Improving the Performance in Wireless Sensor Networks using Energy Transfer Technique

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***Abstract*-Wireless Sensor Networks has been used in various applications such as remote environment monitoring and target tracking. Sensor nodes use batteries as the sole energy source. A major challenge affecting the performance of wireless sensor network s is the limited battery energy. To recharge the battery at each sensor node, a mobile wireless charging vehicle(WCV) is employed, which periodically travels inside the sensor network. For prolonging the lifetime of the sensor network,this mobile charging vehicle travelsinside the sensor networks, wireless power transfer technology is used to wirelessly recharge the sensor nodes via wireless charging vehicle using magnetic resonant coupling method. Energy Weighted Moving Average Routing Protocol is used to find the optimal travelling path for the WCV, which reduces the energy wastages in the WCV that will be used when visiting the sensor node which has maximum energy and thus overall lifetime of the network is increased.**

I.INTRODUCTION

Wireless Sensor Network has many important applications which include the field of Structural Health Monitoring, Wildlife Monitoring, Remote environment Monitoring, Target tracking and etc. In spite of their broad utility, energy efficiency remains a critical challenge in WSNs. Consider a Network of Sensors, each with a certain quantity of data designated collector node. In general, a sensor network may be simultaneously performing a variety of tasks including sensing, processing and communication. Wireless Sensor Network consists of battery-powered nodes that are endowed with a multitude of sensing modalities and scalar data. Although there have been significant improvements in processing design and computing, advances in battery technology still lag behind, making energy resource considerations cause a fundamental challenge in the WSNs.

Since the network lifetime is considered to be the most important metric for the evaluation of performance of the sensor networks many approaches such as Energy Harvesting, Battery Replacement and etc. have been proposed to address the limited lifetimeproblem but none of them were considered to have high lifetime for the sensor nodes.

As the Wireless Power Transfer technology is being commercialized, it has been considered to become an alternative to energy constraint problem in sensor networks. The Wireless Power Transfer is becoming a promising solution to address the energy constraint problem since it does not require any physical alignment with the sensor nodes as wireless charging can be done between two electronic devices without any plugs or wires and thy can be kept far apart from each other (say 2m).

Wireless power transfer through Magnetic Resonant Coupling method works effectively when compared to other methodologies. The basic principle behind the magnetic resonant coupling is that if two resonant circuits tuned at same frequency can allow energy transfer from one object to another within a certain amount of time.The magnetic resonant coupling technique is Omnidirectional and it has little interface with surrounding objects in its environment.

A Wireless Charging Vehicle can be employed to bring the clean electrical energy from the service station where the energy is generated to sensor nodes and recharges its battery periodically in a renewable cycle that is the node's battery will exhibit some periodicity over cycle time. The major objective is to maximize the ratio of wireless charging vehicle's vacation time over its cycle time.

The Optimal travelling path for the wireless charging vehicle is formulated using a special protocol named Energy Weighted Moving Average Routing Protocol which was derived from Dynamic Source Routing Protocol. If a neighbor node has been visited by vehicle then RREQ will check its recorded route to manage or to transfer the energy. Route cache implementation is all from DSR, where Neighbor Table is maintained by each node. When vehicle shorten the route, the new route might or might or not work because of the shortening. To modify the route first, and then set the flag. If the route works, the node can works with min energy after that we can modify the route and change the route shortened flag. Causes Energy weighted moving average routing protocol to apply a "smoothing" function to the link layer feedback that is generated by 802.11. In essence, it requires that an RT_MAX_ERROR error occurs within a window of RT_MAX_ERROR_TIME before the link layer. Timer for channel assignment, handle forward is to handle data forward.

