Comparison of Different Routing Protocols using Quadratic Assignment Techniques in Wireless Sensor Networks

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ABSTRACT-Wireless sensor networks with hundreds of sensor nodes have emerged in recent years as important platforms for a wide spectrum of monitoring tasks ranging from environmental to military applications. Its growth is expeditiously increasing and that's why there is an immense field for research in this area. Sensor networks are networks of small embedded low-power devices that can operate unattended to monitor and measure different phenomena in the environment. The aim of this paper is to compare the routing protocols SPEER,DSDV,EQGOR, Geographic routing protocol that balance energy consumption through a mathematical model namely Quadratic Assignment Techniques. This comparison reveals the important features that need to be taken into consideration while designing and evaluating new routing protocols for wireless sensor networks. Comparison of various network parameters is done in the form of tables and graphs. In the last of the paper conclusion is drawn.

Keywords - Quadratic Assignment problems, SPEER, DSDV, EQGOR, Geographic routing protocol , energy efficiency, WSN s.

1. INTRODUCTION

The general Quadratic Assignment problem QAP is known to be NP-Complete. In its basic interpretation, the problem seeks to assign n facilities to n locations with the cost being proportional to the flow between the facilities multiplied with their distances. The objective is to allocate each facility to a location such that the total cost is minimized. Many scientists including mathematicians, computer scientists, operations research analysts, and economists have used the QAP to model a variety of optimization problems. Sahni and Gonzalez (1976) showed that the QAP is *NP*-hard and that there is no of approximation polynomial algorithm for the QAP unless
$P = NP$. Other optimization combinatorial problems such as the traveling salesman problem, maximal clique, isomorphism and graph partitioning can be formulated as a QAP.

WSN network consists of a group of nodes and each node has limited battery power. There may be many possible routes available between two nodes over which data can flow. Assume that each node sensed and generated some information and this information needs to be delivered to a set of destination nodes. A node can easily transmit data to a distance node, if it has sufficient battery power. A node transmits its data to other node without any interference, if node lies in its vicinity. A large battery power is required to transmit the data to a node which is situated far from source node. After few transmissions a node reaches to its threshold battery level and it may exclude from network path and there will come a condition that no node is available for the data transmission and overall lifetime of network will decrease. Whereas network lifetime is defined as the time until the first node in the network dies. For maximizing the lifetime of network, the data should be forwarded such that energy consumption is balanced among the nodes in proportion to their energy reserved, instead of routing to minimize consumed power. This type of communication motivates a different routing service where one end point of the route may be an area rather than an individual node and this is called area multi-cast. And at last since sensors often measure highly redundant information, in some situations it may be sufficient to have any node in an area respond. Such type of communication is called area anycast.

In (4) we proposed a novel energy efficient routing protocol by using quadratic assignment technique. Our protocol achieves energy efficiency by finding an optimal path to transfer the data from source to destination. In this paper the proposed routing protocol, the sensor nodes identifying the neighboring nodes, and by first sending a group of the identity to the intermediate nodes will be named as the selected path till arriving the first actor, during which the next sending will only be carried out through that path. (5) focuses on the development of a new energy efficient scheduling scheme which not only increases the lifetime of a sensor node but also gives the Priorities for the secured node transactions. The aim of the TORA algorithm is to process the multiple route in finding the shortest path. The basic principle of this protocol is to route the neighbor node list updating each node to the index status.

In (6), there are several mobile sensor nodes available with the limitation of mobility in the entire wireless sensor network. This network monitors all the mobility nodes using the efficient QoS aware GOR protocol which helps to overcome the limitation of mobility. First we initialize the energy for the mobile sensor nodes. Based on that we can decide whether it is chargeable or non rechargeable in WSN using EQGOR protocol. This protocol is used for packet delivery based on the neighbor mobile nodes with certain limitations. At the same time all the mobile sensor nodes collect the neighbor mobile nodes details using Forward Candidate Algorithm, which is useful in calculating the connectivity of hop count and the packet size (for storage purpose) to forward to each and every mobile sensor nodes while moving from one location to another location. Suppose if any data is lost by the relay nodes then those node will choose another capable neighbor mobile node to perform the packet transfer of mobile nodes based on the multi objective evolutionary algorithm. This algorithm enables each mobile sensor node to choose the adjacent node for the next hop based on prioritization. Here two kinds of priority exists, one is the higher priority for the highest size packet transmission and the other is the lowest priority for the lowest size packet transmission with timer setting. Hence using Quadratic Assignment technique with EQGOR protocol and the proposed algorithm we can detect data aggregation with limitation of mobile sensor nodes and also we can achieve the transfer of packet delivery more quickly than the available QoS algorithm.

