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A Review on Improved Tabu Search Based Max Flow in Wireless Sensor Networks

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Abstract: Tabu Search is a meta-heuristic that guides a local heuristic search procedure to explore the solution space beyond local optimality. One of the main components of Tabu Search is its use of adaptive memory, which creates a more flexible search behaviour. A novel finding is that such principles are sometimes sufficiently potent to yield effective problem solving behaviour in their own right, with negligible reliance on memory. In rechargeable Wireless Sensor Networks (WSNs), a key concern is the max flow or data rate at one or more sinks. However, this data rate is constrained by the available energy at each node as well as link capacity. After deployment, some sensor nodes may impede the amount of data that arrive at a sink because of their low energy harvesting rate. In this work, the main goal is to construct a fast tabu search algorithm for computing solutions so that max flow rate may achieve. The main objective is to maximize the flow rate at one or more sinks and optimize the network cost. It will investigate the problem of upgrading sensor nodes to maximize the flow rate. All simulations will be implemented in MATLAB.

Keywords: WSN System, Routings in WSN, Tabu Search, QoS in WSN etc.

I. INTRODUCTION

Sensing is a technique used to gather information about a physical object or process, including the occurrence of events (i.e., changes in state such as a drop in temperature or pressure). An object performing such a sensing task is called a sensor. For example, the human body is equipped with sensors that are able to capture optical information from the environment (eyes), acoustic information such as sounds (ears), and smells (nose). These are examples of remote sensors, that is, they do not need to touch the monitored object to gather information. From a technical perspective, a sensor is a device that translates parameters or events in the physical world into signals that can be measured and analyzed. Another commonly used term is transducer, which is often used to describe a device that converts energy from one form into another. A Wireless Sensor Network (WSN) is a self-organized system of small, independent, low cost, low powered and wirelessly communicating nodes distributed over a large area with one or possibly more powerful sink nodes gathering readings of sensor nodes and, may handle a variety of sensing, actuating, communicating, signal processing, computation, and communication tasks, deployed in the absence of permanent network infrastructure and in environments with limited or no human accessibility. The sink serves as the gateway between the user application and the sensor network. The WSN nodes have no fixed topology, but they can configure themselves to work in such conditions. In addition, wireless sensor nodes themselves are exceptionally complex systems where a variety of components interact in a complex way.

Recent advances in sensor technology and wireless communications have enabled design and development of inexpensive, large sensor networks, which are suitable for different civilian, natural, and military applications, such as health environment monitoring, seismic monitoring, space exploration, structural sensing, habitat monitoring, tele medicine, avionics and battle fields surveillance. With multi-hop wireless communication, sensor nodes have made it possible to build reactive systems that have the ability to monitor and react to physical events/phenomena. In addition to resource constraints, sensor networks are also failure prone. Therefore, fault tolerance is as critical as other performance metrics such as energy efficiency, latency and accuracy in supporting distributed sensor applications. The topology of the WSNs can vary from a simple star network to an advanced wireless mesh network. The propagation technique among the nodes of the network could be routing or flooding. The power of the wireless sensor networks lies in the capability to deploy large numbers of small nodes that assemble and configure themselves. In addition to drastically decreasing the installation costs, wireless sensor networks have the capability to dynamically adapt to changing environments. Adaptation mechanisms can lead to changes in network topologies or can cause the network to shift between different modes of operation.

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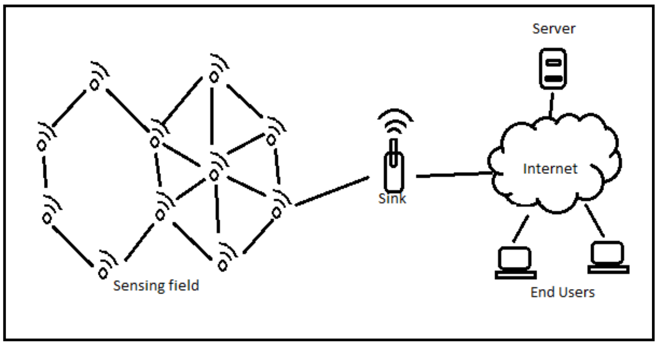

Figure 1: Wireless Sensor Network [1]

The WSN is made of nodes from a few to several hundred or thousands, where each node is connected to one or several sensors. A wireless sensor node, also called "mote", consist of five subsystems.

- Sensor Subsystem - an interface to the physical world designed to sense the environmental parameters like pressure and temperature. It includes both External and internal Sensors.
- Processing Subsystem - is to control different modes of operation for processing of data
- Memory Subsystem - storage for programming data.
- Communication Subsystem - a device like antenna for sending and receiving data over a wireless channel.
- Power Subsystem- supply of energy for smooth operation of a node like battery.

