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Traffic Control Scheme Using Mobile Data Collectors for Wireless Sensor Network

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Abstract- A major challenge affecting the performance of Wireless sensor networks (WSNs) comes from the unbalanced traffic over different parts of networks. High delay in transmitting information from one node to another is the prime reason behind unbalanced energy consumption .delay has continuous nature; even if two nodes are placed in bounded area, there is an infinite number of possible values for delay between them. A natural solution to reduce the delay is to have the data collector that will collect the information from all the nodes but in large network single data collector would not work efficiently; so we propose solution to this problem is to have multiple mobile data collectors so that the load is distributed evenly among all nodes. We investigate this promising direction for balancing the load and, hence, minimized the delay in the network. We divide the network into multiple clusters and placed a mobile data collector in each cluster. We show, by theoretical analysis and simulations, that our approach has the potential to prolong the lifetime of the network significantly by minimizing the delay as comparisons to other schemes.

Index Terms- wireless sensor networks, mobile data collector, performance parameter analysis

I. Introduction

Wireless Sensor Networks can be seen as a large collection of tiny sensor nodes that can organize themselves in an ad-hoc network capable of sensing environmental conditions within their range and have battery operated limited energy and limited processing capabilities, after the sensing phase, a sensor node need to transmit the information to the sink node or base station, where an application will process the data. However, a wireless sensor network usually lacks Infrastructure and sensor nodes must organize themselves in order to create routes that lead to a sink. Therefore, WSNs perform multi hop data propagation in order to relay data to a static sink. In this paper, we address the problem of detecting packet dropping attacks in WSNs. Apart from malicious intent; there can be other reasons of packet dropping like collisions, buffer overflows, congestion, etc. It is important to find solutions that take these factors into account, for example, to prevent false alarms. Packet loss occurs when one or more packets of data travelling across a network fail to reach their destination. Packet loss is distinguished as one of the three main error types encountered in digital communications; the other two being bit error and spurious packets caused due to noise. Packet loss can be caused by a number of factors, including signal degradation over the network medium due to multi-path fading, packet drop because of channel congestion, corrupted packets rejected in-transit, faulty networking hardware, faulty network drivers or normal routing routines .In addition to this, packet loss probability is also affected by Signal to noise ratio and distance between the transmitter and receiver. In this algorithm the packet loss is analyzed with respect to number of packet sent.

II. BACKGROUND

A WSN is composed of a large number of tiny sensor nodes and one or multiple more powerful sink nodes. Sensor nodes collect data from the surrounding environment and deliver the collected data to a sink node. Each sensor node has one or more sensors, a general purpose Central Processing Unit (CPU) to perform arithmetic and logical operations, and a small amount of storage space. The power is supplied to these untethered sensor nodes through small, non-replenish able batteries. A sensor node has a wireless communication interface through which it can communicate with other nodes in its vicinity. Due to the scarcity of the power reservoir and due to the fact that communication is the dominant power consumer in a sensor node, the transmission range of these devices is limited for power efficiency purposes. Sensor nodes, which are spatially distant from the sink node, can report their data in a multi-hop fashion. A sink node is usually a more powerful device with a virtually unlimited power supply.

WSNs have a wide range of potential applications related to scientific, environmental, industrial, and military monitoring. WSNs have been deployed to monitor the seabird nesting environment and behavior in the Great Duck Island. The Zebra Net system is a WSN deployed to support the research of biologists to monitor animal migration in Kenya. WSNs have enabled a new generation of smart environments; an example of such an environment is the Gator Tech smart house in Florida, which is designed to assist elderly and disabled residents. A prototype has been proposed for using WSNs to monitor drinking water quality. The design and implementation for using WSNs to monitor soil moisture is presented. An approach for using WSNs in monitoring the health of civil infrastructures (e.g., bridges and highways) is presented. These are just a few examples of how WSNs can be used to collect important data and facilitate significant services in real life [1] and [3].

