Performance Analysis of Multi-Node Wireless Energy Charging in Sensor Networks

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Abstract

Wireless energy transfer based on magnetic resonant pairing is a auspicious technology to replenish energy to a wireless sensor network (WSN). However, accusing sensor nodes one at a time poses a serious scalability problem. Recent advances in magnetic resonant pairing show that numerous bulges can be charged at the same time. In this paper, we exploit this multi-node wireless dynamism allocation technology and scrutinize whether it is a scalable technology to address energy issues in a WSN. We consider a wireless alleging vehicle (WCV) sporadically traveling inside a WSN and charging sensor nodes wirelessly. Based on charging range of the WCV, we intend a cellular configuration that partitions the two-dimensional plane into contiguous hexagonal cells. We pursue a recognized optimization framework by jointly optimizing traveling path, flow routing, and alleging time. By employing discretization and a novel Reformulation-Linearization Technique (RLT), we develop a provably near-optimal clarification for any preferred level of accuracy.

Index term: wireless charging vechicle, Parameter based Event Detection(PED), Parameter based Area Detection(PAD).

1.INTRODUCTION

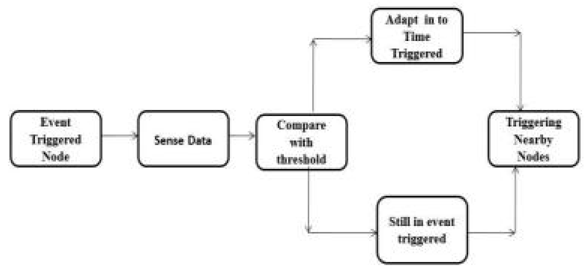
Wireless energy transfer based on magnetic resonant coupling is widely regarded as a breakthrough technology in our time [12]. By having magnetic resonant twirls operating at the same resonant frequency, Kurs *et al.* validated that energy could be transferred efficiently from a cradle coil to a receiver coil via non-radiative electromagnetic field (without any physical contact, i.e., wirelessly).1 What makes such wireless dynamism allocation technology particularly attractive is that it is efficient even under omnidirection, does not entail line-of-sight (LOS), and is obtuse to the neighboring environment. Since its inception, magnetic resonant pairing has quickly found marketable applications (see, e.g., [15], [18], and [26]). In [25], we first applied this technology to a wireless sensor network (WSN) and showed that through periodic wireless energy allocation, a WSN could endure functioning always, i.e., infinite lifetime. Specifically, we showed that by having a wireless charging vehicle (WCV) visit each antenna lump in the network and burden it periodically, one can guarantee that each sensor node never runs out of energy. An open tricky in [25] is scalability of wireless alleging. That is, as the node density rises in a WSN, how can a WCV confirm that each node is charged in a judicious mode before it runs out of energy? The wireless charging technology developed in [12] was partial to alleging one lump at a time and is not accessible as node concentration surges. Kurs *et al.* also recognized this problem and recently developed an superior technology (by properly tuning coupled resonators) that allows energy to be transported to *multiple* reception nodes concurrently [13]. Interestingly, they showed that the entire competence was larger when charging multiple devices than alleging each device independently. Inspired by this new advance in wireless dynamism allocation, in this paper, we explore how such multi-node charging technology can address the scalability tricky in charging a WSN. Following the setting in [25], we consider a WCV sporadically migrant inside the network and charging sensor nodes. Upon concluding each trip, the WCV returns to its home service station, takes a "vacation," and starts out for its next voyage. In contrast to [25], the WCV is now capable of alleging multiple nodes at the same time, as long as these nodes are within its blaming range. Under this scenery, we ask the following fundamental questions: 1) How will a multi-node alleging technology affect the WCV's travel path, charging time, and flow routing inside the network? 2) How can such multi-node alleging technology address the scalability tricky in a dense WSN? To best address these two questions, we propose to take a formal optimization tactic. Given the limitation of a WCV's charging range, we intend a cellular configuration that partitions a two-dimensional plane into hexagonal cells (similar to cellular structure for cellular broadcastings). To burden all sensor nodes in a cell, the WCV only needs to visit the epicenter of the cell. Based on a general energy alleging model, we formulate a joint optimization problem for wandering path, flow routing, and charging time, with the impartial of exploiting the ratio of the WCV's vacation time (time spent at its home service station) over the succession time. We show that our optimization problem is a nonlinear program (NLP) and is NP-hard in general. By retaining discretization and a novel *Reformulation-Linearization Technique* (RLT), we develop a provably near-optimal solution for any preferred level of exactness. Using numerical results, we show that our solution can indeed improve significantly upon single-node alleging technology and successfully address the charging scalability problem in a dense WSN.

