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Handling Mobility using Virtual Grid in Static Wireless Sensor Networks

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Abstract**—**Querying a data source and routing data towards sink becomes a serious challenge in static wireless sensor networks if sink and/or data source are mobile. Many a times the event to be observed either moves or spreads across wide area making maintenance of continuous path between source and sink a challenge. Also, sink can move while query is being issued or data is on its way towards sink. In this paper, we extend our already proposed Grid Based Data Dissemination (GBDD) scheme which is a virtual grid based topology management scheme restricting impact of movement of sink(s) and event(s) to some specific cells of a grid. This obviates the need for frequent path modifications and hence maintains continuous flow of data while minimizing the network energy consumptions. Simulation experiments show significant improvements in network energy savings and average packet delay for a packet to reach at sink.

Keywords**—**Mobility in WSNs, virtual grid, GBDD, clustering.

I. INTRODUCTION

VARIOUS energy efficient data dissemination methods have been proposed over the years to reduce energy consumption in Wireless Sensor Networks (WSNs). The network topology used underneath hugely affects the performance of dissemination approach in terms of network overheads, delays and energy consumption etc. Based on network topology, various data routing schemes in WSNs can be categorized into two groups as flat and hierarchical. In flat routing schemes, no clustering is used and all query/data flow multi-hop from node to node with all nodes treated at same level. Directed Diffusion [1], SPIN [2] [3], Gradient Based Routing [4], EAR [5], MCFA [6] and Rumor Routing [7] are few among many routing schemes falling under flat category.

Hierarchical approaches convert entire sensor field into collection of small areas with nodes in each area forming a group or cluster. Organizing nodes in a WSN into groups or clusters provide some degree of modularity for network management by performing coordinated activities within a group or cluster. Clustering also helps in restricting flooding with in a cluster and hides topological details along with providing data aggregation points at cluster heads. TTDD [8], LEACH [9], PEGASIS [10], TEEN & APTEEN [11] and VGA [12] are few schemes representing this category. In the absence of unique node identifiers, forming clusters in WSNs is however not simple and many factors unique to WSN make it very complex task to accomplish. Sensor nodes (SNs) are highly vulnerable to failures due to energy drain, physical damage, environmental conditions, hardware/software malfunction etc.

Apart from these factors mobility of sink and event pose major challenge while developing a data dissemination scheme for WSN that uses some form of clustering. Multiplicity of sinks and events further complicates the path set up and data dissemination in a WSN. Various scenarios that emerge due to mobility and multiplicity of sinks/events in a WSN are: sink or event moves with in a region that is part of current cluster; sink or event slowly moves to different location that falls under different cluster; another sink or event appears at some different region of the network which falls under separate cluster and another sink or event appears in the same cluster.

Keeping above design questions in mind, we had proposed a scheme GBDD [13]. In present paper, we further extend the work with flowchart/pseudocdoe and strengthen with some new simulation experiments. Proposed scheme exploits dual radio modes of a sensor node (SN) to form a virtual grid across sensor field. Virtual grid helps in defining clusters, setting path between source-sink pairs and handling movement as well as multiplicity of sinks/events effectively. Based upon this grid and clustering, we develop methods for handling multiplicity and movements of sinks and events in the sensor field so as to ensure continuous data delivery from a source node to sink.

Rest of the paper is organized as follows. Section II describes the virtual grid construction strategy along with the path setup algorithm and handling of node failures. Section III gives method to handle the movement of event and sink. Section IV describes detailed performance evaluation of proposed scheme duly supported by simulation experimentation. Finally, section V concludes the work.

II. PROPOSED GRID BASED DATA DISSEMINATION APPROACH

A. Grid Construction

The immediate objectives of our proposed approach are to organize randomly deployed SNs in a sensor filed into clusters of suitable size by forming a virtual grid over entire sensor field; to exploit dual radio mode of a SN to decide size of the cell of a grid; and to handle the movement and multiplicity of sink(s) and event(s) for uninterrupted data delivery. The scheme is shown to handle sink and event mobility efficiently by partial path modifications and sharing. We here discuss the grid construction and path setup procedure with the help of flowchart and pseudocode respectively.