The hierarchical or cluster-based network architecture, originally proposed for wired networks, comprises well-known techniques with special advantages related to scalability and energy-efficient communication. The concept of hierarchical architecture is also utilized in WSNs to perform energy-efficient routing. In a hierarchical architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target. This means that creation of clusters and assigning special tasks to CHs can greatly contribute to overall system scalability, lifetime and energy efficiency.
The paper is ordered as follows. In section II, it represents related work of proposed system in WSN network. In Section III, It defines the various routing protocols. Section IV defines the concept of tabu search. The proposed system is defined in section V. Finally, conclusion is explained in Section VI.

II. RELATED WORK

Tengjiao He et al., 2016 [1], presented a novel approach whereby the aim to "upgrade" the recharging rate of a finite number of "bottleneck" nodes using so called Auxiliary Chargers (ACs) equipped with Wireless Power Transfer (WPT) capability. It formulated a Mixed Integer Linear Program (MILP) for the NP-hard problem at hand and proposed three novel solutions to place ACs: (i) Path, which preferentially upgrades nodes on the shortest path amongst paths from sources to sinks, (ii) Tabu, a meta-heuristic that first uses Path as the initial solution. It then searched for a neighboring solution that yields a higher max flow rate.

Gurbinder Singh Brar et al., 2016 [2] proposed directional transmission based energy aware routing protocol named as PDORP. The proposed protocol PDORP had the characteristics of both Power Efficient Gathering Sensor Information System (PEGASIS) and DSR routing protocols. In addition, hybridization of Genetic Algorithm (GA) and Bacterial Foraging Optimization (BFO) was applied to proposed routing protocol to identify energy efficient optimal paths. The performance analysis, comparison through a hybridization approach of the proposed routing protocol gave better result comprising less bit error rate, less delay, less energy consumption and better throughput which leads to better QoS and prolong the lifetime of the network. Moreover, the Computation Model was adopted to evaluate and compared the performance of the both routing protocols using soft computing techniques.

Jaspreet Kaur et al., (2015) [3] proposed a new data aggregation technique called ERA which has improved the performance of the WSNs by using the group based data aggregation but even then it has some limitations. In order to overcome the drawbacks of previous work, a fresh improved technique is proposed in this paper. Principle improvement had been done by using the TABU search based optimization technique for energy efficient routing algorithm. Additionally the use of the compressive sensing also increases the performance further. The compressive sensing uses data fusion to remove redundant data from sensor nodes, so improves the results further. In the end to evaluate the effectiveness of the proposed technique further the effect of the scalability of number of nodes had also been considered.

Meng-Hsiu Jao et. al (2015) [4] proposed a novel and efficient method to detect the wormhole attack without hardware equipment or requiring much information about WSN. The proposed method used a moving average (MA)

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indicator, which has been commonly used in financial fields, to apply to neighbors of sensor nodes; it becomes a dynamic detection indicator of the number of neighbor nodes. Because the combinations are too numerous to arrange, it utilized a Quantum-inspired Tabu Search (QTS) algorithm. This algorithm was efficient and effective in finding the ideal combination of detection indicators to detect wormhole attacks in different scenarios. The simulation result showed our method is intuitive and efficiently detects wormhole.

Madhu. B.M et. al (2014) [5] proposed an improved routing protocol to reduce the power consumption of the embedded node by reducing the computation overhead and data routing through less energy consuming route through sensor nodes of interest. Wireless sensor nodes must utilize the minimal possible energy while operating over a wide range of operating scenarios. Due to the large number of wireless sensor nodes that may be deployed and the long system lifetimes required, replacing the battery is not an option. The data transmission and reception between the wireless sensor nodes and the sink and source nodes contributes to major energy consumption, which needs to be handled with attention.

N. Gaur et. al (2014) [6] proposed that wireless mesh network is a distributed multi-hop relaying network. A large scale wireless mesh network typically has high value of network average path length which results in reduced throughput and increased delay in the network. Average path length can be reduced in the network by implementing a few long-links among the network node-pairs, and thus introduces the small-world characteristics in the wireless mesh networks. However, the conventional routing algorithms were not optimized for small-world wireless mesh networks. In this paper, they proposed a Load-aware Non-Persistent small-world long link Routing (LNPR) algorithm for small-world wireless mesh networks to achieve lower average transmission path length for data transfer sessions among a set of source-node and destination node pairs in the network. LNPR used load balancing strategy to better distribute the network traffic among the normal-links and the non-persistent long-links in the small-world wireless mesh networks for efficient use of long-links which are precious data transmission paths in the network.

