockwise until they arrive at R_2 - b_4 (in this case, only one hop is required).

B. *Effective Failure Handling*

Infrastructure is very flexible so that any change in the status of the node will give only local updates. Failure management is depending on two strategies.

- Fragmentation: if any default or failure is happening in a ring is does not spread over the network so that it gives less impact on the framework.
- Role –based operation: All nodes plays different function so that load is distributed in efficient manner so that it decreases failure.

Nodes are determined fail when they does not give response to the packet transmitted by the leader node for purpose of discovering failure. If any backbone node is failed then internal neighbors of that backbone parent node is directly switch to other parent node. And if any internal node is failed in a network then it is ignored and leaving that cut point (hole) as it is and ignored during communication

C. *Addition of new nodes*

In RIP it is easy to add a new node in infrastructure, because it does not need any global updates. Status of the node is determined by local neighbor information collected from one-hop physical neighbor. Suppose x node is added in the network then following rules are applied for that.

- If there are no backbone nodes within neighbors of x and all internals are belong to same ring R_i then x is known as dangling node of that same ring. If internal nodes are not of that node then x is FINs in inter ringR_i.
- if x has a backbone neighbors having a same ring R_i then x is directly known as internal node of R_i and select a parent.

IV. EVALUATION OF PERFORMANCE

In that section we provide a simple cost model which shows cost of our system. And also prove that ability of RIP to reduce energy expenditure, stand against the failure and flexibility of system. We present cost model and detailed MATLAB results to show above features of proposed protocol.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

A. System cost

The total cost of the system includes number of rings formed in the network which consist of number of rings and nodes as well as the number of access points and mobile probes associated with rings.

RIP divide WSN into number of concentric rings and size or area is decreases from outermost ring to the innermost ring. Therefore the cost of the network is sum of the cost of each ring in rings.

$$C_t = \sum_{i=1}^{m} c_i \quad (1)$$

Where m is the number of determined rings, and C_t is the total cost of network. Where C_i is the cost of single ring and according to system design $C_i > C_{i+1}$.

For calculating m we assume that r_1 is the radius of outermost ring. And all nodes are uniformly distributed.

The number of discovered rings are m = r_1/T_x where T_x is the transmission range.

r_1 Does not need to know it is calculated according to c. If outermost ring R_1 is consider as polygon with set of k access points (P_1 , P_2 , P_k) as its virtual vertices, then r_1 can be calculated using equation 2

$$r_1 = \text{Max} \parallel c, \{P_1 , P_2 \quad P_k\} \parallel \quad (2)$$

Where D_i is the width of each ring.

$$D_i = (r_1 - r_{1+1}) \geq T_x \quad (3)$$

If d is the average number of one-hop neighbors (degree of connectivity), then number of nodes for each ring are calculated as

$$N_i = \leq d \mid B_i \mid \quad (4)$$

B_i= Number of hops required to complete a full circuit.

Number of access points for each ring is calculated as

$K_i = \mid B_i \mid / h$

The total number of access points in the network is given as.

$K = \sum_{i=1}^{m} k_i$

But the total communication cost is the function of communication in terms of number of energy expenditure required in network for the given task and time required to complete that task.

$$C_t = f(m, B, h) \quad (5)$$

Where,

m = Number of discovered rings

B = Time required to complete one circuit (ring)

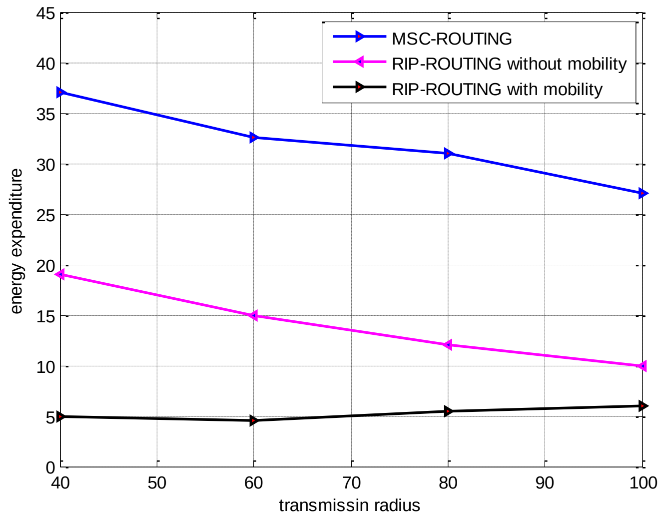
h = Number of hops/ tunable parameter for RIP

B. MATLAB Results

Very first we prove the efficiency of RIP and then show the flexibility of network at any failure. And the main thing is we compared RIP with Hybrid tree-based and cluster-based multi-scale communication described in [6]. The MSC produces multi-scale communication overlay for sensor network by forming clusters and trees.RIP effectively support upper layer process.

