OPTIMIZED FRAMEWORK FOR COLLECTION OF DATA MOBILITY IN ENERGY HARVESTING WIRELESS SENSOR NETWORK

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ABSTRACT*:* We introduce environment as energy harvesting technologies. energy harvesting can be described as mechanism used to generate energy from network ambient we adaptively select a subset of sensor locations where the SenCar stops to collect data packets in a multi-hop fashion. We present three-hop step method for mobile data collection in energy harvesting sensor network. Firstly we collect the location status of our nodes and SenCar and on the basis of its information we partition the nodes in clusters of different regions. We then develop an adaptive algorithm to search for nodes based on their energy and guarantee data collection tour length is bounded. At last, we focus on designing distributed algorithms to achieve maximum network utility by adjusting data rates, link scheduling, and flow routing that adapts to the spatial-temporal environmental energy fluctuations.Our analysis shows that we achieved our aim of maximum network utility with an optimized framework.

Index terms: Wireless sensor networks, energy harvesting, K-Means Clustering, adaptive node selection, mobile data gathering, distributed algorithms, Travelling Salesman Problem, Tool Command Language, Aho Weinberger Kernighan.

I INTRODUCTION

ENVIRONMENTAL energy harvest home has emerged as a promising technique to supply property energy sources for powered wireless detector networks (WSNs), whose network longevity is unnatural by battery capacity[1, 2, 3]. Renewable energy sources like star, wind, thermal necessitates Cyber Physical Systems (a network consists of sensors and actuators to act with the physical world) for achieving energy potency and value effectiveness [2,3]. For example, star harvest home is proved to be helpful to provide energy to sensors from a solar array of comparatively similar size of sensors. Thermo electrical conversion offers opportunities to reap energy via heat transfer once the temperatures of objects or environments are totally different[6]. When power from associate degree close energy supply (such as star, wind or thermal, etc.) is brought into a WSN, it becomes rechargeable, and is feasible to attain infinite network time period by careful network coming up with and energy harvesting aware designs. Admittedly, there are an excellent quantity of analysis efforts on energy harvesting-aware styles for WSNs[6, 8]. Most of them either targeted on optimizing performance of individual detector or studied the way to route packets in associate degree energy economical manner (energy-aware routing)[7]. However, to the simplest of our data, these works have unnoticed impact from heterogeneous spatial distributions of environmental energy whereas sensors are working along from totally different geographical locations, so they would still suffer from traffic bottlenecks if energy shortage is inevitable insure regions. so as to bypass possible energy constraints caused by heterogeneous environmental energy distribution, we tend to approach the matter from a replacement perspective by using a mobile mechanism (called SenCar henceforth) for information gathering[10]. Adopting a mobile collector has well-known advantages to distribute energy consumption additional equally compared to a static information sink, as a result of nodes near to the information sink tend to consume additional energy for forwarding packets[11, 12]. As energy harvest home rates rely on sensors spatial-temporally, congestion might occur with a static data sink.

- **Wireless Sensor Network:** It's a Wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions [16].

- **NS2:** A network simulator is software that predicts the behavior of a computer network. Network Simulator (Version 2), widely known as NS2, is an event- driven simulation tool that is useful in studying the dynamic nature of communication networks. Simulation of wired further as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2. In general, NS2 provides users with the way of specifying such network protocols and simulating their corresponding behaviors[1, 5, 6, 14].

- **NAM:** Nam (Network Animator) is an animation tool to graphically represent the network and packet traces. Network animator (Nam) may be a Tcl/TK primarily based animation tool for viewing network simulation traces and globe packet traces. It is mainly intended as a companion animator to the ns simulator simulator After the trace file is created Scripting languages such as AWK (Aho Weinberger Kernighan) script and PERL script are often wont to calculate the performance metrics. Here we are using AWK for calculating performance analysis constraints.

II RELATED WORK

In earlier work, some papers explore the weather forecasts to improve a system's ability to satisfy demand by improving its predictions[3, 5]. Some authors worked on path planning to control latency between nodes. Also some used embedded system like Heliomote for power management that improves energy. Different papers work on different algorithms to achieve energy efficient network[4, 9]. We also have seen one paper that gives us the clear idea about creation of wireless sensor network environment. In one the paper, author has developed an framework called QuARES that manages in two mode offline for path planning and online stage to tackle the fluctuation in time-varying energy harvesting profile[5,10, 14]. One of the paper mentions about Randomized Routing and Sencar based routing algorithms for finding their neighbors. Energy consumption is not achieved properly in previous methodologies.

