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EFFICIENT RECHARGING FOR ENERGY CONSUMPTION IN WSN

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Abstract – In this paper we have approached the real-time recharging framework supports single or multiple mobile vehicles. Employing multiple mobile vehicles provides more scalability and robustness. To efficiently deliver sensor energy status information to vehicles in real-time, concepts and mechanisms are leveraged from named data networking (NDN) and design energy monitoring and reporting protocols. Theoretical results are derived on the energy neutral condition and the minimum number of mobile vehicles required for perpetual network operations. Then the detailed study should be done, to minimize the total travelling cost of vehicles while guaranteeing all the sensor nodes can be recharged before their batteries deplete, which is NP-hard. To accommodate the dynamic nature of node energy conditions with low overhead, an algorithm is used that selects the node with the minimum weighted sum of travelling time and residual lifetime. This scheme not only improves network scalability but also ensures the perpetual operation of networks. Extensive simulation results demonstrate the effectiveness and efficiency of the proposed design.

Key Words: WSN, NDN, Multi hop, Energy Consumption,

1. INTRODUCTION

In WSN networks consist of individual nodes that are able to interact with their environment by sensing or controlling physical parameters; these nodes have to collaborate to fulfill their tasks as, usually, a single node is incapable of doing so; and they use wireless communication to enable this collaboration. In essence, the nodes without such a network contain at least some computation, wireless communication, and sensing or control functionalities. Despite the fact that these networks also often include actuators, the term wireless sensor network has become the commonly accepted name. Sometimes, other names like "wireless sensor and actuator networks" are also found. A Spatially distributed autonomous sensor to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. is called wireless sensor network (WSN).

1.1 APPLICATIONS

The original motivation behind the research into WSNs was military application. Examples of military sensor networks include large-scale acoustic ocean surveillance systems for the detection of submarines, self-organized and randomly deployed WSNs for battlefield surveillance and attaching micro sensors to weapons for stockpile surveillance. As the costs for sensor nodes and communication networks have been reduced, many other potential applications including those for civilian purposes have emerged.

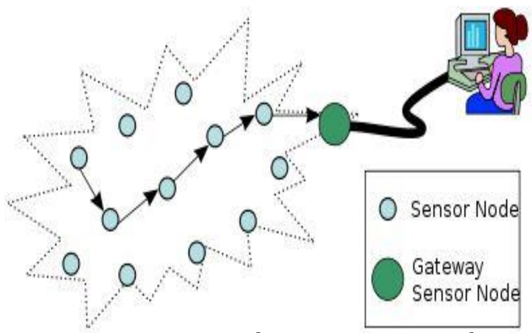

Figure.1 wireless sensor networks

Basic features of wireless sensor networks are:

- Self-organizing capabilities
- Short-range broadcast communication and multihop routing
- Dense deployment and cooperative effort of sensor nodes
- Frequently changing topology due to fading and node failures
- Limitations in energy, transmit power, memory, and computing power

1.2 ENVIRONMENTAL MONITORING

Environmental monitoring can be used for animal tracking, forest surveillance, flood detection, and weather forecasting. It is a natural candidate for applying WSNs, because the variables to be monitored, e.g. temperature, are usually distributed over a large region. One example is that researchers from the University of Southampton have built a glacial environment monitoring system using WSNs. They collect data from sensor nodes installed within the ice and the sub-glacial sediment without the use of wires which could disturb the environment. WSN deployment is used to provide spatially dense measures the risk management, and the resulting model will assist in the prevention of avalanches and accidental deaths.

1.3 TRAFFIC CONTROL

Sensor networks have been used for vehicle traffic monitoring and control for some time. At many crossroads, there are either overhead or buried sensors to detect vehicles and to control the traffic lights. Furthermore, video cameras are also frequently used to monitor road segments with heavy traffic. However, the traditional communication networks used to connect these sensors are costly, and thus traffic monitoring is usually only available at a few critical points in a city. WSNs will completely change the landscape of traffic monitoring and control by installing cheap sensor nodes in the car, at the parking lots, along the roadside, etc. A company which uses sensor network technology to help drivers find unoccupied parking places and avoid traffic jams. The solutions provided by Street line can significantly improve the city traffic management and reduce the emission of carbon dioxide.