In this work, we obtained results via numerical calculations in MATLAB platform. We used BPSK modulation and demodulation for the communication purpose between the sensors. We have used the same system architecture as in previous work [26] and some modifications are done for reducing the energy expenditure for same transmission radius. Here our goal is to minimize overall energy expenditure for that we have used two scenario. Firstly we have increased bandwidth up to 1 MHZ = 10^6 and then we have done proper synchronization between transmitter and receiver. For successful data transmission proper synchronization between transmitter and receiver required. Hence this will save unnecessary use of energy required for transmission. In that case till the proper synchronization between transmitter and receiver is not happen transmitter cannot send data so that unnecessary transmitting energy reduced. As overall energy required for communication is reduced automatically infrastructure cost also reduced.

While performing MATLAB coding, we assume some parameter such as Nsym = 10^6 which denote bandwidth, nDSC =52 as data subcarrier, ipbit as a data bit which we modulate. And parameter such as Ct which gives cost of infrastructure, h as number of hops between two access point and B is time required complete one circuit. Network size is varied from 100 to 400 nodes and transmission range is up to 100. And with the help of that all parameter we compare the MSC communication with RIP communication. And also prove that RIP is better than MSC. Also cost required for RIP is less as compare to MSC.



Fig, 4. Communication cost Vs transmission radius for routing

The routing performance for both RIP and MSC are calculated and results are shown in figure 4. In RIP both in-ring and inter-ring communication is performed for transmission of message from source to destination. Results are shown for both mobility and no mobility. The results show that RIP saves more energy as compared to MSC. With mobility energy expenditure of RIP is very less as compare to MSC. Or in case of no mobility MSC requires more than double energy as compare to RIP.

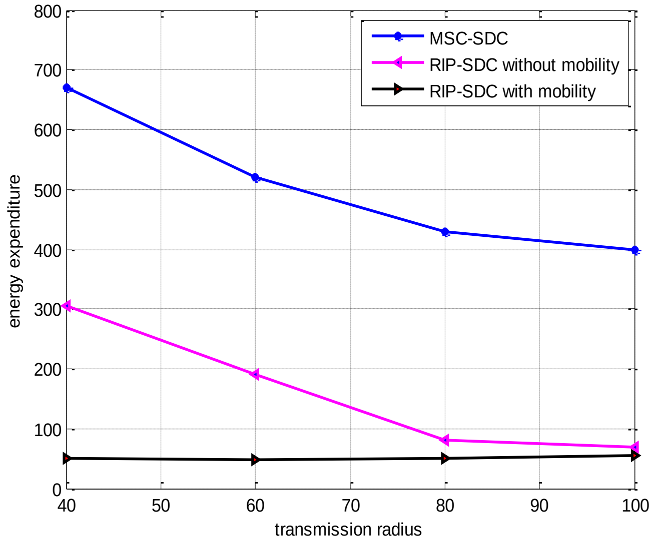


Fig.5. Energy expenditure Vs transmission radius for selective data collection

Figure 5. Shows results for selective data collection in RIP and MSC .Here twenty nodes are randmly selected as to transmit nformation packet to the data collectors (four MAs in RIP and four cluster heads in MSC). Figure 5. Shows that overall cost for average communication. In thae case of mobility RIP save more than 800 % energy compare to MSC. In static scenario RIP saves less than half of energy as compared MSC.