2.1 DSDV protocol

In Destination-Sequenced Distance Vector routing protocol (DSDV), routing messages are exchanged between neighboring mobile nodes. Updated messages are got triggered in case routing information from one of the nearby node. This data get change in the routing table data. Packets for which route to its destination is unknown that packets are cached and, its routing queries are sent out in that duration. The packets are allowed to receive till route-replies are received from the destination. The precise maximum buffer size of memory is available for collecting those packets, waiting for routing information. If the packets are received beyond that size then, that packets may be dropped. The sequence number to each entry is allotted. This numbers are generated by destination, and it is mostly even number if a link is present otherwise it is an odd number. Further, it is necessary for the transmitter to transmit the next update with this sequence number Routing protocol DSDV is explored by C. Perkins and P. Bhagwat in 1994. It is based on the Bellman- Ford algorithm and it is a table-driven protocol. [5].

2.2 AODV Protocol

Ad hoc On Demand Distance Vector (AODV) protocol is suitable for unicast and Multicast routing. It is designed for ad hoc mobile networks. It is loop-free and self-starting protocol. It builds routing paths between the nodes only if demanded by the source nodes. This routing path will remain connected, till that particular node requires the same. It is suitable for large numbers of mobile nodes and it give new sequence numbers to newly generated routes. To assign a new destination sequence number, for every route entry is the unique feature of AODV protocol. Sequence number is use to keep track on updated information at that destination node. It consists of route information, which it has to send, to requesting nodes. When there is a choice between two routes then requesting node have to select that route with the greatest sequence number

2.3 AOMDV Protocol

An extension to AODV is Ad-hoc on-demand Multipath Distance Vector (AOMDV) routing protocol which is for computing multiple loop-free and link disjoint paths. For each destination, along with the respective hop counts it contains a list of the routing entries of the next-hops. Same sequence number is allocated to all next hops. This helps for keeping track of a route. A node maintains the assigned hop count, which is the maximum hop count for all the paths at each node. Loop freedom is assured for a node by accepting another path to destination if it has a less number of hop counts than the assigned for that destination. AOMDV allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. During route discovery, its message overhead is high, due to increased flooding. Since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overhead [7]..

III. PROPOSED TECHNIQUE

The scheme we propose here takes in consideration delay-tolerant data. Accordingly, sensor nodes use two routing schemes to deliver their data to data collector: delay-tolerant routing and delay-sensitive routing. In the delay-tolerant routing, data packets are sent to any trajectory node where they wait for the data collector to come and pick them up and it needs to locate the data collector in order to send the data to an active trajectory node.

3.1 Delay-tolerant routing

In order for sensor nodes to deliver their delay-tolerant to the data collector, they need to have a path to at least one trajectory node. Each sensor node n_i has a Trajectory Node Record (TNR_i) which has the following fields:

Id: the id of trajectory node to which delay-tolerant data will be sent.

Next_hope: a neighbor of n_i which is used as next hop towards the trajectory node.

Number_of_hops: the number of trajectory hope to trajectory node.

Algoritham 1 describes the process of setting the trajectory node records of all sensor nodes, assuming that each sensor node uses the nearest trajectory nodes in terms of number of hopes. To simplify the presentation of our scheme, we assume one TNR for each sensor node. However, each sensor node can have multiple TNRs to recoup failures of trajectory nodes and alters in the topology of the network.

Algoritham 1: setting Trejectory node records

Foreach sensor node n_i do
If n_i is a trajectory node
then
  TNR_i.id==i;
  TNR_i.next_hop==i;
  TNR_i.number_of_hops== 0;
  Broadcast TNR_i to all neighbors of n_i ;
Else
  TNR_i.number_of_hops==M+1 ;
End
End
When a sensor node n_i recives a broadcast TNR_j **:**
If TNR_i.number_of_hops +1<TNR_i.number of_hops **then**
TNR_i.number_of_hops==TNR_j.number_of_hops+1;
TNR_i.id== TNR_j.id ;
TNR_i.next_hop==j ;
End
End

3.2 Traffic control by mobile data collector:

We propose traffic control scheme using multiple mobile data collectors. But before discussing scheme we should look at the traffic in wireless sensor network. Traffic is not as random as in ad hoc networks. Karlof and Wagner [14] classify WSN traffic into one of three categories:

1. *Many-to-one*: Many sensor nodes send readings to a base station or aggregation point in the network.
2. *One-to-many*: A single node (typically a base station or an aggregator) flow several sensor nodes with query or control information.
3. *Local communication*: Neighboring nodes send localized messages to discover and coordinate tasks.