This paper differs from Delay Tolerant Network in which the network may experience

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frequent, long-duration partitioning and may never have an end-to-end contemporaneous path. Various delivery mechanism such as data MULEs and message ferry where employed here. MULEs pick up data from sensors when in close range, buffer it and drop off the data to the destination base station. This can lead to substantial power saving at the sensor Base station. They only have to transmit over a short range. Message Ferrying is a mobility-assisted approach which utilizes a set of special mobile nodes called message ferries to provide communication service for the nodes in the networks. This improves data delivery performance and reduce energy consumptions in nodes under a variety of network conditions

II. DESIGN OF SENSOR NETWORK WITH A MOBILE WCV

A Sensor network may contain several sensor nodes which perform their task of monitoring the environment, generate sensory data and periodically sends its data to the Base station. The most important notation that has to be consider in this network is its functional lifetime that is the maximum number of times the task of delivering all the data to the base station can be repeated before some nodes run out of energy. In general the lifetime of the sensor network can be defined as the time until the first node failure. Failure in the sense that the particular node has no further energy to perform its task.

Consider a set of sensor nodes distributed over a two dimensional area. Each sensor node has a battery capacity of E_{max} and is fully charged initially. That there is no limit on the number of times batteries can be recharged. In rechargeable batteries can be recharged only for a limited number of times. The battery capacity also decreases, and batteries may eventually need to be replaced. Also, E_{min} the minimum energy at a sensor node battery (for it to be operational). Network lifetime as the time until the energy level of any sensor node in the network falls below $E_{min.}$ Within the sensor network, there is a fixed base station, which is the sink node for all data generated by all sensor nodes. Multihop data routing is employed for forwarding data by the sensor nodes.

There were multiple approaches used to recharge the sensor nodes battery but none of them were considered to improve the sensor networks performance via increasing the lifetime. Comparing to conventional techniques, wireless charging can replenish energy in more controllable and efficient manner since it doesnot require accurate location for

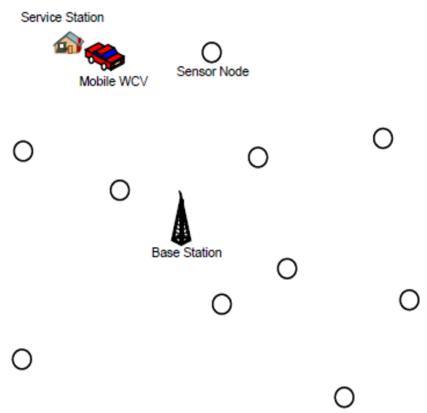

Fig. 1.A Sensor Network with Mobile WCV

physical alignment to sensor nodes. So, a wireless charging vehicle (WCV) is employed inside the network to periodically recharge the sensor nodes battery whenever the battery energy level reaches below $E_{min.}$ This wireless charging vehicle is equipped with an energy transmitting antenna for recharging. There will be service station located inside the network in which the energy is being generated. The wireless charging vehicle will return to its service station whenever the WCV recharges all the sensor nodes whose energy level is below E_{min} for recharging or replacing of batteries. The time spend by the WCV in its service station is said to be Vacation time and the time spend in the network field for recharging of sensor node battery is said to be Cycle time.

III. IMPLEMENTATION OF WIRELESS POWER TRANSFER

The basic principle of Wireless power transfer (WPT) based on Magnetic resonant coupling is that two self-resonators that have the same resonant frequency can transfer energy efficiently over midrange distances. It was also reported that Magnetic resonant coupling has several valuable advantages, such as efficient midrange power transfer, non-radiative, and nearly omnidirectional.

It is certain that these properties will help to improve the performance of current wireless power transfer systems and be utilized well for various wireless power transfer applications such as electric vehicles, consumer electronics, smart mobile devices, biomedical implants, robots, and so on.

Wireless power transfer through the use of strong coupled magnetic resonances works very well for

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efficient power transfer in dynamic environment compared to other technologies. This method has many advantages since there will be no interferences between the sender and receiver of the transmission and has very little interferences with its surrounding objects. In Traditional Inductive coupling method the power transmission of energy decreases at a rate of $1/x^2$ as the distance increases. This can be reinforced in the magnetic resonant coupling technique by including two resonant coils in the charging vehicle and the sensor node battery. These two resonant coils when driven at same frequency greater and greater energy will be transmitted between them. The coils will yield better energy transmission when they are separated.

