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Virtual Structure based Data Dissemination Schemes in WSN-A Study

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Abstract : *Wireless sensor network are highly distributed autonomous sensor nodes to monitor the environment. The self-organizing ability of WSNs permits one to access data from dangerous and hostile environments which otherwise would not be possible. Some potential applications of WSNs include : habitat monitoring, border patrol, battle field surveillance, remote health monitoring, early warning of natural disasters like forest fire, wildlife tracking, smart transportation, industrial process control and etc. Data dissemination in wireless sensor network consumes lot of energy, various protocols or scheme has been proposed over decades to reduce the energy consumption of wireless sensor network. Survey highlights variety of data dissemination schemes, each scheme has its own advantages and disadvantages. Various schemes are helpful to reduce the energy consumption of wireless sensor network by creating the virtual grid. Grid is constructed only when if there is no valid grid is present in sensor filed and if valid grid is present then be use the exiting grid which reduce the energy consumption of sensor node to create grid again and again if event is occurred. Sensor nodes have strong constraints on their energy usage and data transfer needs to be energy efficient, for maximizing the network lifetime.*

Keywords*- Data Dissemination, LBDD, TTDD, VGDRA, VCCSR*

I. Introduction

A wireless sensor network (WSN) is a distributed system of smart sensor nodes interconnected by a wireless communication network. The heart of any WSN lies in the sensors. The past decade has seen rapid advancement in multiple sensing technologies such as Micro electromechanical systems (MEMS), CMOS based sensors, LED sensors etc and wireless technology [1]. This development makes sensor become a technology that is suitable for collecting contexts from real world. The node may be static or mobile which are capable of communicate with each other to collect data accurately. Each node in the network is capable of sensing, processing and communicating. The most important application of wireless sensor network is the monitoring and tracking. The application of wireless sensor network is extended to other field such as battle field, volcano monitoring, industry monitoring, traffic monitoring etc. The main characteristics of wireless sensor networks are power consumption, ability to cope with node failures, mobility of nodes, heterogeneity of nodes, ease of use etc. The base stations are one or more components of the wireless sensor network with much more computational, energy and communication resources. They act as a gateway between senor nodes and the end user as they typically forward data from the WSN on to a server.

In wireless sensor networks each sensor node is equipped with one or more sensing devices to monitor the ambient environment and collect data. The sensor node is also equipped with a processor to process the collected data and communication hardware to exchange data with other local sensor nodes within its radio range. Data collected at the sensor nodes is propagated to control centres called sinks where the information is required. Traditionally, the sinks have been static and the data collected is disseminated to the sinks using sensor-to-sensor multi-hop data propagation. This approach normally incurs significant energy consumption at the energy-constrained sensors. Sensor nodes spend lot of energy in coordinating and transmitting data through multi-hop paths to reach the sink. Nodes near the sink fail relatively earlier due to repeated relaying of data from nodes that are farther away. The lifetime of a sensor network is often defined as the first time the network gets disconnected due to the failure of certain sensor nodes that keep the network connected. Sensor nodes are not often rechargeable and redeployment may be next to impossible in certain scenarios.

In wireless sensor network different kinds of routing protocols exists for the purpose of data dissemination and data gathering. Mobility of sink has more advantages when compared with static sink, sink mobility improves the network connectivity as well as network life time.Many energy efficient routing algorithms or protocols have been proposed with techniques like clustering, data fusion, multi-path, location tracking and sink

mobility. Using sink mobility technologies can avoid excessive transmission overhead at sensor nodes since those sensors can forward their traffic only when sink node is nearby. Energy consumption can also get balanced since the hotspot nodes will rotate as sink nodes move around throughout the sensor network, and this will cause prolonged network lifetime. Besides, sink mobility technologies can ensure good network connectivity under sparse or disconnected sensor networks.