A Wireless Sensor Network is a highly dense network deployed over a large area of interest. Therefore, several nodes are used in order to deliver a single packet to a remote sink. Furthermore, sensor nodes closer to the sink will drain their energy and use more resources than other nodes in the network, simply because they are in the way of many routes to the sink. As a result, the sink's adjoining nodes will suffer from high congestion and packet losses that affect negatively the communication with the sink, Existing resolution for locating packet dropping in ad hoc networks by supervising peculiar node. Sleep-wake up schedules followed by nodes in a WSN [14] makes continuous guarding impractical. Also, monitoring individual nodes is too costly for WSNs. Researchers are inspecting the use of mobile object that can gather information from the sensor network while moving within the persisted area. A mobile collector approach will not only remove the burden of the nodes nearer to a sink, but it will give a mechanism to reach and gather data from network areas that are far away from sink, as well as to increase network performance. The first one assumes the existence of predefined tracks (e.g., a road network) spanning the sensing field, and data collectors can be moved over and placed at any point along these tracks. This would be practical in a situation where data collectors are carried on robots that move along paved roads only. In the second one, a data collector can be placed anywhere in the sensing field. For the on-track placement problem, a data collector may be placed at any point on any track as long as it is within the transmission range of at least one sensor node. This results in an infinite number of possible locations for each data collector and, hence, an infinite search space. Recall that a track is modeled as a line segment; we will use the terms line segment and track interchangeably.

3.3 Load balancing through Clustering in WSN

It is widely accepted that energy consumed in one bit of data transfer can be used to perform a large number of arithmetic operations in the sensor processor [12]. Moreover in a densely deployed sensor network the physical environment would produce very similar data in near-by sensor nodes and transmitting such data is more or less redundant. Therefore, all these facts encourage using some kind of grouping of nodes such that data from sensor nodes of a group can be combined or compressed together in intelligent way and transmit only compact data. This can not only reduce the global data to be transmitted and localized most traffic to within each individual group, but reduce the traffic hence contention in a wireless sensor network. This process of grouping sensor nodes in a densely deployed large sensor network is known as clustering. The intelligent way to combined and compress the data belonging to a single cluster is known as data aggregation. One mobile data collector is placed into each cluster. We define the notations of entry points, exit points, and tangent points. Each line segment (i.e., track) has a set of intersection points; an intersection point is a point where the line segment intersects with the boundary of the transmission disk of a sensor node. In figure 1, the line segment st has 7 intersection points: a, b, c, d, e, f, and g. By walking over a line segment from left to right (and from down to up if the line segment is parallel to the y-axis), intersection points incident to that line segment can be classified into entry points, exit points, and tangent points. An entry point is one at which the intersection of a line segment and a transmission disk begins. An exit point is one at which the intersection of a line segment and a transmission disk ends.

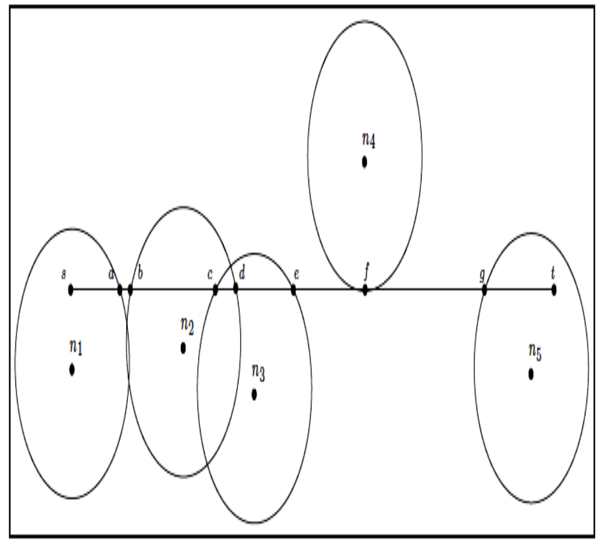

Figure 1: Intersection points on a line segment.