III PROBLEM STATEMENT

- Design a comprehensive framework such that mobile data gathering network utility is maximized.
- Packet latency is bounded by a predetermined threshold for energy harvesting sensor network.

IV PROPOSED SYSTEM

First we proposed a new framework by introducing mobile data collective for energy harvesting sensor network. Second we used K-Means algorithm for dividing our network nodes in cluster regions so that all the nodes in the network are at least once visited by SenCar which are mobile data collector. Third, we develop an adaptive anchor selection algorithm for SenCar a balance between data collection amount and latency Fourth, given the selected anchors, we propose distributed algorithms to find optimal data rates, link flows for sensors and sojourn time allocation for the SenCar[1]. Finally, we provide extensive evaluations to demonstrate that the proposed scheme can converge to optimum, react to the dynamics of energy income effectively, maintain perpetual network operation and improve network utility significantly compared to the network with a static data sink. To the best of our knowledge, this is the first work that gives a comprehensive solution from where the SenCar should stop for data gathering to how to optimize network utility under spatial-temporal energy variations and achieve scalabiltiy in network.

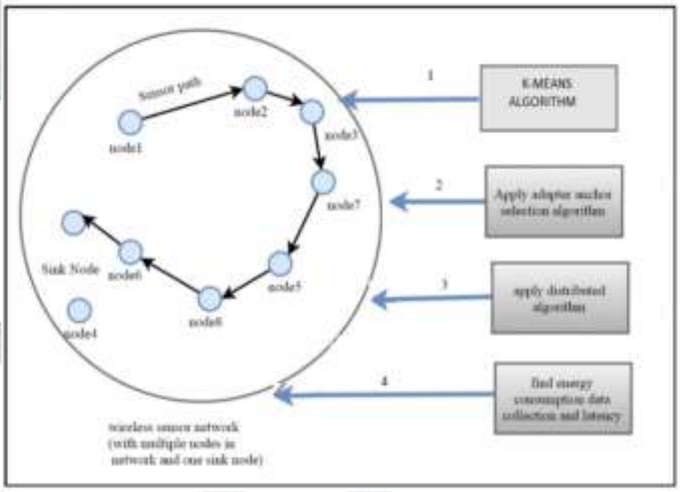


Fig. 1 System Architecture

4.1 K-Means Clustering Algorithm

The aim of K-Means algorithm in this paper is to divide the WSN in Clusters so that SecCar can collect their information and status to update it to the base station. This is done so that all the 4 SecCar in the network can work iteratively and cover all the nodes in the network within given time constraints. At the end all the data must be gathered at the base station for further process of obtaining optimized results of energy harvesting in the network [7].

K-Means Algorithm Steps

- Initialize cluster centers as base station.
- Assign observations to the cluster center base station.
- Revise cluster centers as mean of assigned observations.
- Repeat step 2 and step 3 until convergence.

4.2 Adaptive Anchor Selection Algorithm

We develop an adaptive algorithm to search for nodes based on their energy and guarantee data collection tour length is bounded. Second, we focus on designing distributed algorithms to achieve maximum network utility by adjusting data rates, link scheduling, and flow routing that adapts to the spatial-temporal environmental energy fluctuations [1, 11].

This means we select appropriate node Among overall WSN Network anchor and sink node is used here sink node gather information to one sink node after travelling in network, we consider a static WSN which is composed of one sink and randomly distributed sensor nodes , in a two-dimensional sensing field, where is the number of the deployed nodes. The path selection is done using TSP (Travel Sales persons) problem which is used to calculate the distance between two nodes by returning to the base station [1, 13].

The anchor selection algorithm works for meeting two requirements.

- First, it should select a subset of sensors while maximizing the amount of data collected.
- Second, it should minimize the number of anchors so that each data collection tour can be planned to meet the delay requirement [1, 11, 13].