Geographic protocols are very promising for sensor networks. These protocols take advantage of the location information of nodes to provide higher efficiency and scalability. In wireless environments, the locations of nodes correspond to their network connectivity, which makes geographic protocols natural components in these environments and it is expected that they will become major elements for the development of these networks. Paper (7) describes the software architecture of an intelligent autonomous gateway, which is designed to provide the necessary middleware between locally deployed sensor networks based on mobile node and a remote location. The gateway provides hierarchical networking, auto management of the mobile wsn (MWSN), alarm notification and SMS/Internet access capabilities with user authentication. The main concern of QoS-based quadratic assignment technique is to increase reliability of network along with lifetime of the network. With the improvement of the traditional WSN gateway nodes, the users on the internet can access the data of the wireless sensor network flexibly through wired or wireless mode.

2. MATHEMATICAL FORMULATION OF QAP

Let the set of nodes be $N = 1,2,3,....n$ and three nxn matrices $F=(f_{ij}),\ D=(d_{ij})$ and $C=(c_{ij})$ the quadratic assignment problem with coefficient matrices F, D and C shortly denoted by QAP can be stated as follows:

$$\min_{x \varepsilon X} \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{n}\sum_{l=1}^{n} f_{ik} d_{jl} x_{ij} x_{kl} + \sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij} x_{ij} \qquad (1)$$

Such that

$$\sum_{i=1}^{n} x_{ij} = 1 \qquad , i \varepsilon N$$

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad , j \varepsilon N$$

$$x_{ij}\ \varepsilon\ 0,1 \qquad , i, j \varepsilon N$$

f_{ik} denotes the amount of flow between facilities i and k, d_{jl} denotes the distance between location j , l and C_{ij} denotes the cost of locating facility i at location j. A more general version of the QAP was introduced by Lawler(10). In this paper we are using flow distance products $f_{ik}\ d_{jl}$ instead of considering dimensional array.

There are enormous numbers of practical applications that can be modeled as QAPs. Steinberg(1961) used QAP to minimize the number of connections between components in a backboard wiring, Heffley (1972, 1980) applied it to economic problems, Francis and White (1974) developed a decision framework for assigning a new facility (police posts, supermarkets, schools) for serving a given set of clients, Geoffrion and Graves (1976) concentrated on scheduling problems, Pollatschek et al. (1976) mentioned QAP to define the best design for typewriter keyboards and control panels, Krarup and Pruzan (1978) applied it to archeology. Hubert (1987) applied it in statistical analysis, Forsberg et al. (1994) used it in the reaction chemistry analysis and Brusco and Stahl (2000) used it in numerical analysis. Though, the facilities layout problem is the most popular application for QAP: Dickey and Hopkins (1972) applied QAP to the assignment of buildings in a University campus, Elshafei (1977) in a hospital planning and Bos (1993) in a problem related to forest parks. Benjaafar (2002) introduced a formulation of the facility layout design problem for minimizing work-in-process (WIP).

2.1 Exact Algorithm

The phrase *exact algorithm* is used when talking about an algorithm that always finds the optimal solution to an optimization problem. As opposed to *heuristics* that may sometimes produce worse solutions. A subset of these are the *approximation algorithms* -- those are the ones where we can prove a guaranteed bound on the ratio between the optimal solution and the solution produced by the exact algorithm but not long time network lifetime.