A tangent point occurs if the line segment and a transmission disk intersect at exactly one point. In figure, b, c, and g are entry points; a, d, and e are exit points; and f is a tangent point. Now we state the following obvious observation without a proof.

IV. PERFOMANCE PARAMETERS ANALYSIS

We focused to improve following important WSNs parameters

a. Delay
b. Traffic Sent
c. Traffic Received

4.1 Delay

The Delay a packet encounters is proportional to the number of hops between the packet source and destination. The number of hops between two points can be approximated to be a linear function of Euclidean distance between them. Therefore the delay [15] a packet encounters can be expressed by

$$\text{Delay} = \beta M \qquad \textbf{(i)}$$

Where α is a constant and M is the Euclidean distance between packet source and destination. Delay play very significant role in wireless sensor network specially in it works on real time application.

4.2 Traffic Sent

How much efficient is our network can be known by different parameter such as lifetime, delay etc. one of the important parameter is Traffic sent by our network. Traffic Sent by the network is directly proportional to the delay and can be expressed by

$$\textbf{Traffic sent} = \textbf{C*D} \qquad \textbf{(ii)}$$

Where C is the link capacity .while D is delay in propagation.

4.3 Traffic Received

As compare to Traffic sent by the network , Traffic received by the network is bit lesser due to distortion of packets by noise. It can be expressed by

Traffic Received== $T_s - N_p$ **(iii)**

Where T_s is the traffic sent by the network while N_p is the percentage of packet distortion by noise.

V. RESULTS

In order to evaluate and validate the performance of the proposed solution for mobile data gathering in wireless sensor networks. We have implemented our MDC protocol and carried out an extensive set of OPNET MODELER 14.0[16] simulations. We have scattered 100 sensor nodes across an area of 150×150 m. We consider a dense and connected network, i.e., all sensor nodes are able to deliver data to a static sink. It can be observed that we have improved the delay at least by 25% as compare to other schemes. This is due to the load balancing effect that is achieved by exploiting data collector mobility. This is a direct result of the considerations made for residual energy at single nodes. We compared delay of our scheme with four another scheme namely DTPR [15], DCPR [15], 802.11 with DSDV [14] and 802.11 with AODV [14]. First two schemes are far away from our scheme while 802.11 with DSDV is close to our scheme but difference is clearly visible and 802.11 with AODV is closest to OTS even better than it at initial stage but as time passes our scheme perform best among all relative scheme (as shown in Fig.2). The reason is that the OTS scheme may choose a route or a data collector location that spends more energy for the sake of avoiding and reducing the load on sensor nodes with low residual energy. An energy efficient route or data collector location that puts extra load on a sensor node with a critical energy level is not brought forward in the OTS scheme.To generate a trajectory for the data collector, we use a simple method. We divide the sensing field in to four equal-size squares; the trajectory of the data collector is a quadrilateral that has a vertex inside each square.

This is because the number of trajectory nodes using a mobile data collector is the same regardless of the size of the network. This makes the load assigned to each trajectory node proportional to the size of the network. On the other hand, the number of trajectory nodes with a mobile data collector is proportional to the size of the networks; this means that with a larger network, the increase in the amount of data generated over the network is confronted with a similar increase in the number of trajectory nodes. 3.