Anchor Selection Algorithm in interval *K*

- Input: Set of nodes *N*, battery states at the end of *K-1* interval$\boldsymbol{b}_{\boldsymbol{i}}^{(\boldsymbol{K-1})}$, tour length bound $\boldsymbol{L_b}$, connectivity matrix *X* of *m* hops.
- $\forall\ \boldsymbol{i} \in \boldsymbol{N}$, compute weighted average $\boldsymbol{W_i}$.
- Sort $\boldsymbol{N}$ in ascending order regarding $\boldsymbol{W_i}$, denote result as $\boldsymbol{N_s}$.
- Initialize node index $\boldsymbol{i = 1, j = |N_s|}$
- While $\boldsymbol{N_s}$ is not exhaust, Obtain *jth* element in $\boldsymbol{N_s}$ and insert to $\boldsymbol{A^{(K)}}$;
- For *i* from 1 to *j*, If $\boldsymbol{X_{ij} > 0, N_s \leftarrow N_s - i}$ and set i as descendant of j; otherwise let$\boldsymbol{N_s \leftarrow N_s - j}$ and recompute $\boldsymbol{j = |N_s|}$;
- Obtain candidate $\boldsymbol{A^{(K)}}$ list from above
- Compute the shortest migration tour $\boldsymbol{L_{tsp}^{(K)}}$through sensors in $\boldsymbol{A^{(K)}}$
- If $\boldsymbol{L_{tsp}^{(K)} A^{(K)} \leq L_b}$, Break; or Else Remove anchors with $\boldsymbol{W_i}$ least from$\boldsymbol{A^{(K)}}$.

4.3 Distributed Algorithm

The distributed algorithm works in two levels, low level for rate control for optimal data rate and flow routing sub algorithm for optimal routing path and flow rate on each link[14]. The next step is to update the Lagrangian multipliers iteratively and forward the values to their direct neighbors. In the higher level the results obtained at lower level are input, these results are derivated for second time as mentioned in the algorithm. Also sojourn time is updated until the convergence of Lagrangian multipliers is achieved to obtain utility function with respect to data rate for optimized results.

Distributed Algorithm for Mobile Data Gathering

- Initialize $y_i^{(k)} = \left\{y_{i,a}^{(k)} \mid a \in A^{(k)}\right\}$ to non-negative values.
- Repeat the process of Updating $y_i^{(k)}$for all $a \in A^{(k)}$
- Initialize $\tau_a^{(k)}(0)$ sourjan time and $\varpi_a^{(k)}(0)$ lagrangian multipliers to non-negative values.
- Repeat the Higher-level optimization iterations by Initializing$\xi_{i,a}^{(k)}(0)$ flow rate and $v_{i,a}^{(k)}(0)$ consumed energy to non-negative values.
- Repeat the Lower-level Optimization iterations by determining$r_i^{(k)}(t) = \left\{r_i^{(k)}(t)\right\}$,By the rate control sub algorithm in algorithm which computes $r_{i,A}^{(K)*} = U_i'\left(R_i^{(K)*}\right) + m_{i,A}^{(K)*}/c_i.(U_i' of R_i^{(K)}$ is the first order derivative)
- Determine Flow routing sub algorithm $f_i^{(k)}(t) = \left\{f_{i,j,a}^{(k)}(t) \mid j \in P_{i,a}^{()}\right\}$, which computes $X_i = \left\{(j,a) \mid \xi_{i,a}^{(K)} - \xi_{i,a}^{(K)} - v_{j,a}^{(K)}\mu_{i,j}^{tx} - v_{i,a}^{(K)}\mu_{i,j}^{rx} > 0,\right\}$ which is flow conversation price, average energy consumed to receive and transmit dart at node *i* .
- Update Lagrangian Multipliers $\xi_{i,a}^{(k)}$ and $v_{i,a}^{(k)}$ using second order derivative. Send updated $\xi_{i,a}^{(k)}$ and $v_{i,a}^{(k)}$ to its neighbors and SenCar;
- Until $\left\{\xi_{i,a}^{(k)}(t)\right\}$and $\{v_{i,a}^{(k)}(t)\}$ converge to $\xi_{i,a}^{(k)*}$ and $v_{i,a}^{(k)*}$. repeat the process until we receive updated information of all anchor nodes in the network.
- SenCar computes $\tau_a^{(k)}$(t) and $\varpi_a^{(k)}(t)$.By the sojourn time allocation subalgorithm, sencar simultaneously compute $\tau_a^{(k)}$(t+1), update Lagrangian multipliers $\{\varpi_a^{(k)}$(t)}Until converge to $\varpi_a^{(k)*}$
- Set $y_i^{(k)}[n+1] = r_i^{(k)}[n]$ in the *n*th proximal iteration
- Until $y_i^{(k)}$ converges to optimum $r_i^{(k)}$.