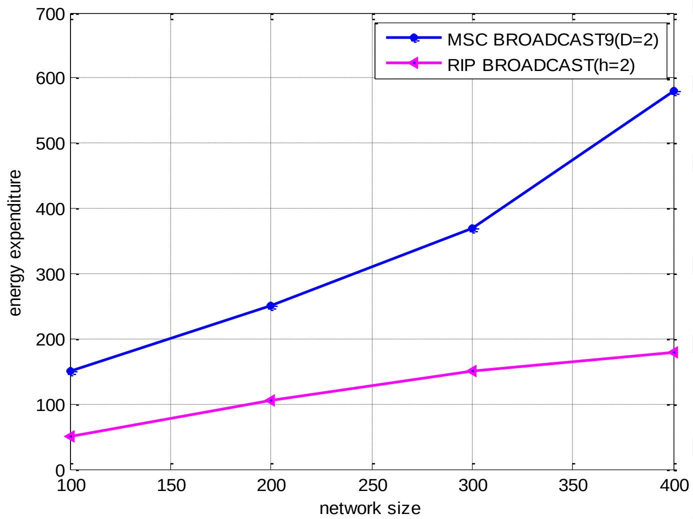


Fig.6. Energy expenditure Vs transmission size for broadcast

In figure 6. We take tunable parameter for both approach such as (D= MSC and h= RIP) results shows that in RIP transmission from the backbone node is enough for broadcasting. But in MSC all nodes must transmit data to cover entire network. So the communication cost occurred by RIP is less than MSC So all above graph shows that energy expenditure RIP is always less than the MSC approach in all the process of communication such as routing, data collection and broadcast purpose.

V. CONCLUSION

In this work we proposed the construction of ring framework by using RIP protocol. The main goal of our infrastructure is to support upper layer processes. RIP shows great flexibility and also overcomes failure in the infrastructure by segmentation and role based approach. The test results are shown via numerical calculations in MATLAB platform and that proposed work shows that with the help of using that infrastructure we can reduce double energy expenditure as compare to expenditure in MSC approach. And the test a result also shows that by using this infrastructure cost of communication is also reduced. Also the ring infrastructure support interesting features such as it provides both data-mule and multi-hop communication model and also ability to add new node with minimum aloft.

ACKNOWLEDGMENT

We would like to thanks anonymous referees for their valuable comments and suggestions to improve the quality of paper.

REFERENCES

[1] I. F. Akyildiz, W. Su, Y. Sankara subramaniam, and E. Cayirci, ``Wireless sensor networks: A survey," Comput. Netw., vol. 38, no. 4, pp. 393_422, 2002.

[2] J. Wu, ``Reliable routing protocols for dynamic wireless ad hoc and sensor networks," Ph.D. dissertation, Dept. Elect. Eng., Math. Comput. Sci., Univ. Twente, Enschede, The Netherlands, 2007.

[3] E. Yoneki and J. Bacon, ``A Survey of wireless sensor network technologies: Research trends and middleware's role," Dept. Comput. Lab., Univ. Cambridge, Cambridge, U.K., Tech. Rep. UCAM-CL-TR646, 2005.

[4] S. Hashish and A. Karmouch, ``Mobility-based generic infrastructure for large scale sensor network architecture," in Proc. IEEE ICC, Jun. 2009, pp. 1_6.

[5] R. Silva, J. Sa Silva, and F. Boavida, ``Mobility in wireless sensor networks_Survey and proposal," Comput. Commun., vol. 52, pp. 1_20, Oct. 2014.

[6] S. Palchaudhuri, R. Kumar, R. G. Baraniuk, and D. B. Johnson, ``Design of adaptive overlays for multi-scale communication in sensor network," in Proc. Int. Conf. Distrib. Comput. Sensor Syst. (DCOSS), 2005, pp. 173_190.

[7] A. A. Abbasi and M. Younis, ``A survey on clustering algorithms form wireless sensor networks," Comput. Commun., vol. 30, nos. 14_15, pp. 2826_2841, Oct. 2007.

[8] O. Younis, M. Krunz, and S. Ramasubramanian, ``Node clustering in wireless sensor networks: Recent developments and deployment challenges," IEEE Netw., vol. 20, no. 3, pp. 20_25, May 2006.

[9] A. Wadaa, L. Wilson, and M. Eltoweissy, ``Wireless sensor networks: Leveraging the virtual infrastructure," IEEE Netw., vol. 18, no. 4, pp. 51_56, Jul./Aug. 2004.

[10] S. Olariu, A. Wadaa, Q. Xu, and I. Stojmenovi¢, ``A virtual infrastructure for wireless sensor networks," in Handbook of Sensor Networks: Algo- rithms and Architectures, I. Stojmenovi¢, Ed. Hoboken, NJ, USA: Wiley, 2005, pp. 107_140.