Fig 3 And Fig.4 shows the comparisons of traffic sent and traffic received of our OTS scheme with the other two important schemes 802.11 with DSDV and 802.11 with AODV. Traffic sent by our scheme is extremely low at beginning but it catches the pace after some interval of time, other two schemes are close to each other but go far away from our scheme as time passes. Our scheme does not improve only traffic sent by our network by 10-20% as compare to other scheme but traffic received by network also improved by 5-15% as shown in Fig 4. 802.11 With DSDV and 802.11 with AODV here also close to each other and close to our OTS scheme too but difference is clearly visible here too.

Fig 5 Bring most significant result as our scheme reduced the rate of data dropped by the network to almost zero while, this rate in other two schemes 802.22 with DSDV and 802.11 with AODV are extremely high due to high congestion in vicinity area of sink. Data dropped rate reduction in network does not only improves the lifetime of network but it makes network energy efficient too. High data dropped rate create problems of the sink node to arrange the packet in proper sequence. We get efficient result just because of the clever use of data collector and load balancing due to dividing a large network into small size clusters. Load balancing in sink vicinity area is much important rather remote areas where traffic is very low.

In fig. 6,7,8 and 9 we compare average values of parameter delay, traffic sent, traffic received, data dropped rate respectively so that we can confirmed that our results are efficient for long lasting network too. As we focused earlier in this paper that our primarily aim is to enhance the lifetime of WSN network and that can only we do when our nodes are highly energy efficient, energy consumption of a sensor node depend on each factor that we improved in this paper so indirectly we also improved the lifetime of network. In table 1 we showed summary of our all the simulation results of our parameters such as delay, traffic sent, traffic received, data dropped rate. Our scheme is not only suitable for delay tolerant application but it is also suitable for delay sensitive application of WSN.