For mobile sink based wireless sensor network virtual infrastructure strategy are most efficient. Virtual infrastructure can achieve better scalability and energy efficiency [2]. Virtual infrastructure can be classified in to two types such as rendezvous based and backbone based. Backbone based approach is a kind of self organizing scheme but in rendezvous structure a localized rendezvous area defined within the sensor field [2]. In the present scenario lots of rendezvous or backbone based virtual infrastructure routing schemes are available. Virtual Grid Based Dynamic Routes Adjustment Scheme (VGDRA) and Virtual Circle Combined Straight Routing (VCCSR)are two data dissemination protocol used in a mobile sink based wireless sensor network[3]. Both the scheme consists of a structure based routing with virtual backbone. But individually each scheme has its own advantages and disadvantages. The remaining part of this paper organized as follows: Section II describes various existing data dissemination schemes and virtual structure based data dissemination scheme. Section III represents the performance comparison of different virtual structure based data dissemination schemes. Finally, Section IV concludes the paper.

II. Overview of Data Dissemination Schemes

Data dissemination is the process of broadcasting data throughout the network, is two steps process in which in first step interest of nodes is broadcasted in network and in second step nodes after receiving the request sends data having requested data. Various data dissemination schemes have been proposed over the years to reduce the energy consumption in Wireless Sensor Networks. Data dissemination protocol can be classified based on different criteria, according to the nature of the data disseminated it may be meta data dissemination and sink location dissemination [2].Data dissemination in the case of multiple sink consumes lots of energy. Energy consumption is an important constraint for efficient data delivery, virtual infrastructure based data dissemination scheme reduces the energy consumption [3]. Various virtual structure based data dissemination protocols have been introduced in WSN. Virtual infrastructures can be divided into rendezvous-based approaches and Backbone based approaches. In rendezvous based approach each node is aware of its location through the use of Global positioning System or some virtual coordinate system [2].In backbone based approach use a self organizing scheme to build a virtual infrastructure over the network[2].

2.1 Dynamic Directed Backbone Scheme

Dynamic directed backbone (DDB) protocol [8] is built on top of the low energy self-organization scheme. Initiate message of sink nodes can be sent through the non-directed backbone, which is built by localized self-organization scheme. Only a set of sensors will be chosen to send neighbouring information, and will be defined as leader nodes interconnected by gateways. Leader nodes and gateways form the self-organized backbone. When a node joins, it will decide whether to be a leader node or not. A directed dissemination structure can be constructed by sending a sink request message through the self-organized backbone. Query message will be injected into the network once a sink node arrives, and will be translated by sensors which capture it. DDB can effectively reduce data traffic during data dissemination phase and save energy.

2.2 Mobile Routing Algorithm with Registering

To effectively improve the network lifetime, sink mobility technology and clustering technology are combined to construct sensor networks. A mobile routing algorithm with registering (MRAR) in cluster-based architecture [10] is proposed to minimize the energy consumption while maintain certain network lifetime. Each sensor needs to establish a neighbour information table in order to hold the information about geographical address and the status of energy supply. Nodes with higher energy will be chosen as cluster heads, and then broadcasts the message to neighbour nodes. Neighbour nodes stop the wait time and join into the newly formed cluster. After completing the formation of clusters, sink node will move around according to those calculated random waypoints, and send out messages containing address information. Cluster heads compare the address information and then make the corresponding reflection to set up data transmission path based on the remaining energy capacity.

2.3. Two Tier Data Dissemination Schemes

The Two Tier Data Dissemination TTDD scheme proactively maintains a grid-based propagation structure over the whole network in spite of the actual locations of the sinks, and the structure should be updated whenever the source location changes [5].The source node selected as the start crossing point on the grid and send notification to the adjacent crossing points [5].The process is continues until the entire grid structure is formed. Queries can easily propagate throughout the grid and data reports are directly transmitted from source to sink. This scheme cannot support mobile sink and source, when the sink are mobile it limit the network lifetime [2][5]. In TTDD building of virtual grid structure support efficient data dissemination in large-scale sensor fields. TTDD can effectively deliver data from multiple sources to multiple, mobile sinks with performance comparable with that of stationary sinks [8].