[11] S. Olariu, M. Eltoweissy, and M. Younis, ``ANSWER: Autonomous networked sensor system," J. Parallel Distrib. Comput., vol. 67, pp. 111_124, Jan. 2007.

[12] H. Van Luu and X. Tang, ``Constructing rings overlay for robust data collection in wireless sensor networks," J. Netw. Comput. Appl., vol. 36, pp. 1372_1386, Sep. 2013.

[13] M. Akhlaq, T. R. Sheltami, and E. M. Shakshuki, ``C3: An energy-efficient protocol for coverage, connectivity and communication in WSNs," Pers. Ubiquitous Comput., vol. 18, no. 5, pp. 1117_1133, 2014.

[14] Y. Zhou and M. Medidi, ``Sleep-based topology control for wakeup scheduling in wireless sensor networks,'' in Proc. IEEE 4th Annu. Commun. Soc. Conf. Sensor, Mesh Ad Hoc Commun. Netw., Jun. 2007, pp. 304_313.

[15] M. Ali and K. Langendoen, ``A case for peer-to-peer network overlays in sensor networks,'' in Proc. Int. Workshop Wireless Sensor Netw. Archit. (WWSNA), 2007, pp. 56_61.

[16] M. Caesar, M. Castro, E. B. Nightingale, and A. Rowstron, ``Virtual ring routing: Network routing inspired by DHTs,'' ACM SIGCOMM Comput. Commun. Rev., vol. 36, pp. 351_362, Oct. 2006.

[17] L. Gao and M. Li, ``Multi-level virtual ring: A foundation network architecture to support peer-to-peer application in wireless sensor network,'' in Proc. Austral. Telecommun. Netw. Appl. Conf. (ATNAC), 2009, pp. 1_6.

[18] N. Katneni, V. Pandit, H. Li, and D. P. Agrawal, ``Hybrid Gaussian-ring deployment for intrusion detection in wireless sensor networks,'' in Proc. IEEE Int. Conf. Commun. (ICC), Jun. 2012, pp. 549_553.

[19] S. Hashish and M. Ahmed, ``Ef_cient wireless sensor network rings overlay for crowd management in Arafat area of Makkah,'' in Proc. IEEE SPICES, Feb. 2015, pp. 1_6.

[20] A. Ghosh and S. Das, ``Coverage and connectivity issues in wireless sensor networks: A survey,'' Pervas. Mobile Comput., vol. 4, pp. 303_334, Jun. 2008.

[21] Q. Fang, J. Gao, and L. J. Guibas, ``Locating and bypassing routing holes in sensor networks,'' in Proc. 23rd Conf. IEEE Commun. Soc. (INFOCOM), Mar. 2004, pp. 2458_2468

[22] Q. Fang, J. Gao, and L. J. Guibas, ``Locating and bypassing holes in sensor networks,'' Mobile Netw. Appl., vol. 11, pp. 187_200, Apr. 2006.

[23] D. Jea, A. Somasundara, and M. Srivastava, ``Multiple controlled mobile elements (data mules) for data collection in sensor networks,'' in Proc. IEEE DCOSS, Jun./Jul. 2005, pp. 244_257.

[24] B. Chen, K. Jamieson, H. Balakrishnan, and R. Morris, ``Span: An energy-ef_cient coordination algorithm for topology maintenance inad hoc wireless networks,'' in Proc. 7th Annu. Int. Conf. Mobile Comput. Netw. (MobiCom), 2001, pp. 85_96.

[25] L. M. Feeney and M. Nilsson, ``Investigating the energy consumption of a wireless network interface in an ad hoc networking environment,'' in Proc. IEEE INFOCOM, Apr. 2001, pp. 1548_1557.

[26] Sonia Hashish, ``Dynamic concentric ring infrastructure for efficient communication in Wireless Sensor Network,'' in proc IEEE vol 4, jun 2016, pp. 2169_3536.

[27] D. Culler et al., ``Towards a sensor network architecture: Lowering the waistline,'' in Proc. HOTOS, 2005, p. 24.

[28] K. Dantu, M. H. Rahimi, H. Shah, S. Babel, A. Dhariwal, and G. S. Sukhatme, ``Robomote: Enabling mobility in sensor networks,'' in Proc. 4th Int. Symp. Inf. Process. Sensor Netw., 2005, p. 55.