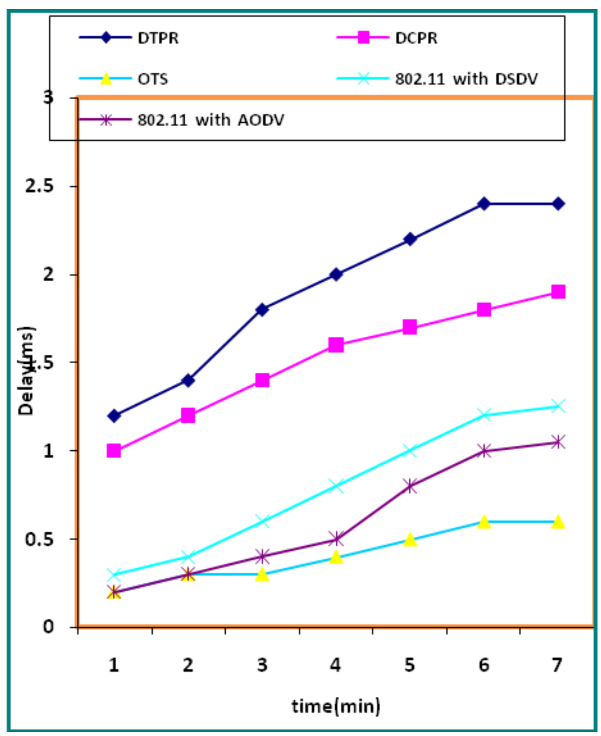

Fig2: Delays in different schemes

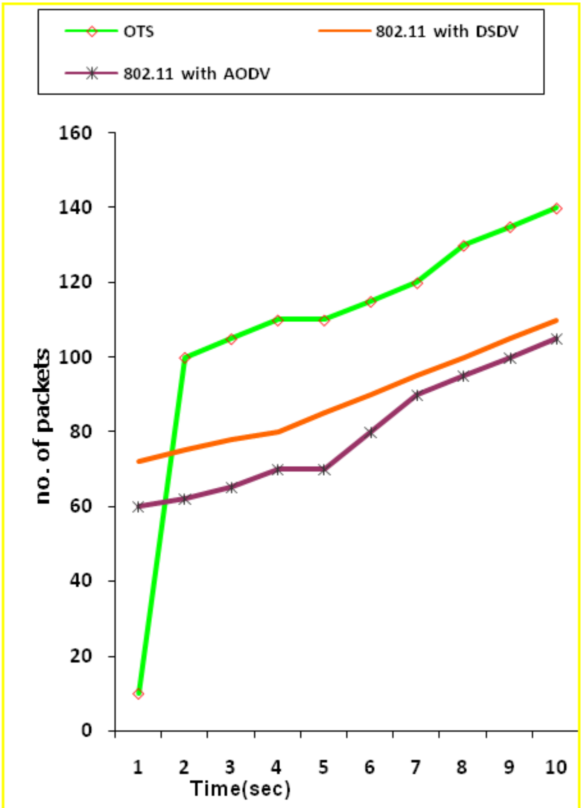

Fig 3: Traffic Sent comparison

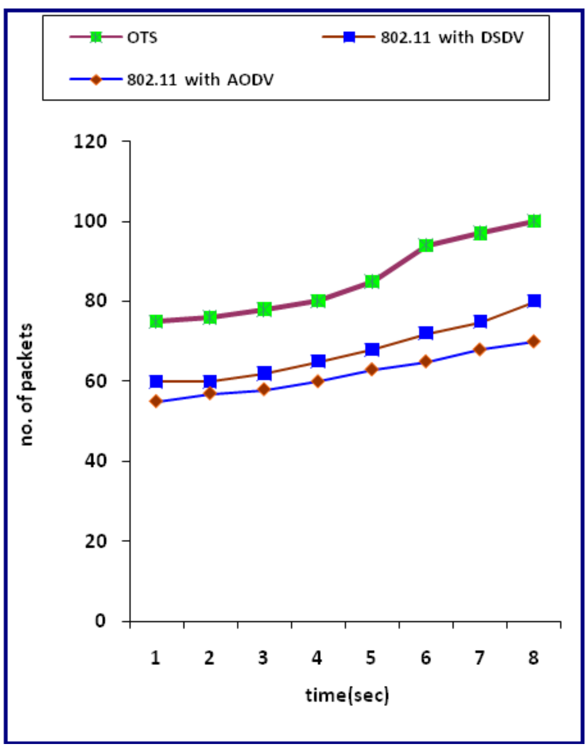

Fig4: Traffic Received comparisons

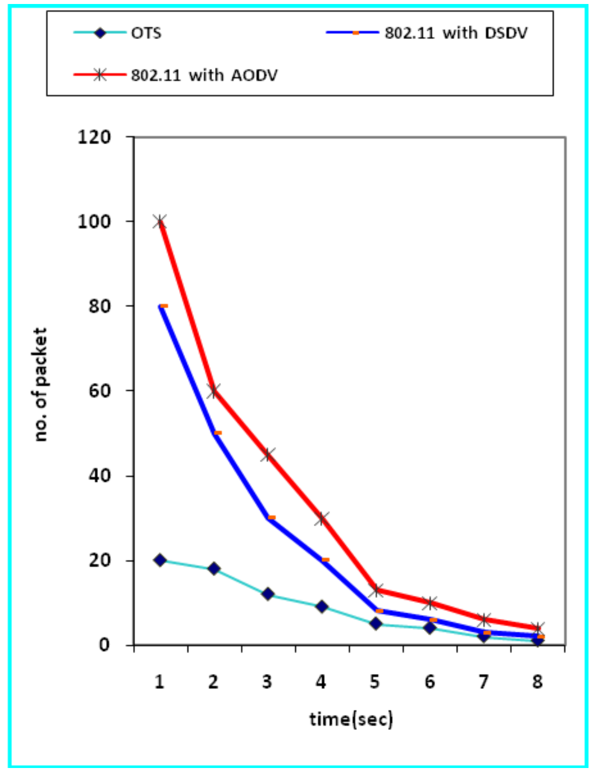

Fig 5: Data Dropped Comparisons

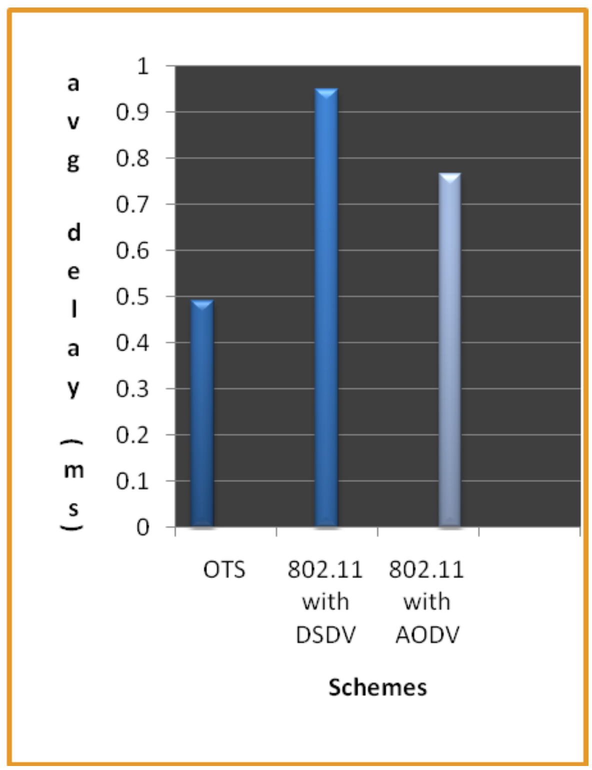

Fig 6: avg. delays in different schemes

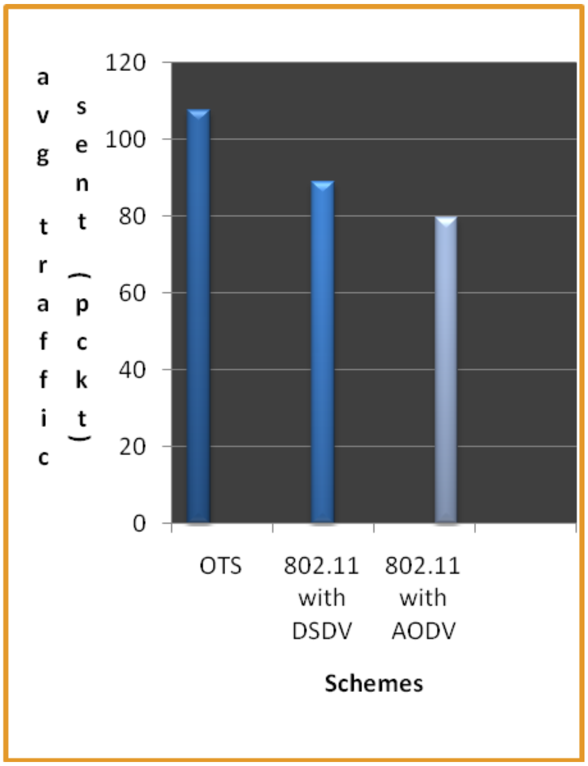

Fig 7: Avg. traffic sent comparisons

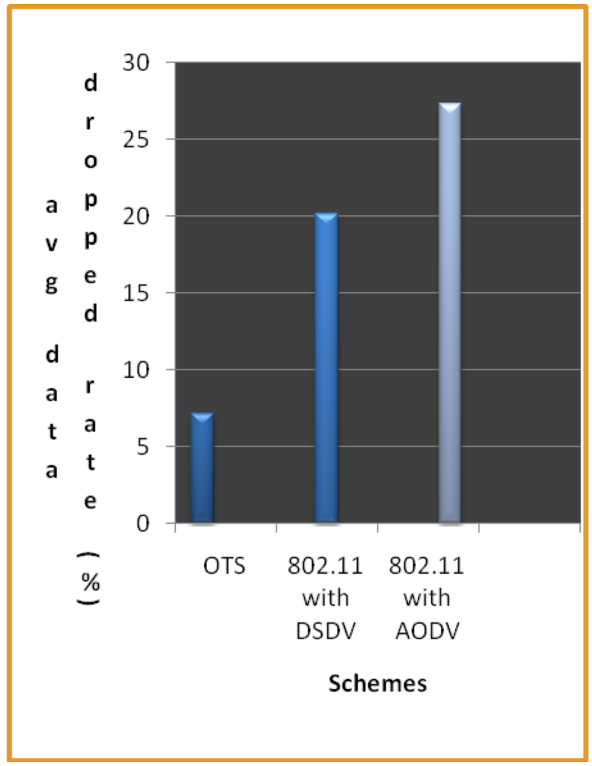

Fig 9: avg. data dropped in different schemes

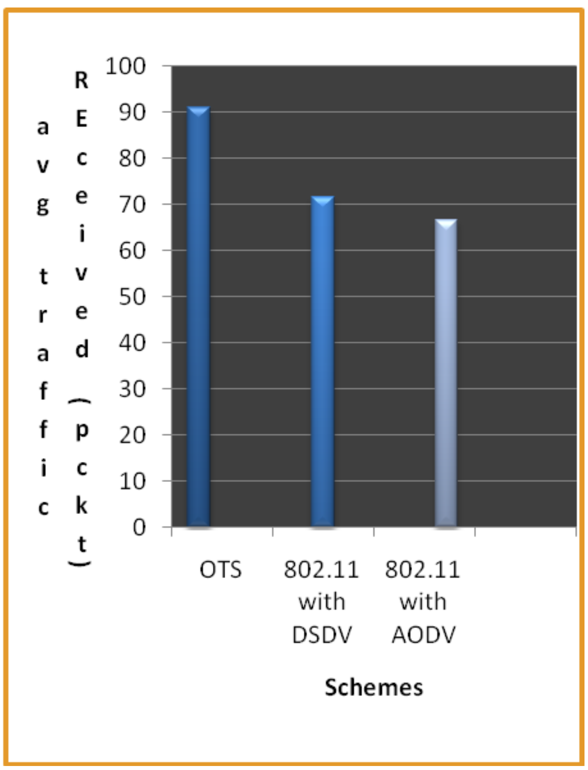

Fig 8: avg. traffic received comparisons

Time	**Delay(ms)**	**Traffic sent (pckt.)**	**Traffic received (pckt.)**	**Data dropped rate(%)**
1	0.2	20	75	20
2	0.3	100	76	18
3	0.3	105	78	12
4	0.4	110	80	9
5	0.5	110	85	5
6	0.6	115	94	4
7	0.6	120	97	2
8	0.6	130	100	1
9	0.7	135	110	0.5
10	0.7	140	115	0.1

Table 1: OTS scheme simulation results summary