2.2 New Shortest Route Selection Algorithm

The algorithm exists in many variants; Dijkstra's original variant found the shortest path between two nodes, but a more common variant fixes a single node as the "source" node and finds shortest paths from the source to all other nodes in the graph, producing a shortest-path tree. This algorithm finds the shortest path between that node and every other nodes. It can also be used for finding the shortest paths from a single node to a single destination node by stopping the algorithm once the shortest path to the destination node has been determined. For example, if the nodes of the graph represent cities and edge path costs represent driving distances between pairs of cities connected by a direct road, Dijkstra's algorithm can be used to find the shortest route between one city and all other cities. As a result, the shortest path algorithm is widely used in network routing protocols.

2.3 Temporally Ordered Routing Algorithm (TORA)

The TORA attempts to achieve a high degree of scalability using a "flat", non-hierarchical routing algorithm. In its operation the algorithm attempts to suppress, to the greatest extent possible, the generation of far-reaching control message propagation. In order to achieve this, the TORA does not use a shortest path solution, an approach which is unusual for routing algorithms of this type. TORA builds and maintains a Directed Acyclic Graph (DAG) rooted at a destination. No two nodes may have the same height. Information may flow from nodes with higher heights to nodes with lower heights. Information can therefore be thought of as a fluid that may only flow downhill. By maintaining a set of totally ordered heights at all times, TORA achieves loop-free multipath routing, as information cannot 'flow uphill' and so cross back on itself.

The key design concepts of TORA is localization of control messages to a very small set of nodes near the occurrence of a topological change. To accomplish this, nodes need to maintain the routing information about adjacent (one hop) nodes. The protocol performs three basic functions:

- Route creation
- Route maintenance
- Route erasure

During the route creation and maintenance phases, nodes use a height metric to establish a directed acyclic graph (DAG) rooted at destination. Thereafter links are assigned based on the relative height metric of neighboring nodes. During the times of mobility the DAG is broken and the route maintenance unit comes into picture to re-establish a DAG routed at the destination. Timing is an important factor for TORA because the height metric is dependent on the logical time of the link failure. TORA's route erasure phase is essentially involving flooding a broadcast clear packet (CLR) throughout the network to erase invalid routes.

2.4 CANDIDATE FORWARD ALGORITHM

Backtracking is a general algorithm for finding all (or some) solutions to some computational problems, notably constraint satisfaction problems, that incrementally builds candidates to the solutions, and abandons each partial candidate *c* ("backtracks") as soon as it determines that *c* cannot possibly be completed to a valid solution. The classic textbook example of the use of backtracking is the eight queens puzzle, that asks for all arrangements of eight chess queens on a standard chessboard so that no queen attacks any other. In the common backtracking approach, the partial candidates are arrangements of k queens in the first k rows of the board, all in different rows and columns. Any partial solution that contains two mutually attacking queens can be abandoned. Backtracking can be applied only for problems which admit the concept of a "partial candidate solution" and a relatively quick test of whether it can possibly be completed to a valid solution. It is useless, for example, for locating a given value in an unordered table. When it is applicable, however, backtracking is often much faster than brute force enumeration of all complete candidates, since it can eliminate a large number of candidates with a single test. It is often the most convenient (if not the most efficient) technique for parsing, for the knapsack problem and other combinatorial optimization problems. It is also the basis of the so-called logic programming languages such as Icon, Planner and Prolog.