2.4 Grid based Data Dissemination Schemes

In GBDD dual radio a mode is exploited to form the grid across the sensor field. The grid is constructed in the sensor field is done when sink is initiated in the sensor field if no valid grid is present in sensor filed if the valid grid is present in the sensor filed then it goes through the exiting grid and cell size is decided on the long and short range of the dual radio transmission range and ensure the continuous delivery of measurement or data from source node to sink by handling multiplicity of sink, source and event. Grid is constructed by keeping itself as one of the crossing point and two dimensional coordinates of the sink become the start point of the grid construction. The long radio transmission range and short radio transmission of dual radio is used to determine the cell size and the cell form the cluster with the one of the node at the corner is represented with the cluster head and low radio is used for handling the failure of the dissemination node and also in the selection of the dissemination node In GBDD the sensor once deploy and remain stationary and cannot can their position their own .The cell size is decided of sensor network is calculated with the help of high radio range as well low radio range.

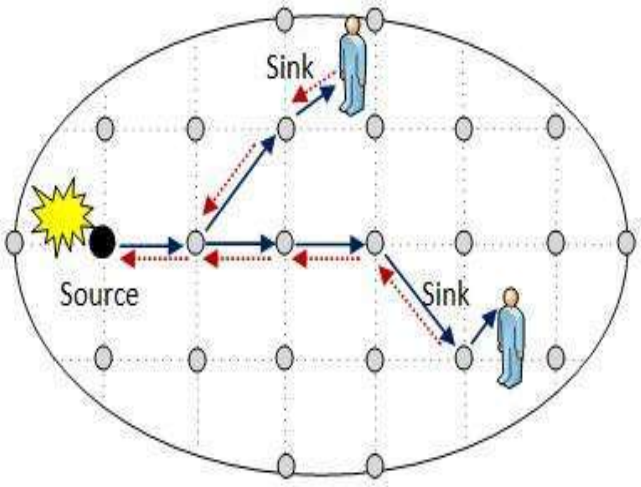

Fig 1: GBDD Design of Data Dissemination [16]

2.5 Energy Efficient Data Dissemination Scheme

Energy efficient Data Dissemination EGDD scheme uses virtual grid based structure for data transmission [4].EGDD reduces energy consumption due to query flooding by multiple sinks located at different geographical locations [4].Energy aware grid based data dissemination scheme provides a shortest path between source and sink for query and data forwarding. Energy efficiency is the major concern in EGDD scheme and it is more energy efficient for multiple sink and multiple source in large wireless sensor networks [9].

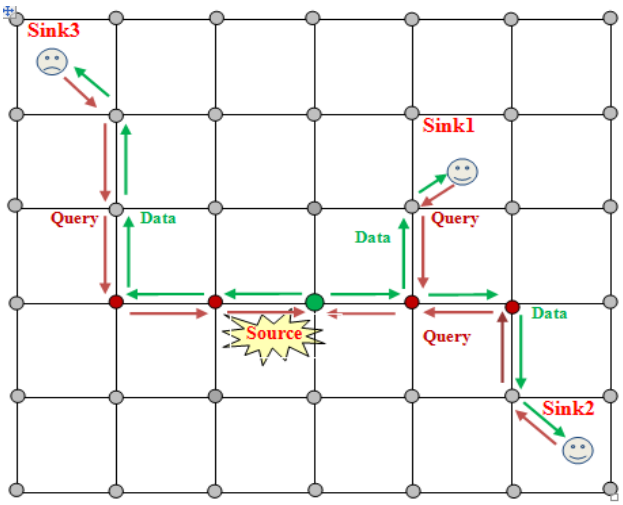

Fig 2: Query and data forwarding in EGDD [4] [9]

2.6 Line Based Data Dissemination Scheme

A line-based data dissemination (LBDD) protocol [9] supporting unpredictable mobile sink nodes is proposed to offer good network scalability. In LBDD, the whole sensor network is divided into two equal parts by a vertical line, as is illustrated in Fig 4. Sensor nodes within the boundaries of this vertical line are defined as inline-nodes. The core part of this protocol is the concept of a rendezvous region which decouples data dissemination operation. Therein, the vertical line acts as the rendezvous region, and it is located at the center of the sensing field. When an ordinary sensor node generates a data report, it will transmit the report to the virtual line. And the report will then be kept in an inline-node which is closest to the source node. Then sink node sends a query message which will be propagated along the line until reaching the storing node. Finally, new data reports can be transmitted to mobile sink node directly. LBDD can effectively address the hot spot problem with good network scalability.