VI. CONCLUSION AND FUTURE WORKS

The last decade has witnessed a growing interest in WSNs due to their unique potential in a wide range of environmental, scientific, and civilian applications. Sensor nodes are known to be untethered in terms of power and communication. While that is the key for enabling this bunch of applications, it brings several challenges in the hardware and software design of these sensor nodes. One of these challenges is the limited energy supply and, hence, the limited lifetime of these battery-operated devices. The multi-hop relaying, which is a direct result from the energy constraints, causes the energy expenditure to vary significantly over different parts of the network; nodes closer to the data collector do much more work and run out of energy much faster than other nodes. A promising solution to this problem is to employ multiple data collectors and to change their locations periodically to distribute the load evenly among different parts of the network. The work presented in this thesis strives to extend the network lifetime through exploiting mobile data collectors. In future, Current proposals for data collectors' placement suffer either a high computational complexity or a low performance in practice. A low complexity heuristic that is capable of finding good placements (rather than optimal ones) is missing. And also, it is assumed that the trajectory of the data collector is given. An interesting problem is finding a good trajectory given the data generation rates of sensor nodes and the routing protocol they are using. Sensor nodes send requests to the data collector to come and pick the delay-tolerant data rather than using a fixed trajectory for the data collector. In this case, a good route for the data collector to visit nodes which have sent data pick-up requests is needed.

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