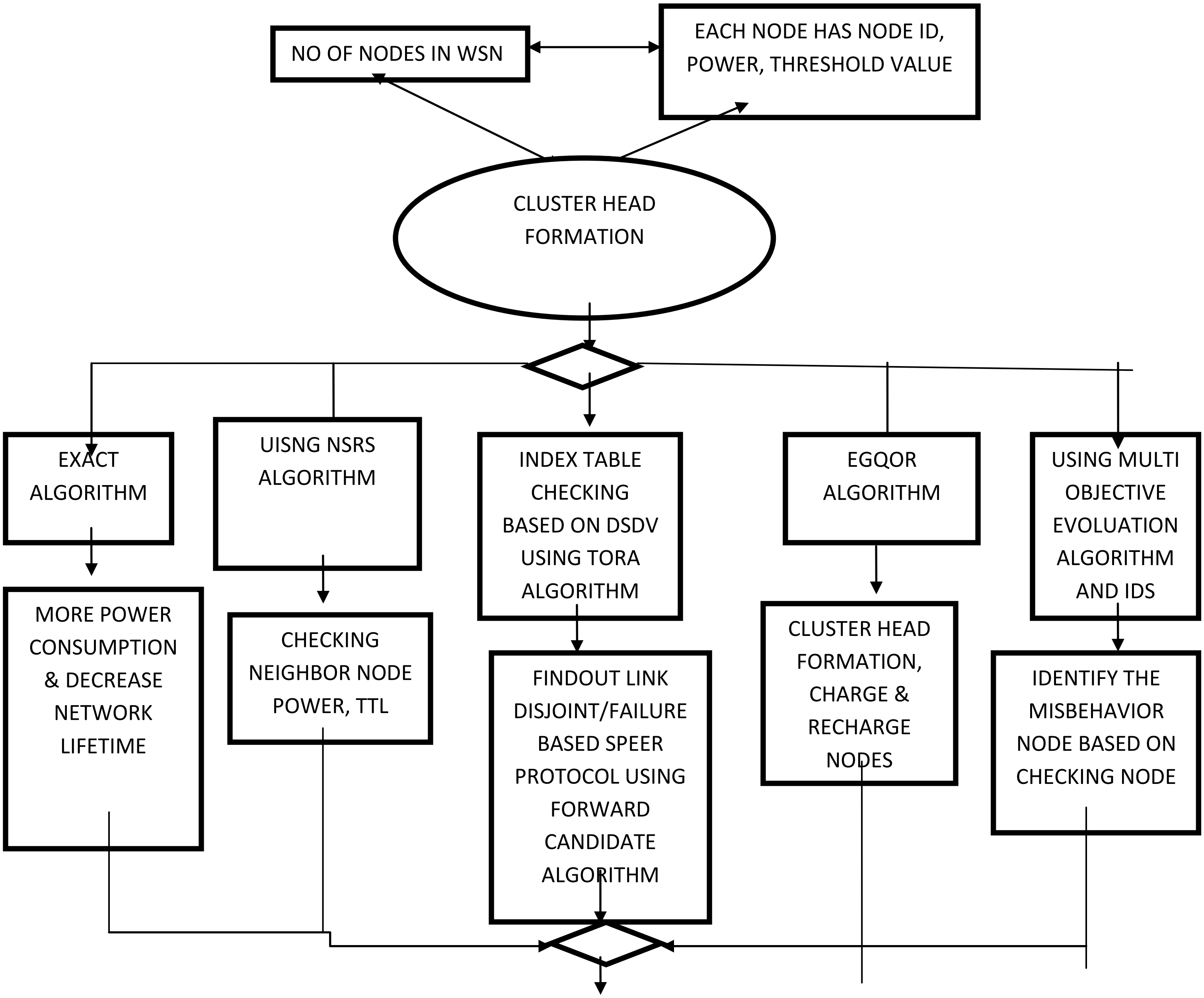
Backtracking depends on user-given "black box procedures" that define the problem to be solved, the nature of the partial candidates, and how they are extended into complete candidates. It is therefore a metaheuristic rather than a specific algorithm – although, unlike many other meta-heuristics, it is guaranteed to find all solutions to a finite problem in a bounded amount of time.