IV.IMPLEMENTATION OF RENEWABLE ENERGY CYCLE

The energy level of a sensor node exhibits a renewable energy cycle if it meets the followingtwo requirements: (i) it starts and ends with the same energylevel over a period of time and (ii) it never falls below E_{min} . During a renewable cycle, the amount of charged energy at a sensor node i during τi must be equal to the amount of energy consumed in the cycle. Renewable energy cycle where the remaining energy level in a sensor node's battery exhibits some periodicity over a time cycle. In this both necessary and sufficient condition for renewable energy cycle and feasible solutions satisfying these conditions can offer renewable energy cycles and, thus, unlimited sensor network lifetime.

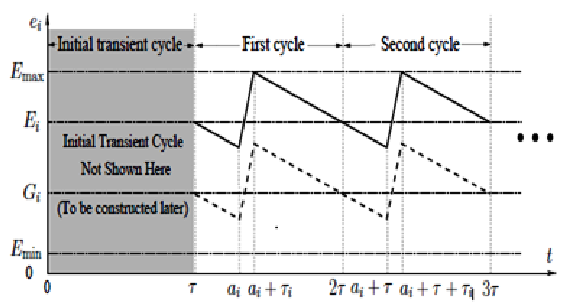

Fig. 2. Energy cycle

G_i=Starting energy of sensor nodes
$g_i(t)$=Energy level at time t

The amount of energy recharges by WCV to a sensor node depends fully on the recharging time.

So, $g_i(a_i) <= g_i(t) <= g_i(a_i+T)$

V. ENERGY WEIGHTED MOVING AVERAGE ROUTING PROTOCOL

Initially the neighbouring sensor nodes will form a cluster based on its location. In each cluster the sensor nodes whose location is nearer to each other will be present. There will be a cluster head for each cluster. The cluster heads of each cluster will have the energy level of its cluster member. The adjacent sensor nodes will become the neighbour nodes for each sensor node in the cluster. There will be neighbour table maintained by each sensor node. Periodically the sensor nodewill multicast its own energy level to all its neighbour. The wireless charging vehicle will travel inside the network after its vacation time. The WCV will enter inside the first cluster which is located nearer to the service station. Inside the cluster the WCV will visit the cluster head and mark it as visited. The WCV will checks cluster head's energy level and recharges its battery if required. Once the cluster head is visited the WCV will move on to its neighbouring node whose energy level is below $E_{max}$by using its neighbour table. Then the recharging process continues until all the sensor nodes whose energy level is below. Once the WCV visits all the required sensor nodes(below energy level) it has to move to the next cluster. The process continues until the WCV visits all the clusters in the network.

VI. PERFORMANCE EVALUATION

Simulations were done and the experimental results were carried out for the network with the proposed algorithm with the other existing methods. Simulation results are as follows:

*1)Overall energy consumption in network:*The overall energy consumption in the network during data transmission between the sensor nodes is shown below.

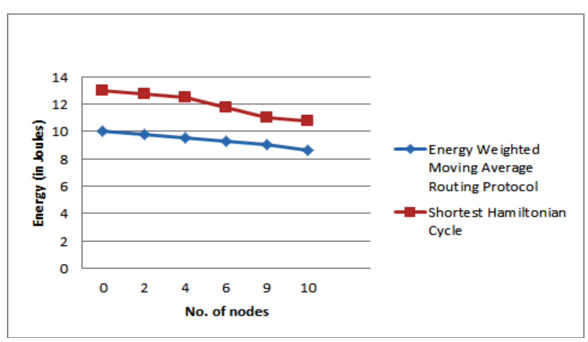

Fig. 3.Overall Energy Consumption

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2) Individual energy consumption in the network: The individual energy consumption for each sensor node in the network is shown below.