Shih et. al (2013) [7] proposed a fault node recovery algorithm to enhance the lifetime of a wireless sensor network when some of the sensor nodes shut down. The algorithm was based on the grade diffusion algorithm combined with the genetic algorithm. The algorithm could result in fewer replacements of sensor nodes and more reused routing paths. In this simulation, the proposed algorithm increased the number of active nodes up to 8.7 times, reduced the rate of data loss by approximately 98.8%, and reduced the rate of energy consumption by approximately 31.1%.

P. Chanak et. al (2013) [8] reported a distributed multipath fault tolerance routing scheme for wireless sensor network (DFTR). The multipath fault tolerance routing provided better resilience to various faults in wireless sensor network (WSN). However, the multipath fault tolerance routing had suffered by two problems regarding the routing strategy design. The first problem was that the traffic overhead becomes very high if the data are transmitted individually by the large number of duplicate routing paths between the source and base station. The second one was that the high traffic creates energy hole in the network which decrease the network life span rapidly. In this, a distributed multipath fault tolerant routing scheme had developed to tackle these problems in WSN. Effective size cluster formation was employed to prevent traffic over head and energy hole.

III. TYPES OF WIRELESS SENSOR NETWORKS

There are 5 types of Wireless Sensor Networks: Terrestrial WSN, underwater WSN, Underground WSN, Multi-media WSN and mobile WSN.

1. Terrestrial Wireless Sensor Networks

Terrestrial wireless sensor network consists of hundreds to thousands of sensor nodes which are deployed in ad-hoc or in pre-planned manner in the target area. In terrestrial networks, reliable communication is very important, that is, nodes must be able to effectively communicate and transfer the data to the base station. Since battery power in sensor nodes is limited, so sensor nodes can be equipped with additional power source like solar cells. In a terrestrial WSN, energy can be conserved with short range transmission, multi-hop routing, eliminating data redundancy, delay minimization and using low duty cycle operations [30].

2. Underground Wireless Sensor Networks

In underground sensor networks, sensor nodes are buried underground to monitor underground conditions. Additional sink nodes are deployed above ground to route the data from the sensor nodes to the base station. Underground sensor networks are more costly because appropriate equipments are required to ensure communication through soil, water and rocks. Careful planning is required for deployment of an underground WSN. Energy and cost considerations must be taken into account while deploying underground WSNs.

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3. Underwater Wireless Sensor Networks

In underwater WSNs, sensor nodes are deployed under water. In comparison with terrestrials WSNs, these networks are more expensive. Autonomous underwater vehicles are used for data gathering and exploration from sensor nodes. Opposing to terrestrial WSNs, lesser number of nodes are deployed underwater. Underwater wireless communication takes place through transmission of acoustic waves. But acoustic communication suffers from several challenges like limited bandwidth, signal fading issue, long propagation delay and environmental conditions. Underwater sensor nodes must be able to adapt to ocean environment and like other sensor nodes, these are also equipped with limited battery power, energy efficient networking techniques should be developed.

4. Multimedia Wireless Sensor Networks

Multimedia sensor networks consist of sensor nodes equipped with cameras and microphones. These networks have enabled tracking and monitoring of events in the form of multimedia such as audio, video and imaging. Sensor nodes are deployed in a pre-planned way to ensure full coverage. Multimedia information such as video requires very high bandwidth for the information to be delivered, thus leading to more energy consumption. So transmission techniques supporting low power consumption and high bandwidth have to be developed. Quality of Service provisioning is also a challenging task in these networks due to variable channel capacity and data delay. So certain level of quality of service must be achieved for reliable communication.

5. Mobile Wireless Sensor Networks

Mobile sensor networks consist of mobile sensor nodes which can move on their own and interact with the environment. They have all the capabilities of static nodes in addition to the ability of repositioning and organizing itself in the network. Another difference is data distribution. Instead of fixed routing or flooding used in static WSNs, dynamic routing is used in mobile WSN. Challenges faced by mobile sensor networks include localization, maintenance, coverage, self-organization, energy, navigation and control, deployment and data process. Mobile WSNs can be used for many applications. For example, in environmental monitoring in disaster areas applications, manual deployment of sensor nodes might not be possible. Similarly in military surveillance and tracking mobile sensor nodes can achieve higher degree of connectivity and coverage compared to static sensor nodes.

IV. TABU SEARCH TECHNIQUE

Tabu search is an adaptive search technique, using the best improvement local search as the basic ingredient. By allowing temporary solution degradation, tabu search avoids the search process being trapped into the local optimum. Two mechanisms, the short term memory and long term memory, can be applied to keep track of attributes of previously visited solutions and guide the tabu search process.