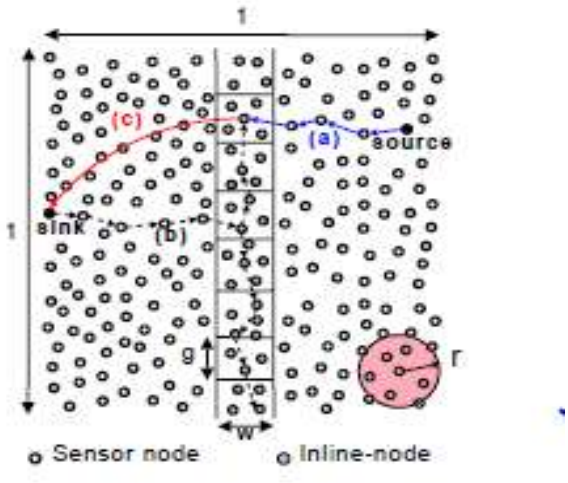

Fig 3: Virtual infrastructure of LBDD [12]

2.7 Novel Energy Aware Data Dissemination Scheme

Novel Energy Aware Data Dissemination NEADD is a novel grid-based data dissemination scheme uses virtual grid infrastructure for query and data forwarding. NEADD is an energy-efficient scheme for addressing the issues of dissemination node failure and excessive flooding of packets in WSNs [6].It is very useful for the large scale wireless sensor network with multiple mobile sinks.

2.8 Virtual Circle Combined Straight Routing Scheme

The novel VCCSR scheme is a virtual infrastructure based data dissemination scheme used for mobile sink based wireless sensor network. The scheme is a structure based routing with virtual backbone [1].The scheme will make an efficient virtual structure to route the data effectively and leads to save energy in wireless sensor networks [1].The algorithm reduces overall maintenance cost of continues data collection for mobile sink in wireless sensor networks [1].In VCCSR, virtual structure consist of combination of virtual circles and straight lines. This makes route readjustment is easy when compared with dynamic tree adjustment scheme. Novel scheme will be decreases the energy consumption and increases the network life time [7].

2.9. Virtual Grid based Dynamic Route Adjustment Scheme

Virtual Grid based Dynamic Route Adjustment scheme [3] is novel data dissemination scheme for energy efficient data delivery in a wireless sensor network. This scheme will reduce the route reconstruction cost and improves the network life time. For a mobile sink based wireless sensor network, novel scheme will maintain the optimal route to the latest location updates. Sensor fields are divided into equal number of cells, each cell contain cell header for data transmission. The neighboring cell headers are communicates through the help of gateway nodes. The gateway nodes and cluster heads are combined to form virtual backbone structure. In dynamic network latest route update should sync with the mobile sink. For dynamic route adjustment only a set of cluster head are involved so it will reduces the network overhead. The route readjustment process is effectively done and the scheme should minimize the route reconstruction cost.

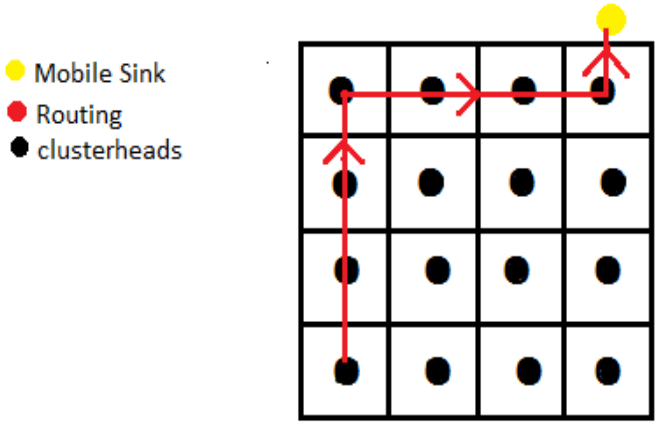

Fig 4: VGDRA shows straight line communication. [3]

III. Performance Evaluation of Virtual Infrastructure Schemes

Virtual infrastructure schemes are most efficient for data collection in large wireless sensor networks. The schemes are highly supported in the case of mobile sink based wireless sensor networks. By using virtual infrastructure schemes it reduces the dissemination cost. The energy consumption is defined as the total energy consumed in the network during communication (transmitting and receiving) excluding the idle. Fig 5 shows a comparison of an energy consumption of TTDD and EGDD schemes, total energy consumption of EGDD is less when compared with TTDD.