II.RELATED WORK

Current wireless energy transfer technologies can be classified into three categories, namely, inductive coupling, electromagnetic radiation, and magnetic resonant coupling. Inductive coupling works by having a primary coil at a cradle spawn a fluctuating magnetic field that induces a voltage across the terminals of a subordinate coil at the receiver. Although this wireless energy allocation technology has found a number of successful applications in transferrable electronic strategies (e.g., electric toothbrush, RFID tags [6], [11], medical implants [24]), it is not suitable for alleging a wireless sensor node. This is because it has rigorous necessities such as close exchange and precise orientation in charging path, etc. Electromagnetic radiation is a radiative technology that allocations power on a radio frequency (e.g., 850–950 MHz [17] or 902–928 MHz [19], both with a center frequency of 915 MHz). Under such radiative technology, an RF spreader broadcasts radio waves in the 915-MHz ISM band, and an RF receiver tunes to the same frequency band to produce radio power. Radiative technology has a number of difficulties in transporting energy. First, it requires unremitting LOS and is sensitive to any obstruction between an energy cradle and a receiver. Second, for omnidirectional radiation, the energy allocation adeptness is very low. Radiative technology has been explored for energy harvesting in a WSN.In [8], He *et al.* found that a receiver could can only obtain about 1.5 mW power when it is 30 cm left from the RF spreader, with about 1.5% energy transfer efficiency. Similar experimental findings were also reported in [16] and [23]. Although this technology may alleviate the energy problem in a WSN to some extent, its applications are very restricted, mainly due to its stumpy energy transfer efficiency. The third category of wireless energy transfer technology is magnetic resonant pairing [12], which is regarded as a major innovation in our time and is the technology that we discover in this paper. Christo Ananth et al. [14] proposed a secure hash message authentication code. A secure hash message authentication code to avoid certificate revocation list checking is proposed for vehicular ad hoc networks (VANETs). The group signature scheme is widely used in VANETs for secure communication, the existing systems based on group signature scheme provides verification delay in certificate revocation list checking. In order to overcome this delay this paper uses a Hash message authentication code (HMAC). It is used to avoid time consuming CRL checking and it also ensures the integrity of messages. The Hash message authentication code and digital signature algorithm are used to make it more secure . In this scheme the group private keys are distributed by the roadside units (RSUs) and it also manages the vehicles in a localized manner. Finally, cooperative message authentication is used among entities, in which each vehicle only needs to verify a small number of messages, thus greatly alleviating the authentication burden.

The WCV is employed to charge sensor nodes, while a mobile base station is used as a sink node for all data that is composed from sensor nodes. Note that in this paper, we have both a *mobile* WCV and a *fixed* base station. Second, the goal of this paper is to have each sensor node in the network never run out of energy, i.e., infinite lifetime. On the other hand, the goal of [7] and [20] is to maximize lifetime, under a finite energy restraint at each sensor node. Due to these differences, existing solution approaches for a mobile base station such as those in [7] and [20] cannot be applied to the problem in this paper.

III.PROPOSED SYSTEM



Procedure for Hybrid Sink Gathering Protocol:

- 1.Form the sensor nodes up to 100 .
- 2.Initially set the sensor node working as event trigger.
- 3.Measure the real time temperature value on the individual nodes.
- 4.Apply PED Algorithm on the individual node to switch in to time trigger mode when the level of temperature reaches the abnormal level.
- 5.Apply PAD Algorithm on the individual node to set the time-to-live (TTL) and valid time (VT).

- Broadcast this information to the near by neighboring nodes based on TTL and VT.

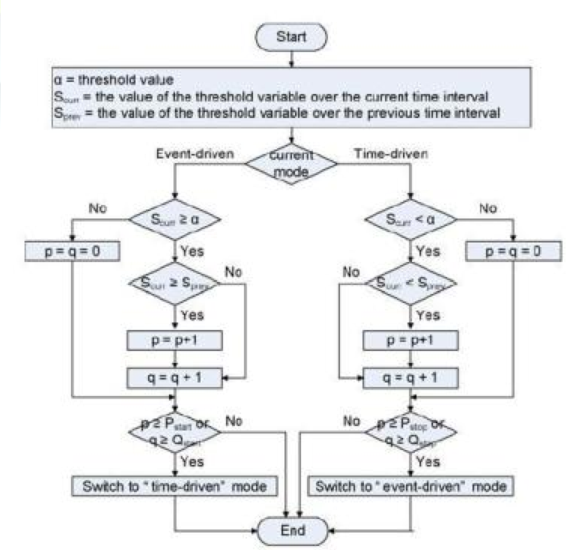
The novel aspect of our Proposed Hybrid WSN is that not only the sensor nodes that are perceiving an event of interest but also those nodes that will hypothetically sense the incident in the near future become betrothed in the time-driven data-reporting manner. This capability enables data from potentially relevant areas to be proactively collected without requiring observer intrusion.