Tabu Search is a meta-heuristic that guides a local heuristic search procedure to explore the solution space beyond local optimality. One of the main components of Tabu Search is its use of adaptive memory, which creates a more flexible search behavior. Memory-based strategies are therefore the hallmark of tabu search approaches, founded on a quest for “integrating principles,” by which alternative forms of memory are appropriately combined with effective strategies for exploiting them. A novel finding is that such principles are sometimes sufficiently potent to yield effective problem solving behaviour in their own right, with negligible reliance on memory. Over a wide range of problem settings, however, strategic use of memory can make dramatic differences in the ability to solve problems. Pure and hybrid Tabu Search approaches have set new records in finding better solutions to problems in production planning and scheduling, resource allocation, network design, routing, financial analysis, telecommunications, portfolio planning, supply chain management, agent-based modelling, business process design, forecasting, machine learning, data mining, bio-computation, molecular design, forest management and resource planning, among many other areas.

The TS technique is rapidly becoming the method of choice for designing solution procedures for hard combinatorial optimization problems. A comprehensive examination of this methodology can be found in the book by Glover and Laguna (1997). Widespread successes in practical applications of optimization have spurred a rapid growth of the method as a means of identifying extremely high quality solutions efficiently. TS methods have also been used to create hybrid procedures with other heuristic and algorithmic methods, to provide improved solutions to problems.

The localization steps followed by using Tabu Search Algorithm are that it takes the results of Mobile Anchor Positioning as its input. The results of MAP, giving the approximate solution of the location of each sensor at each specified time instance is given as the input to the post optimization method. At any iteration it has to find a new solution by making local movements over the current solution. The possible solution of a node which was predicted by MAP algorithm is maintained in a tabu list. The average distance of neighbour nodes of the corresponding nodes are calculated. The difference between the location and the average distance of the node are calculated. If the solution is less than the average value then that value is considered as a best solution. The “next solution" is the best among all (or a subset of) possible solutions in the neighbourhood in order to carry out the exploration process, the recently visited solutions are avoided. Tabu list is maintained. Therefore once a solution is visited, the movement from which it was obtained is considered as tabu. N(Ω) will be changing along the

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exploration, so in a certain sense dynamic neighbourhood is compared to the previous local search algorithms where remains static. Typically there are two kinds of tabu lists, a long term memory and short term memory. Long term memory maintains the history through all the exploration process as a whole and a short term memory is to keep the most recently visited tabu movements. A movement with a tabu status (tabu movement) is avoided to be applied, unless it satisfies certain aspiration criteria. This aims to avoid falling into local optima. Tabu list size is fixed before the hand each element of the list belongs to it for a number of iterations bounded by given maximum and minimum values. Repeat the iterations until the stopping criteria are met.

V. PROBLEM FORMULATION

The topic of WSN continues to grow as a fertile research area. Efforts continually seek to overcome the complications of reliable, or even fault-tolerant, communications in large wireless networks. The network fails due to the depletion of energy in the central ring of nodes around the sink node, leaving the sink node segmented from the remaining viable network nodes. With the existing protocol, at the extinction of the network (when the sink is isolated from the remaining live network nodes), the remaining energy is effectively consumed with zero efficiency because it is no longer available for useful work which negates the premise that their approach minimizes energy consumption within the network.

In this work, the effects of the mobile sink in the most of the energy efficient protocols have been ignored. No optimization technique is considered for the effective route selection in Energy efficient protocol. Energy consumption is one of the constraints in Wireless Sensor Networks (WSNs). In rechargeable Wireless Sensor Networks (WSNs), a key concern is the max flow or data rate at one or more sinks. However, this data rate is constrained by the available energy at each node as well as link capacity. After deployment, some sensor nodes may impede the amount of data that arrive at a sink because of their low energy harvesting rate. Due to this, The aim is to improve the recharging rate of some nodes such that the sinks observe a higher flow rate using Tabu Search. Then, a modified protocol is proposed to improve max flow into the network. The Proposed protocol, in conjunction with the characterization of the remaining network energy, seeks to extend the useful life of the network, increasing efficiency in terms of energy expended, network cost and max flow of network.

VI. CONCLUSION

The network fails due to the depletion of energy in the central ring of nodes around the sink node, leaving the sink node segmented from the remaining viable network nodes. With the existing protocol, at the extinction of the network (when the sink is isolated from the remaining live network nodes), the remaining energy is effectively consumed with zero efficiency because it is no longer available for useful work which negates the premise that their approach minimizes energy consumption within the network. In rechargeable Wireless Sensor Networks (WSNs), a key concern is the max flow or data rate at one or more sinks. It models the conflict graph for the feature of interferences from Inter-network and Intra-network to the connection links. It will investigate the problem of upgrading sensor nodes to maximize the flow rate. It will use the concept of path and Tabu to analyse the performance of system.

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