2. TECHNICAL CHALLENGES

In WSNs, most nodes are static; however, the network of basic sensor nodes may be overlaid by more powerful mobile sensors that, guided by the basic sensors, can move to interesting areas or even track intruders in the case of military applications. Network nodes are equipped with wireless transmitters and receivers using antennas that may be Omni directional, highly directional (point-to-point), possibly steerable, or some combination thereof. At a given point in time, depending on the nodes' positions and their transmitter and receiver coverage patterns, transmission power levels, and co channel interference levels, a wireless connectivity exists in the form of a random, multi hop graph between the nodes. This ad hoc topology may change with time as the nodes move or adjust their transmission and reception parameters. Because the most challenging issue in sensor networks is limited and unrechargeable energy provision, many research efforts aim at improving the energy efficiency from different aspects.

In sensor networks, energy is consumed mainly for three purposes:

- Data transmission
- Signal processing
- Hardware operation

It is desirable to develop energy-efficient processing techniques that minimize power requirements across all levels of the protocol stack and, at the same time, minimize message passing for network control and coordination.

2.1 DESIGN OF ENERGY-EFFICIENT PROTOCOLS

It is well acknowledged that clustering is an efficient way to save energy for static sensor networks. Clustering has three significant differences from conventional clustering schemes. First, data compression in the form of distributed source coding is applied within a cluster to reduce the number of packets to be transmitted. Second, the data-centric property makes an identity for a sensor node obsolete. In fact, the user is often interested in phenomena occurring in a specified area, rather than in an individual sensor node. Third, randomized rotation of cluster heads helps ensure balanced energy consumption. Another strategy to increase energy efficiency is to use broadcast and multicast trees, which take advantage of the broadcast property of Omni directional antennas. The disadvantage is that the high computational complexity may offset the achievable benefit. For sensor networks, this one-to-many communication scheme is less important; however, because all data must be delivered to a single destination, the traffic scheme is the opposite. In this case, clearly the wireless multicast advantage offers less benefit, unless path diversity or cooperative diversity schemes are implemented. The exploitation of sleep modes is imperative to prevent sensor nodes from wasting energy in receiving packets unintended for them. Combined with efficient medium access protocols, the "sleeping" approach could reach optimal energy efficiency without degradation in throughput.

2.2 CAPACITY/THROUGHPUT

Two parameters describe the network's capability to carry traffic: Transport capacity and throughput. The former is a distance-weighted sum capacity that permits evaluation of network performance. Throughput is a traditional measure of how much traffic can be delivered by the network. In a packet network the (network-layer) throughput may be defined as the expected number of successful packet transmissions of a given node per timeslot. Important results include the scaling law for point-to-point coding, which shows that the throughput decreases with $1/\sqrt{N}$ for a network with N nodes.

2.3 ROUTING

In ad hoc networks, routing protocols are expected to implement three main functions:

Determining and detecting network topology changes; maintaining network connectivity; and calculating and finding proper routes. In sensor networks, up-to-date, less effort has been given to routing protocols, even though it is clear that ad hoc routing protocols are not suited well for sensor networks since the main type of traffic in WSNs is "many to one" because all nodes typically report to a single base station or fusion centre. Nonetheless, some merits of these protocols relate to the features of sensor networks, like multihop communication and QoS routing. Routing may be associated with data compression to enhance the scalability of the network.