V RESULTS

The proposed work is implemented using NS2's NAM (Network Animator) software so the output is in graphical form. Wireless Sensor Network (WSN) is created with Anchor nodes, SenCar (Mobile Data Collector), and a Sink node as Base station in Fig 2. it's a topological representation. The SenCar travels in the WSN is displayed after that a Trace file of TCL shows the values calculated for utility function in Fig. 3. later the graphs shows how with respect to time the Average consumed energy, Average remaining energy, No. Of Packet send, No. Of packet received, Delay, Jitter, PDR , Throughput, Goodput, Control overheads, normalized overheads, No. Of packets Dropped and its Dropping Ratio can be displayed with respect to nodes with good energy and nodes of less energy after optimization. These shows how optimized our network is and its efficiency.

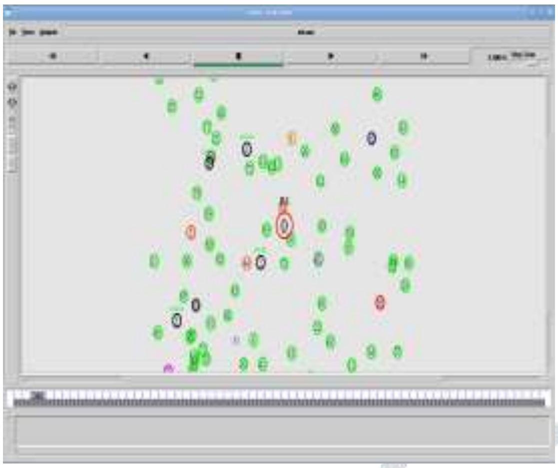


Fig. 2 Nam Output- Topological Representation

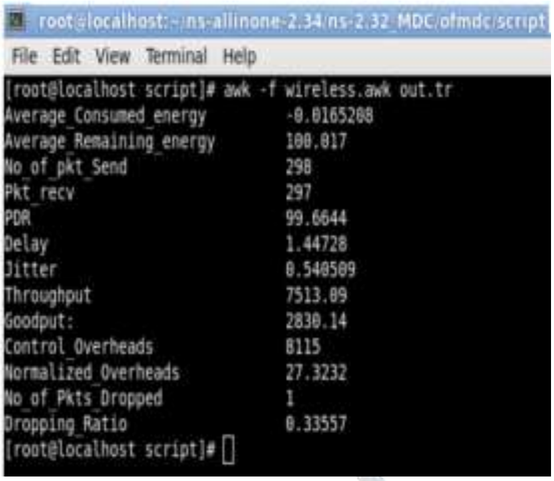


Fig. 3 Output Values of Traced file

The Fig. 4 displays the graph representation of packet received in the network with respect to time in the using the proposed methodology .Table. 1 represents the graph values.

Graph. 1 Graph representation of packet received with respect to time

Table: 1 Packet Received with respect time before optimization and after optimization