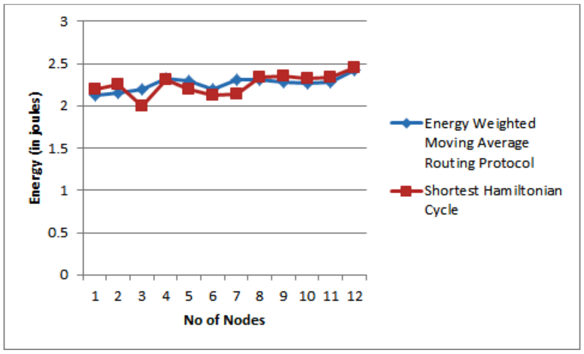

Fig. 4. Individual Energy Consumption

3) Throughput in the network: Simulation result for average throughput of the network with the usage wireless charging vehicle (WCV) is increased.

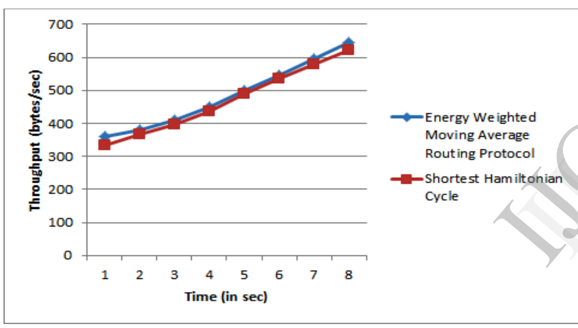

Fig. 5. Throughput in the Network

4) Scheduling in Minimum hop: The minimum hop for transmission of data between one node to another is shown below.

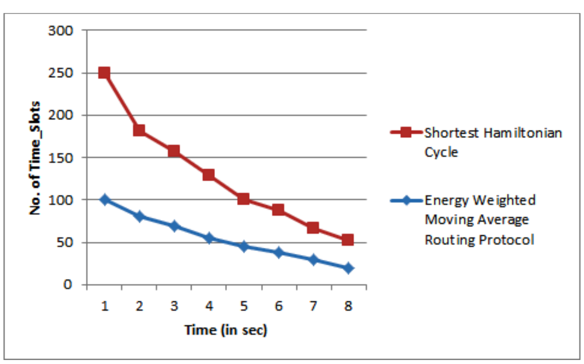

Fig. 6. Minimum Hop

5) Communication cost: Simulation result for the communication cost for data transfer between the nodes in the sensor network for the existing system and proposed system by using WCV with EWMA protocol is used.

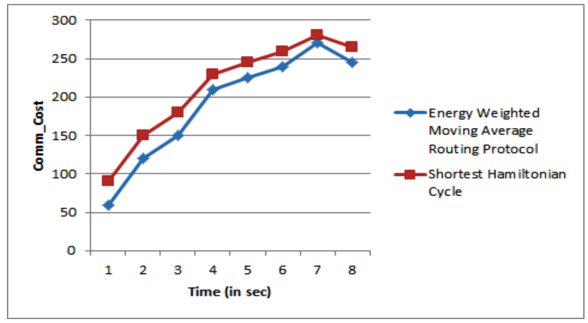

Fig. 7. Communication Cost

VI. CONCLUSION AND FUTURE WORK

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Existing wireless sensor networks have many constraints particularly it has limited battery energy and thus the life time of sensor network is confined. In this paper, the wireless charging vehicle will travel in a renewable cycle around the sensor networks under optimal travelling path which will consider the direction of routing and charging time required for sensor nodes. This nonlinear optimization is a NP-Hard Problem. So, Piecewise linear optimization technique is applied for each nonlinear term and a tight linear relaxation is obtained which is a feasible solution and desired level of accuracy is attained. Wireless power transfer using magnetic resonant coupling technique does not require accurate localization of sensor nodes. The EWMA Routing Protocol eliminates the unnecessary consumption of energy which may occur in visiting the sensor node whose battery is already in maximum level. So, optimization of energy is achieved when compared with existing system.

The wireless power transfer can be performed by using a single energy source that can recharge multiple energy receiving sensor nodes. In future, thus a WCV can be used to transfer energy to multiple sensor nodes simultaneously in its travelling path which also overcomes the scalability problem in the wireless sensor network.

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