2.4 CHANNEL ACCESS AND SCHEDULING

In WSNs, scheduling must be studied at two levels: the system level and the node level. At the node level, a scheduler determines which flow among all multiplexing flows will be eligible to transmit next (the same concept as in traditional wired scheduling); at the system level, a scheme determines which nodes will be transmitting. System-level scheduling is essentially a medium access (MAC) problem, with the goal of minimum collisions and maximum spatial reuse. Most of the current wireless scheduling algorithms aim at improved fairness, delay, robustness (with respect to network topology changes) and energy efficiency. Some also propose a distributed implementation, in contrast to the centralized implementation in wired or cellular networks, which originated from general fair queuing. Also, wireless (or sensor) counterparts of other wired scheduling classes, like priority scheduling and earliest deadline first (EDF), confirm that prioritization is necessary to achieve delay balancing and energy balancing.

Consequently, the traffic pattern is highly non uniform, putting a high burden on the sensor nodes close to the base station. The scheduling algorithm and routing protocols must aim at energy and delay balancing, ensuring that packets originating close and far away from the base station experience a comparable delay, and that the critical nodes do not die prematurely due to the heavy relay traffic.

2.5 MODELLING

The bases for analysis and simulations and analytical approaches are accurate and tractable models. Comprehensive network models should include the number of nodes and their relative distribution; their degree and type of mobility; the characteristics of the wireless link; the volume of traffic injected by the sources and the lifespan of their interaction; and energy consumption models are:

- Wireless Link
- Energy Consumption
- Node Distribution and Mobility
- Traffic

2.6 CONNECTIVITY

Network connectivity is an important issue because it is crucial for most applications that the network is not partitioned into disjoint parts. If the nodes' positions are modeled as a Poisson point process in two dimensions (which, for all practical purposes, corresponds to a uniformly random distribution), the problem of connectivity has been studied using the tool of continuum percolation theory. For large networks, the phenomenon of a sharp phase transition can be observed: the probability that the network percolates jumps abruptly from almost 0 to almost 1 as soon as the density of the network is bigger than some critical value. Most such results are based on the geometric disk abstraction. It is conjectured, though, that other connectivity functions lead to better connectivity. A practical consequence of this conjecture is that fading results in improved connectivity. Recent work also discusses the impact of interference. The simplifying assumptions necessary to achieve these results leave many open problems.

2.7 QUALITY OF SERVICE

Quality of service refers to the capability of a network to deliver data reliably and timely. A high quantity of service, capacity, is generally not sufficient to satisfy an application's delay requirements. Consequently, the speed of propagation of information may be as crucial as the throughput.

2.8 OTHER ISSUES

Distributed signal processing, most tasks require the combined effort of multiple network nodes, which requires protocols that provide coordination, efficient local exchange of information, and, possibly, hierarchical operation. Wireless programming, a deployed WSN may need to be reprogrammed or updated. So far, no networking protocols are available to carry out such a task reliably in a multi hop network. The main difficulty is the acknowledgment of packets in such a joint multi hop/multicast communication. When the energy consumption rates of these nodes exceed the charging capability, they deplete their energy quickly and the extension in the network lifetime is limited. Alternatively, if energy-balanced routing is used, the overall energy consumption in the network is increased as routes with longer length (and hence higher energy consumption) are used to bypass low-energy nodes which are on shorter and more energy efficient routes. Hence, the energy replenished into the network may not be utilized efficiently.

3. ENERGY PROVISIONING IN WIRELESS RECHARGEABLE SENSORNETWORKS

Wireless rechargeable sensor networks (WRSNs) have emerged as an alternative to solving the challenges of size and operation time posed by traditional battery-powered systems. The study on WRSN built from the industrial wireless identification and sensing platform (WISP) and commercial off the- shelf RFID readers has been performed. The paper-thin WISP tags serve as sensors and can harvest energy from RF signals transmitted by the readers. This kind of WRSNs is highly desirable for indoor sensing and activity recognition, and is gaining attention in search community.

Point provisioning uses the least number of readers to ensure that a static tag placed in any position of the network will receive a sufficient recharge rate for sustained operation. Mobile tags can harvest excess energy in power-rich regions and store it for later use in power-deficient regions.