2.5 MULTI OBJECTIVE EVOLUTIONARY ALGORITHM

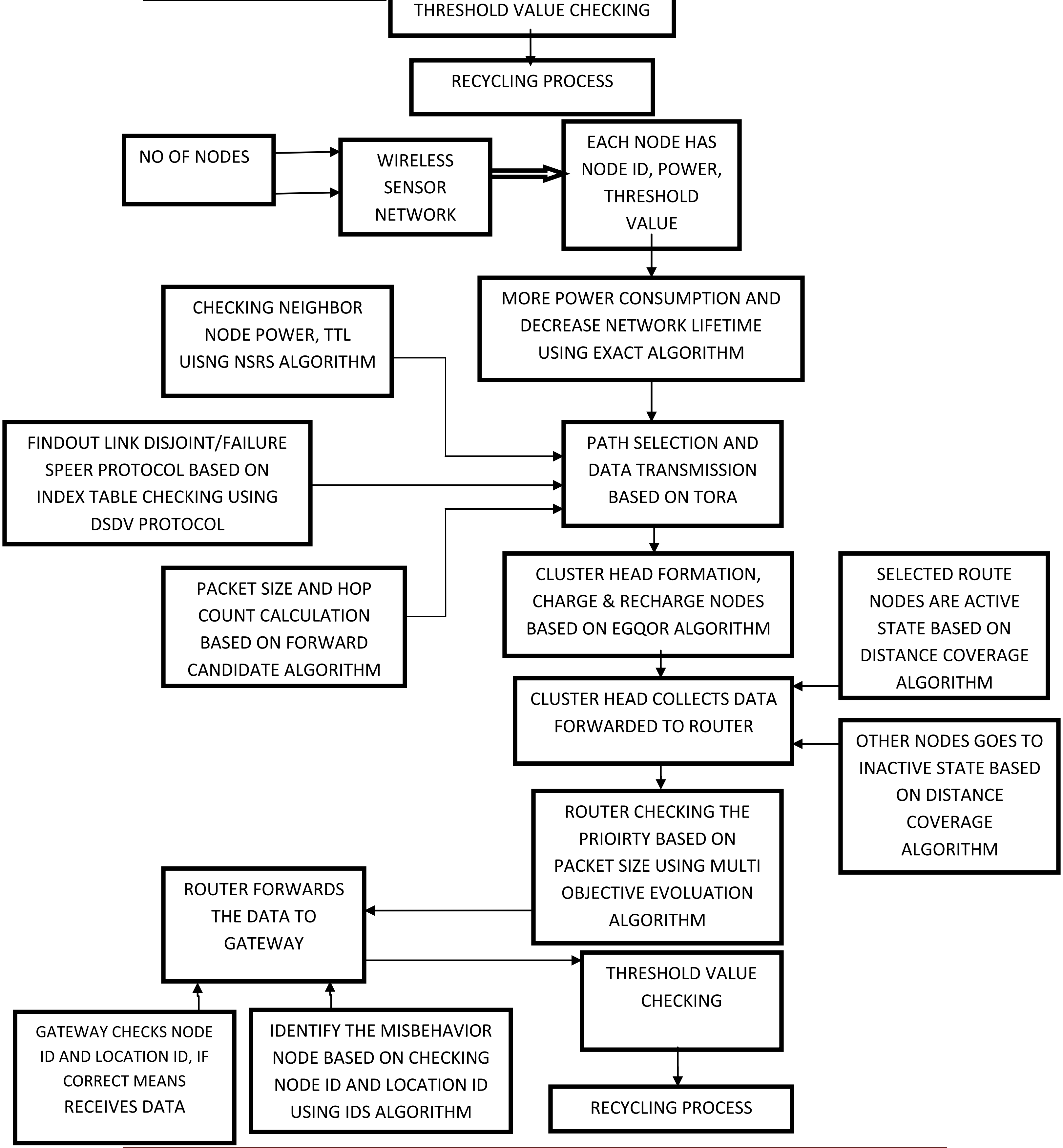
Multi-objective optimization (also known as multi-objective programming, vector optimization, multi-criteria optimization, multi attribute optimization or Pareto optimization) is an area of multiple criteria decision making, that is concerned with mathematical optimization problems involving more than one objective function to be optimized simultaneously. Multi-objective optimization has been applied in many fields of science, including engineering, economics and logistics where optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives.