Data Gathering in Proposed Adaptive Hybrid WSN:

Consider a forest fire recognition system. As soon as a fire disruptions out, it is instantly testified to an spectator because the sensor nodes in the burning area react to the quick increase in temperature. By unremittingly in receipt of raw temperature data from not only the burning area but also the adjacent areas in which no fire has yet been identified but may momentarily travel, an spectator is able to accurately recognize where the fire instigated, forecast where it may be caption, and conclude where the fire extinguishing operation should focus. Similarly, an earthquake exposure scheme is able to wrinkle advance analyses of seismic waves created both at the epicenter and in neighboring areas and swiftly raise an alarm for earthquake-prone buildings.

PAD Algorithm

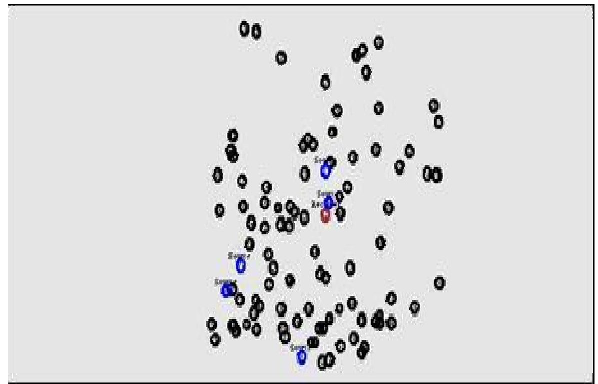
Once a sensor node changes to the time-driven data reporting scheme, it broadcasts its change to engage adjacent sensor nodes in the endless data broadcasting. The range of the zone is determined by the PAD algorithm, which is based on two configurable parameters: Time-to-live (TTL) and valid time (VT). The use of TTL in the PAD algorithm is similar to that in computer network technology, where TTL specifies the number of stages that a dispatch can travel to previously it should be superfluous. When a sensor node takes a recording memorandum comprehending a TTL value that is greater than zero, it changes to the time-driven data-reporting scheme and rebroadcasts a TTL value decremented by one. This process continues until the TTL value becomes zero. VT is the other important constraint of the Parameter based Areas Detection algorithm, and it stipulates how long a sensor node should consumption the time driven data-reporting scheme unrelatedly of the result of its Parameter based Event Detection algorithm. Therefore, without VT, they could instantly change rear to the event-driven data reporting scheme, trailing the chance to acquire important information in advance.

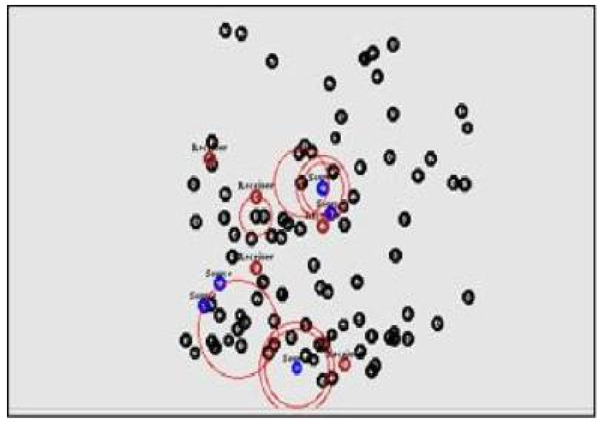


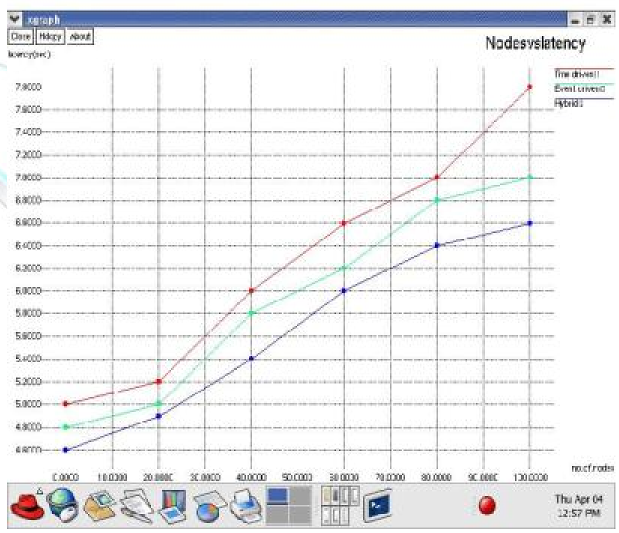
Determination of Threshold:

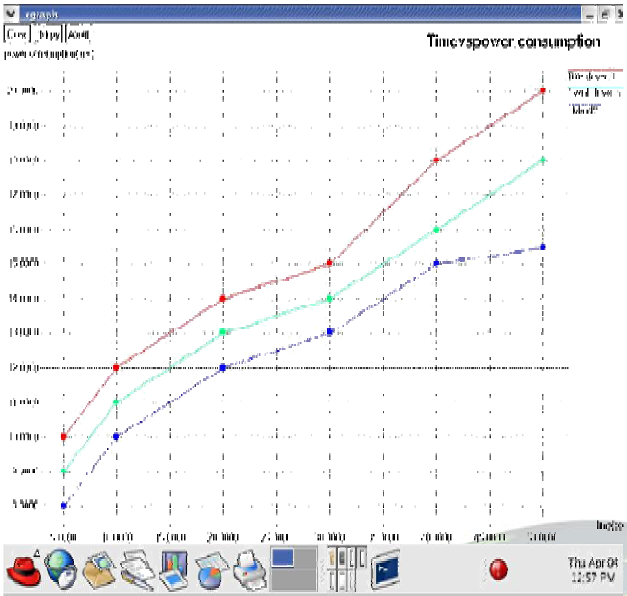
The PED algorithm is given a threshold value, a threshold variable, and two counter-variables controlling the aggressiveness level for changes in data-reporting schemes. The threshold value determines the occurrence of an event of interest. That is, when the value of the sensed attribute is beyond the threshold value, a sensor node must report it to a base station. The threshold variable is the average of the values of the sensed attribute over a time interval. p: the number of consecutive time intervals with increasing (for starting the time-driven data-reporting scheme) or decreasing (for stopping the time-driven data-reporting scheme) slope of the threshold variable; q: the number of consecutive time intervals that the threshold variable is above (for starting the time-driven data-reporting scheme) or below (for stopping the time driven data-reporting scheme) the threshold value. Two pairs of constants, Pstart and Qstart, and Pstop and Qstop,are parameters of the algorithm such that Pstart ≤ Qstart and Pstop ≤ Qstop. The

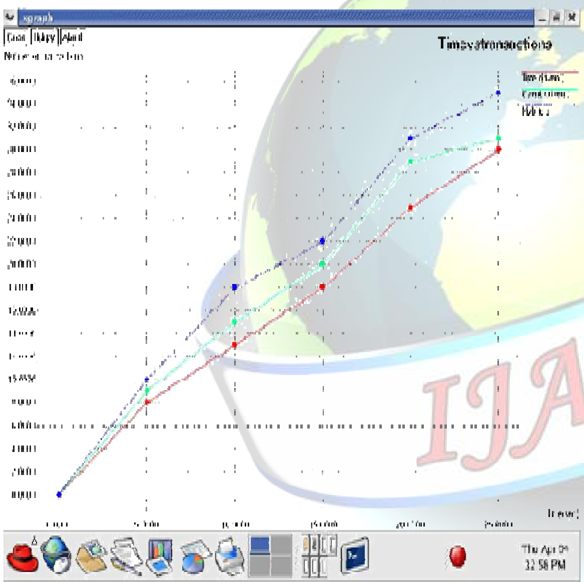
PED algorithm works as follows. Suppose that the current data-reporting scheme of a sensor node is event-driven. A sensor node periodically computes the average of the sensed attribute over a recent time window and updates the two counter-variables, p and q, accordingly. If (p ≥ Pstart) or (q ≥ Qstart), a sensor node switches to the time-driven data reporting scheme and reports the sensed attribute continuously over time.











IV.CONCLUSION

In order to evaluate the effectiveness of our approach, we implemented the hybrid data-gathering protocol on a Jprowler network simulator, an event-driven wireless network simulator written in Java. The simulator can operate in either the deterministic mode to produce replicable results while testing an application or in the probabilistic mode to simulate the non-deterministic nature of the communication channel and the low-level communication protocol of the sensor nodes. The simulation was performed on a network of 1000 sensor nodes and a fixed base station.The hybrid data gathering scheme achieves 40% energy reduction than the time driven data gathering. The data accuracy has been improved by reducing Root Mean Square Error by 0.2 compare to event driven data gathering. Hybrid algorithm outperforms time driven data gathering in energy conservation and event driven algorithm in data accuracy. The nodes were placed randomly in the network, and it was assumed that they do not change position. This technique will use in real time application also.

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