TIME	PACKET_RECV_MDC	PACKET_RECV_OFMDC
150	95	259
175	109	276
200	152	297
225	176	383
250	192	466

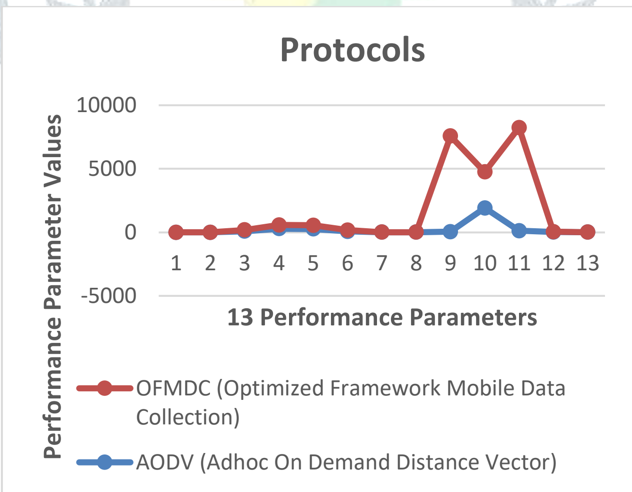
VI PERFORMANCE ANALYSIS

- **Performance Analysis with respect to protocols**

The performance evaluation we have done with respect to the two protocols one implemented in previous work as AODV (Adhoc On Demand Distance Vector) and the one which we have implemented the OFMDC(Optimized framework Mobile Data Collection) protocol. The Table: 1 shows the analysis and Graph: 1 shows the chart representation of the the analysis.Hence we can say that OFMDC has proved to be better protocol than AODV.

Table. 2 Performance Analysis of protocols AODV and OFMDC

Protocol / Performance Parameters	AODV (Adhoc On Demand Distance Vector)	OFMDC (Optimized Framework Mobile Data Collection)
Average_Consumed_Energy	-0.24875	-0.01653
Average_Remaining_Energy	78.88	100.017
No. Of Packet Send	278	298
Packet Received	256	297
PDR (Packet Delivery Ratio)	73.14	99.6644
Delay	1.7722	1.44728
Jitter	0.66723	0.540509
Throughput	50.57	7513.09
Goodput	1910.16	2830.14
Control_Overheads	115	8115
Normalized_Overheads	15.86	27.3232
No._of _Packets_Dropped	7	1
Dropping_Ratio	26.86	0.33557



Graph: 2 Performance Analysis of protocols AODV and OFMDC

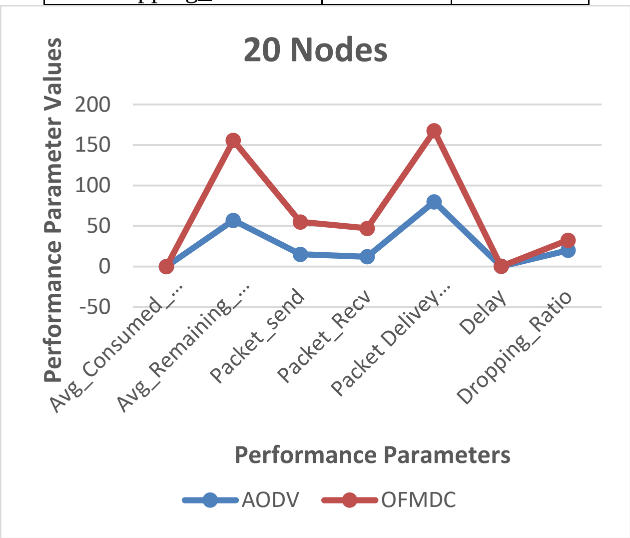
- **Performance Analysis on 20 Nodes**

We have performed performance evaluation on 20 nodes , considering 7 performance parameters with respect to the protocols used in previous system which is AODV and the one used in Proposed system which is OFMDC. The average consumed energy of previous system -0.12876 is more as of proposed system energy -0.01325. Likewise average remaining energy is 56.88 which is also less as compared to 98.756 in this system. Packet send and received also has difference proposed system give more packet count as of existing system. On the basis of packets received and send packet delivery ratio is calculated is good in proposed system. The delay is the time taken by packet to reach to destination from source which is less in our case and more in existing system. Last parameter I analyzed is the dropping ratio which is more using AODC protocol is 20 were as using

OFMDC it is 12.5. At last our evaluation say that the proposed work is good and better from existing system on 20 nodes. As shown in Table. 3 and Graph. 3.

Table: 3 Performance Analysis with respect to 20 nodes

20 Nodes	AODV	OFMDC
Avg_Consumed_Eng	-0.12876	-0.01325
Avg_Remaining_Eng	56.88	98.756
Packet_send	15	40
Packet_Received	12	35
Packet Delivery Ratio	80	87.5
Delay	0.06667	0.01428
Dropping_Ratio	20	12.5



Graph. 3 Performance Analysis with respect to 20 nodes

- **Network Wide Performance**

We have simulated the proposed algorithm using NS-2's NAM animator tool. We implemented the algorithms on Link layer and extended the Optimized Framework Mobile Data Collection (OFMDC).