An intrusion detection system (IDS) is a device or software application that monitors network or system activities for malicious activities or policy violations and produces electronic reports to a management station. IDS come in a variety of "flavors" and approach the goal of detecting suspicious traffic in different ways. There are network based (NIDS) and host based (HIDS) intrusion detection systems. NIDS is a network security system focusing on the attacks that come from the inside of the network (authorized users). Some systems may attempt to stop an intrusion attempt but this is neither required nor expected of a monitoring system. Intrusion detection and prevention systems (IDPS) are primarily focused on identifying possible incidents, logging information about them, and reporting attempts. In addition, organizations use IDPS es for other purposes, such as identifying problems with security policies, documenting existing threats and deterring individuals from violating security policies. IDPS es have become a necessary addition to the security infrastructure of nearly every organization.

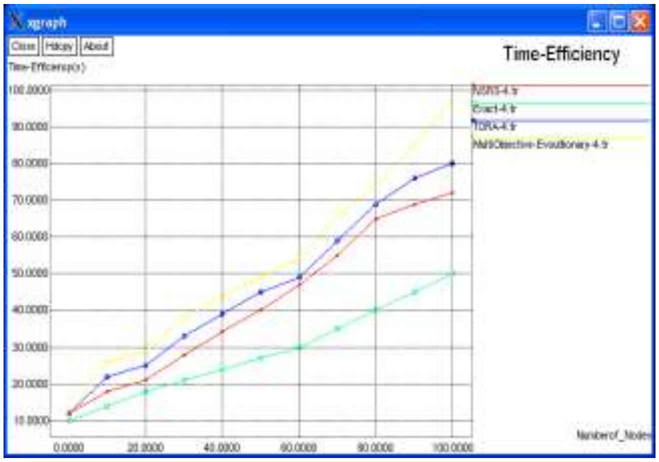
3. DATA FLOW DIAGRAM:



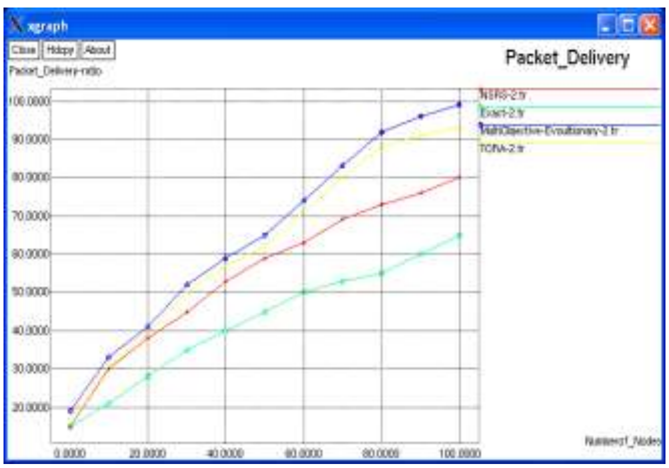
4. ARCHITECTURE DIAGRAM



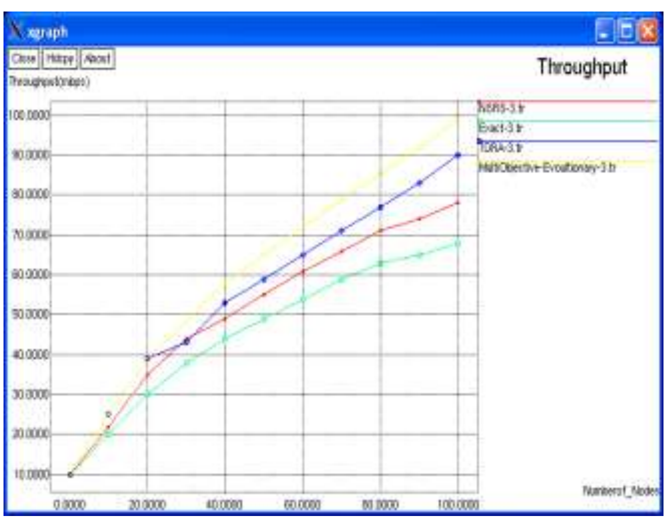
5. GRAPHS



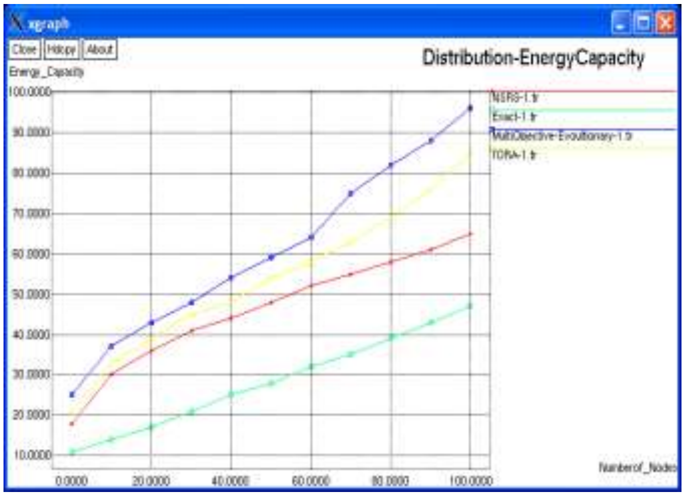
In X-axis is the Number of nodes and Y-axis is the Time Efficiency (ms) of the router formed with sensor nodes monitoring from the gateway with the designed algorithm.



In X-axis is the Number of nodes and Y-axis is the Packet Delivery Ratio (Mbps) of the router formed with sensor nodes monitoring from the gateway with the designed algorithm.



In X-axis is the Number of nodes and Y-axis is the Throughput (Mbps) of the router formed with sensor nodes monitoring from the gateway with the designed algorithm.



In X-axis is the Number of nodes and Y-axis is the Energy Capacity (Joules) of the router formed with sensor nodes monitoring from the gateway with the designed algorithm.

6. TABULAR COLUMN :

Network Size	2000x800
Number of Nodes	49
Number of Routers	4
Number of Gateway	1
Range	50m (100m – 300m)
Throughput	50 Mbps (45.0 Mbps, 34 Mbps)
Bandwidth	40.0 Mbps
Frequency	50 Hz
Average Speed of nodes	600.0 m/s
Data Transmission	1200 Bytes
Packet Rate	100 Packets per second (pps)
Request message interval	10 – 50 Seconds
Mobility Factor	200 seconds
Initial Energy Assigned	100 Joules
Energy Consumption	90 Joules
Simulation Time	3500 seconds

7. COMPARISON OF DIFFERENT ROUTING PROTOCOL USING QUADRATIC ASSIGNMENT TECHNIQUES IN WIRELESS SENSOR NETWORK

PROTOCOL	NETWORK LIFE TIME	DATA AGGREGATION	QOS	OVERHEAD	SCALABILITY	ENERGY CONSUMPTION	PACKET SIZE	THROUGHPUT RANGE	TIME
Specific *Protocol* Exceptions to Expedited Reporting protocol	Poor	No	No	High	No	Very High	Few	50 Mhz	High
Dynamic Source Distance Vector protocol	Good	No	No	Medium	Limited	Few High	High	50 Mhz	Few High
Energy Qos-aware geo-graphic routing protocol	Very Good	Yes	No	Low	Medium	Few Less	Med	50 Mhz	Less
Energy efficient routing protocol	Best	Yes	Yes	Medium	Good	Less	High	50 Mhz	Very Less
Geo – graphic routing protocol	Excellent	Yes	No	Very Low	Very Good	More Less	Very High	50 Mhz	More Less

CONCLUSION:

In this work, we focused on the routing problems in wireless sensor networks using Quadratic Assignment techniques. We have presented an extensive simulation study to compare three on-demand protocols (SPEER, DSDV, EQGOR, Geographic routing protocol) using a variety of workloads such as network lifetime, Data aggregation, QOS, Overhead, scalability, energy consumption, packet delivery ratio, routing over head, throughput range and time. According to practical results, the Geographic routing protocol gives the better performance for WSNs. The result of our experimental work shows the comparing which protocol is more energy efficient routing protocol for WSN in the form of energy consumption and cost of sensor nodes.

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