As shown in Fig. 1(flowchart) and Fig. 2, given its own coordinates (x, y) and α the size of a square sized cell of grid, sink calculates coordinates of four adjoining crossing points (CPs) of grid. As elaborated in [13], size of a cell is set such that its diagonal $d = R_H - R_L$ i.e side of a cell $\alpha = (R_H - R_L)/\sqrt{2}$, where R_H is high power radio range of a node and R_L is low

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Open Science Index, Computer and Information Engineering Vol:6, No:3, 2012 publications.waset.org/7582.pdf

power radio range of a node. Since α is taken much smaller than R_H, sink can transmit a signal in single hop up to any of crossing points (CPs) of grid. However, in practical scenario, there may not be a SN located exactly at the mathematically calculated CP (x_i, y_i). Therefore, a node nearest to CP is found and is designated as dissemination node (DN). Nearest SN to calculated CP is found using geographic greedy forwarding method [14]. Here, sink forwards grid formation message with coordinates of respective CPs in each of four directions. Finally, grid formation message stops at a node that has least distance to CP among all its neighbors. However, if distance D_L of this node from CP is less than or equal to half of low power radio range (i.e. $D_L <= R_L/2$), it is finalized as DN, otherwise node simply drops the message. This condition helps in terminating the grid formation process at the boundaries of sensor field by estimating that if nearest node is more than $R_L/2$ distant from new calculated CP than CP lies outside the actual nodes deployment area.

A cell of a grid is treated as one cluster with one of its four corner DNs selected as cluster head. Each SN in a cluster communicates directly in single hop with its cluster head. The selection of cluster head among its corner DNs is based on the direction of the sink who initiated the grid formation process.

SN in a cell receives grid formation message from every surrounding DN during geographic greedy forwarding process of grid construction. This message includes the coordinates of the new CP, coordinates of sink, as well as sender DN's coordinates. This enables nodes to know the direction of the sink with respect to its own coordinates. Thus, SNs in a cell select DN with minimum geographical distance to sink as their cluster head.

B. Path Setup

Immediately after grid formation, SNs which have event in their sensing range send path set up message M_{setup} to their cluster head DN called especially as Source Dissemination Node (SDN). If event is not yet present, no path setup takes place and this also prevents sink from unnecessarily issuing queries. Once event appears, SNs detecting it send path setup message M_{setup} to corresponding SDN as above. SDN forwards M_{setup} to its upstream DN i.e, DN towards sink. Note that all DNs gather information about upstream neighbor during grid formation process (i.e. out of its entire one hop DNs, it selects the one which is nearest to sink). Upstream DN also forwards it to its upstream DN and so on till M_{setup} reaches at sink. This sets up path for query and data flow between source and sink.

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After initial path set up, query is issued by the sink for required data item which flows DN to DN till it reaches a SDN. On receiving query message regarding certain type of data from SDN, each SN in the vicinity of the event senses the desired parameter and sends individual reading to its cluster head i.e. SDN. SDN aggregates readings to infer actual data item and forwards it towards sink.

III. HANDLING MOVEMENT

A. Handling Event Movement

When event location changes within a cell, the only change that occurs is in the nodes that sense event i.e. for some nodes event may go out of range and for few others it may come in their sensing range. Nodes having event in their sensing range become active (i.e. they wake up) and all other nodes remain in sleep mode. While SDN is to fetch data from sensing nodes, it broadcasts message in the cell for which it is a cluster head and all active nodes respond to it by sensing the required parameter and transmitting it back to SDN. Therefore, event movement within cell is automatically handled. When event crosses boundary of a cell and comes in the sensing range of a nodes in new cell, they become active and a path setup procedure is initiated.

Active nodes immediately transmit path setup message M_{setup} to their CHN which now becomes new SDN for the event in this cell. M_{setup} includes current values of all programmed parameters about the event. These parameters help DNs of new path (which may be the old SDN) and existing path to decide whether event is new or old event moved to new cell. If event moves to a cell whose one of corner nodes is old SDN or other DN on existing path and no other corner node is on data/query path, then it is used as new SDN.

Movement of event within a cell and to adjoining cells is effectively handled simply by checking the corner nodes of new cell. Any corner node already acting as SDN or is a DN on existing path is immediately appointed as SDN for new cell. Rest of the path to sink remains same as the old existing path. If none of the corner nodes of new cell is SDN or DN on existing path, then as discussed previously the closest DN to sink is appointed as new SDN and path setting towards sink follows until either sink is reached or existing path is intersected i.e. in case a corner node is found closet to sink and is already an active DN on existing path, then rest of the path to sink remains same as in existing path and path setup stops.