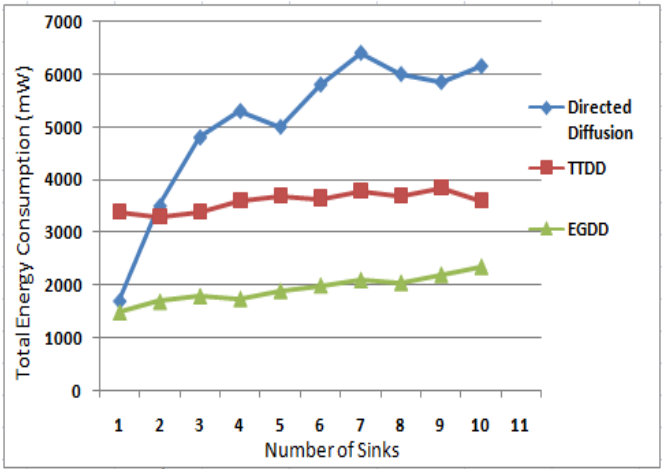

Fig 5: Total energy consumption with different number of sinks

The novel schemes VGDRA and VCCSR both support multiple mobile sink based wireless sensor network, they differ only in the structure of virtual backbone. Based upon the virtual backbone structure it gives various performances. The schemes are compared based on the parameters such as network convergence time, route reconstruction cost, packet delivery ratio etc. At different network size virtual structure construction cost is very less in VGDRA when compared with VCCSR. In terms of rounds in the sensor field network lifetime is higher in VCCSR.

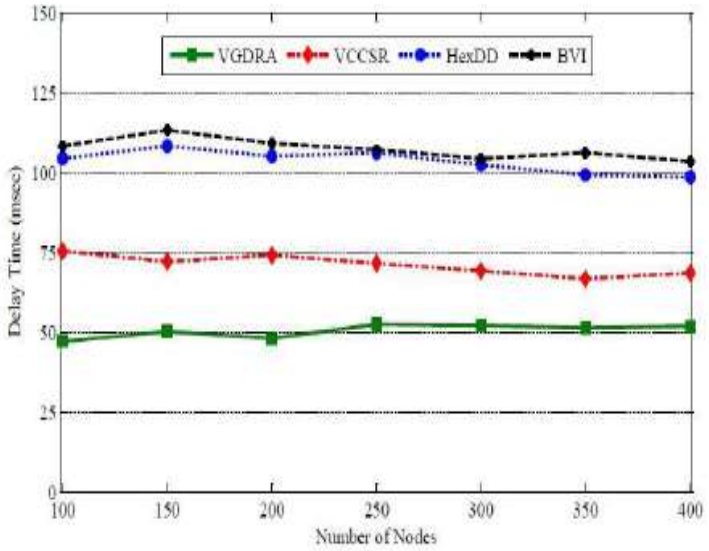

Fig 6: Network convergence time of different schemes [3]

From the Fig 6 VGDRA scheme has faster convergence time than other scheme like VCCSR. In the VGDRA scheme only a part of cell header is involved in the route readjustment process it will reduces the overall network overhead and easily adjust the route towards latest location of mobile sink.

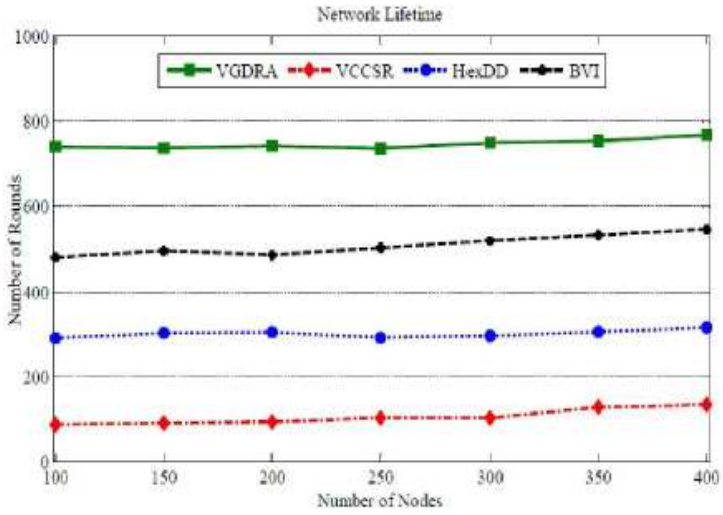

Fig 7: Compairing network lifetime in terms of number of rounds[3]