In the Evaluation, 101 Sensor nodes are placed in the network with field of size $500 \times 500\ m^2$ (Table. 4 shows the parameters set in the WSN) and the anchors with 101 nodes are selected using k-means algorithm to divide then in clusters and later Anchor list is form with nodes having less or decreasing energy. A Mobile Data Collector is added as the SenCar to gather data while moving 2 m/s. so firstly, there is a need to validate that the proposed algorithm can reach a steady optimal state with the SenCar migrating over different anchors. The observation thus indicate that the proposed algorithm find new optimal path for 19 nodes in total. This is a better work than previous work using OFMDC protocol as compared to the base papers AODV protocol.

Table. 4 Simulation Parameters

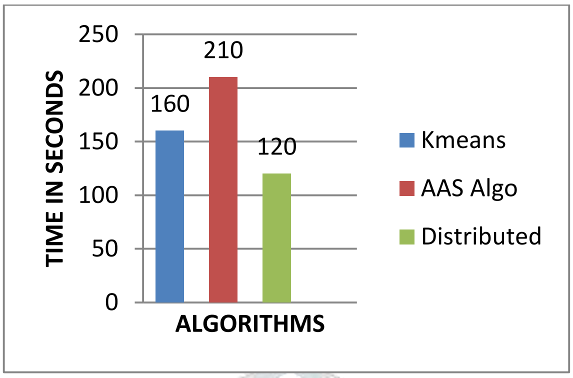
Specification	Data
Size of Network	**$500 \times 500\ m^2$**
No. Of nodes	**101**
SecCar- Mobile Data Collector	**4**
Base Station - Sink Node	**1**
Initial Energy	**100**
Sensor Type	**Passive**
Sensor Range	**79 m**
Network Protocol	**OFMDC**

- **Analysis with respect to time taken by 3 Algorithms**

Another analysis we have done with respect to time taken by all the three algorithms implemented in our project the k-Means, Adaptive Anchor Selection and the Distributed Algorithm. The graph and table shows the time required by all the three algorithms in Table: 5 and Graph: 4 respectively, which is less than the previous work which is shown in Table. 6 and Graph. 5 respectively.

Table. 5 Time Required by Proposed Algorithm

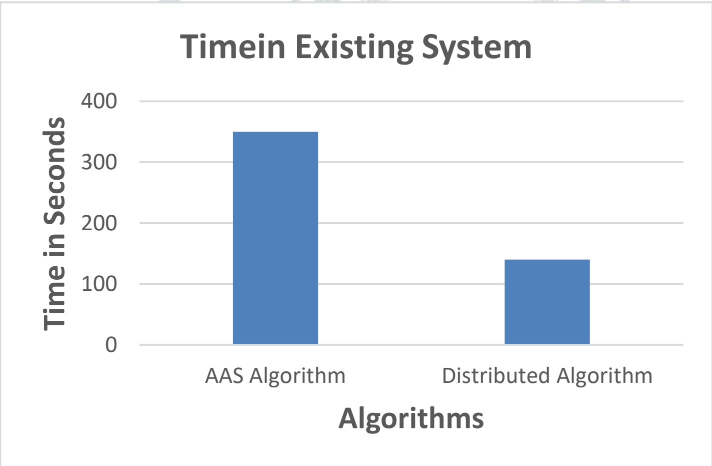
Algorithms	K-means Algorithm	AAS Algorithm	Distributed Algorithm
Times in Sec	160	210	120



Graph. 5 Time Required by the Proposed three Algorithms

Table. 6 Time Required in Existing System

Algorithms	AAS Algorithm	Distributed Algorithm
Time in Sec	350	140



Graph. 6 Time Required by the Existing Two Algorithms

VIIAPPLICATION

- Geographical locations.
- In Solar power measurement.
- Large industries for saving energy.
- Military Application for condition based monitoring, border monitoring and military surveillance.
- Environmental monitoring for agricultural wireless sensors.
- Air traffic control [16, 17].