3.1 STOCHASTIC ANALYSIS OF ENERGY CONSUMPTION WIRELESS SENSOR NETWORKS

In most Wireless Sensor Network (WSN) applications, nodes are powered by batteries, and replacing the batteries is a tedious work. When energy is depleted, nodes become inactive, losing their sensing and communication functionalities. Therefore, to improve network reliability and prolong network lifetime, utilizing and evaluating various energy-saving techniques, such as periodic sleeping, is of great importance in network designs.

Accurately characterizing increasingly sophisticated energy saving techniques is a great challenge. In MAC layer, periodic sleeping based protocols have been developed, where nodes are forced into sleeping mode periodically, while still maintaining network connectivity.

In network layer, energy aware routing protocols are also utilized to further reduce the energy consumption. A

Markov chain-based cross-layer analytical model to investigate the statistics of energy consumption in WSNs. Instead of the average energy consumption, the probabilistic distribution of the energy consumption, i.e., the probability that the consumed energy within any given period is lower than a specific threshold. Protocols in MAC layer and network layer, traffic rate, wireless channels, as well as queuing behaviors are all captured in the developed framework to reveal their effects on the energy consumption.

Accurately characterizing increasingly sophisticated energy saving techniques is a great challenge. In MAC layer, periodic sleeping based protocols have been developed, where nodes are forced into sleeping mode periodically, while still maintaining network connectivity. In network layer, energy aware routing protocols are also utilized to further reduce the energy consumption. Complicated network activities in multiple protocol layers necessitate a comprehensive and generic model to accurately evaluate the energy consumption in WSNs.

The energy consumption distribution is a natural tool to evaluate reliability critical networks. The lifetime analysis is designed to be generic and comprehensive. The Markov process based framework is generic and is parameterized for many WSN protocols.

3.2 ENERGY HARVESTING IN A MOBILE SENSOR NETWORK

Wireless sensor networks are an exciting new area of research. They belong to the class of ad-hoc networks, where the individual nodes have limited sensing, computation, communication and energy. The large scale of such networks prohibits human intervention for network maintenance. One of the very scarce resources for these types of networks is energy.

These networks are expected to have a long lifetime (weeks to years) without human intervention for energy replenishment (recharging or changing the batteries).Some of the nodes are capable of recharging themselves using energy available in the environment using solar panels. These nodes are called as energy producers. The rest of the nodes only consume energy in computation and communication. These nodes are called them as energy consumers.

Mere are two key problems to be addressed. Energy producers need to work with a non-uniform geographic energy distribution, i.e., the available energy pattern in the network environment may be completely different from the energy consumption pattern and it may lead to energy starvation in some portion of the network. This may ultimately result in a fragmented network and uneven sensor coverage because some set of nodes has been completely energy depleted. The second problem is for the energy producers to deliver the energy they have gathered to the consumer nodes. A method to exploit robotic mobility by having energy producers of the mobile robots. These nodes try to keep themselves recharged by moving to locations with abundant energy supply. Once charged they migrate to the service areas in the network for delivering energy to the (static) consumer nodes that have requested energy. In essence mobile energy producers act as energy equalizers in the network by carrying energy 'payloads' from areas where environmental ambient energy is plentiful to areas where it is either unavailable or being used faster than it can be harvested.

4. CONCLUSION

A sensor node receives an energy interest message, it responds with an energy message including its ID and residual energy. The message is returned to the cluster head. The head examines if the reported residual energy is less than the normal recharge threshold. If so, the ID of the node is added to a list, and the energy that can be recharged to this node is added to a summation counter. After the head has collected these messages, it sends an aggregation message, containing the list, the summation counter and its subarea name. Finally, the nearest to a head receives a message with the largest summation counter. It moves there and recharges those nodes in the ID list one by one. Only after recharging those nodes will the sends another normal energy query.

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