Network life time is the amount of time that a wireless sensor network would be fully operative.This matric commonly used in WSN to reflect the time span from the ntwork's initial deployment to the first loss of coverage.The data dissemination scheme in a virtual infrasructure minimizes the maximum node is that one will ensure the maximum networklife time.

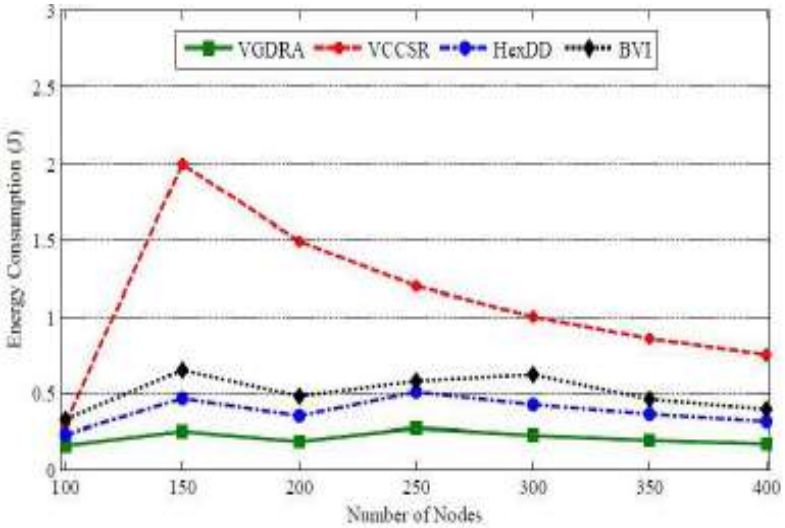

Fig 8: Comparing per round route reconstruction cost for different network sizes [3][1]

Per round route reconstruction cost determines the amount of node energy for readjusting the routes to the latest location of the mobile sink. In the case of VGDRA scheme, it wills always providing the optimal routes towards the latest location of the mobile sink. Using VGDRA scheme reduces the per round route reconstruction cost when compared with other schemes.

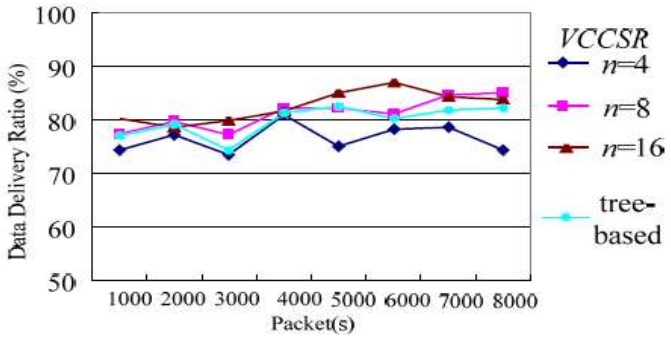

Fig 9: Comparison of Data Delivery Ratio [1]

Data delivery ratio defined as the ratio of data packets received by the destinations to those generated by the sources .VCCSR scheme provides better data delivery ratio compared with other schemes. Using VCCSR scheme it effectively collect data in wireless sensor networks.

IV. Discussions and Conclusions

Wireless sensor networks have been one of the most popular and widely used technologies in 21st century. WSNs have unique characteristics, for example, denser level of node deployment, higher unreliability of sensor nodes, and severe energy, computation, and storage constraints, which present many new challenges in the development and application of WSNs. These networks are widely used in variety of applications such as military applications, medical & healthcare, security &surveillance and environmental applications.

This paper proposed a survey of various virtual infrastructure data dissemination schemes. Virtual infrastructure over the physical network is considered as an efficient approach. The survey study shows virtual infra structure based data dissemination schemes have better performance when compared with other existing novel schemes.

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