VIII CONCLUSION

As the considered problem was of finding optimal mobile data gathering strategies for energy harvesting sensor network. first we have implemented K-means algorithm for achieving scalability feature then the adaptive algorithm for selection of anchor nodes in network then by TSP approach, set of Anchor nodes to be visited are achieved later after visiting optimization is done on them for calculating sojourn time and then achieve harvesting rate based on data rate, scheduling and routing to increase overall network utility.

IX REFERENCES

[1] Cong Wang, Songtao Guo, and Yuanyuan Yang, Fellow, IEEE "An Optimization Framework for Mobile Data Collection in Energy-Harvesting Wireless Sensor Networks", Volume 15, no. 12, December 2016. pp. 2969-2986
[2] M. Rahimi, H. Shah, G. Sukhatme, J. Heideman, and D. Estrin, "Studying the feasibility of energy harvesting in a mobile sensor network," in Proc. IEEE Int. Conf. Robot. Autom., 2003, pp. 19–24.
[3] N. Sharma, J. Gummeson, and D. Irwin, "Cloudy computing: Leveraging weather forecasts in energy harvesting sensor systems," in Proc. 7th Annu. IEEE Commun. Soc. Conf. Sens. Mesh Ad Hoc Commun. Netw., 2010, pp. 1–9.
[4]V. Raghunathan, A. Kansal, J. Hsu, J. Friedman, and M. Srivastava, "Design considerations for solar energy harvesting wireless embedded systems," in Proc. 4th Int. Symp. Inf. Process. Sens. Netw., Apr. 2005, pp. 457–462.
[5] P. Plonski, P. Tokekar, and V. Isler, "Energy-efficient path planning for solar-powered mobile robots," Exp. Robot. Springer Tracts Adv. Robot., vol. 88, pp. 717–731, 2013
[6] J. Paradiso and T. Starner, "Energy scanverging for mobile and wireless electronics," IEEE J. Pervasive Comput., vol. 4, no. 1, pp. 18–27, Jan. 2005.
[7] C. Ma and Y. Yang, "A battery-aware scheme for routing in wireless ad hoc networks," IEEE Trans. Veh. Technol., vol. 60, no. 8, pp. 3919–3932, Oct. 2011.
[8] C. Vigorito, D. Ganesan, and A. Barto, "Adaptove control of duty cycling in energy-harvesting wireless sensor networks," in Proc. 4th Annu. IEEE Commun. Soc. Conf. Sensor, Mesh Ad Hoc Commun. Netw., 2007, pp. 21–30.
[9] M. Gorlatova, A. Wallwater, and G. Zussman, "Networking lowpower energy harvesting devices: Measurements and algorithms," in Proc. IEEE INFOCOM, 2011, pp. 1602–1610.
[10] Nga Dang, ElehahBozorgzadeh,Nalini Venkatasubramanian, QuARES:Quality and energy harvesting in Wireless Sensor Networks, 2011
[11] L. Lin, N. Shroff, and R. Srikant, "Asymptotically optimal energyaware routing for multihop wireless networks with renewable energy sources networking," IEEE/ACM Trans. Netw., vol. 15, no. 5, pp. 1021–1034, Oct. 2007.
[12] R. C. Shah and J.MRabaey, "Energy aware routing for low energy ad hoc sensor networks," in Proc. Wireless Commun. Netw. Conf. 2002, pp. 350–355.
[13] M. Ma and Y. Yang, "SenCar: An energy efficient data gathering mechanism for large scale multihop sensor networks," IEEE Trans. Parallel Distrib. Syst., vol. 18, no. 10, pp. 1476–1488, Oct. 2007.
[14] M. Ma, Y. Yang, and M. Zhao, "Tour planning for mobile data gathering mechanisms in wireless sensor networks," IEEE Trans. Veh. Technol., vol. 62, no. 4, pp. 1472–1483, May 2013.
[15] M. Zhao and Y. Yang, "Optimization-based distributed algorithms for mobile data gathering in wireless sensor networks," IEEE Trans. Mobile Comput., vol. 11, no. 10, pp. 1464–1477, Oct. 2012.

Books Referred

[16]Kazem Sohraby, Daniel Minoli, Taieb Znati, "Wireless Sensor Networks, Technology, Protocols and Application", Wiley Interscience.
[17] Yuanyuan Yang, Cong Wang, "Wireless Rechargable Sensor Network", Springer.