B. Handling Sink Movement

First sink initiates grid construction by taking its coordinates as first CP and accordingly other CPs of grid are calculated. In case of sink movement, a DN closest to its initial CP is elected as Immediate Dissemination Node (IDN). IDN takes over the responsibility of receiving query from sink and communicating data to it. While sink moves in any of four cells around CP,

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IDN can communicate with it in single hop and hence no extra path maintenance is required. However, out of these four cells some cell or cells may have their corner node or nodes (acting as intermediate DN(s)) on existing path. In such a case, DN closest to SDN is selected as new IDN for that sink and link to old upstream node towards old IDN is removed. In case sink moves to a cell none of whose corners DNs falls on existing path, a corner DN of that cell which is geographically closest to old IDN is selected as new IDN.

Once selected as new IDN, a further check is made to see whether this new IDN has only old IDN at one hop distance or does it also have any other DN on existing path including old FDN at one hop distance (FDN is the first DN on data/query path after IDN towards SDN). New IDN learns this neighbor node information from sink as sink retains coordinates of its previous IDN and previous FDN. If old IDN is the only node at one hop distance apart from new IDN, old IDN is made as FDN for new IDN and path completed. In case new IDN has old IDN as well as some other DN on existing path (may be old FDN) at one hop distance, it makes this DN as its FDN and thus modifies path at this DN by changing upstream pointer to point to new IDN and thus completes path. Complete procedure for handling event movement and sink movement along with example is illustrated in our previous paper [13].

C. Handling DN Failure and Grid Lifetime

DN failures are handled by creating Alternate Dissemination Zone (ADZ) around a DN as shown in Fig. 2. To form ADZ around a DN, DN broadcasts a dummy message using low power radio within a region of radius $R_L/2$ from it. Each node in this region broadcasts a tuple comprising its own coordinates (id) and residue energy using low power radio. Hence, each node in zone hears a small tuple from every other node in ADZ. Accordingly, each node in ADZ including DN creates an indexed list of node-ids in descending order of residue energy. Each time an alternate DN is to be selected, it selects a node from indexed list in sequence from top i.e. node with highest residue energy. Proposed grid construction mechanism is such that irrespective of the location of new DN in ADZ, it always will remain in one hop transmission range from all its neighboring DNs and thus listens to their transmissions without any change.

Point to be noted here is that the ADZ once formed remain static and do not change with the selection of alternate DN. If new DN is made center of zone by forming new ADZ, symmetry of grid/DNs will be disturbed and situation may arise where adjoining zones drifts away from each other such that their DNs are not able to communicate directly in single hop. Also, new DN already posses indexed list of nodes in ADZ as above and it simply deletes the entry of the DN from which it has taken over.

GBDD scheme assumes that sink knows in advance the approximate period of observation, which apart from other factors hugely depends on the nature of event to be monitored. Since it is sink that triggers grid construction, therefore grid setup message includes grid lifetime value in it. Grid setup message when traverses from DN to DN provides sufficient knowledge for them regarding the time span during which present grid is valid and which is kept alive for sufficiently long period so that multiple sinks can share it without the need for new grid construction.

IV. PERFORMANCE EVALUATION

In this section, we evaluate the performance of proposed GBDD approach. We first define simulation parameters and performance metrics. We then see the effect of various factors like number of sinks, number of sources and sink movement on the performance of GDDD and compare it with TTDD.

A. Simulation Parameters

We consider a flat and square sized two dimensional sensor field of size $2000\times2000\text{m}^2$ in which 200 SNs are randomly generated and deployed. All nodes are homogeneous and each one has onboard dual mode radio i.e. high power radio and low power radio. Power parameters for high power radio are kept same as used in TTDD. This is done to compare the performance of proposed scheme with TTDD which only uses one type of radio, called high power radio here. Accordingly, values of SN’s power parameters in high power mode are set as: transmitting power=0.66W, receiving power=0.395W and idling power=0.035W. However, apart from high power radio, proposed GBDD uses additional low power radio onboard. Power consumption for transmitting per bit by low power radio is much less than high power radio. For example, 802.11g consumes 112 nJ/bit as opposed to 979 nJ/bit for higher power 802.15.4. This implies that low power radio 802.11g consumes approximately 10 times less energy than high power radio 802.15.4 [15]. For simplicity of analysis, we take this approximation to scale down power consumption by high power radio by a factor of 10 to set power parameters for low power radio onboard on each SN. Accordingly, power parameters for low power radio are set as: transmitting power=0.066W, receiving power=0.0395W and idling power=0.0035W.Node is assumed capable to transmit up to 100m (R_H) while in high power radio mode and upto 25m (R_L) in low power radio mode. Therefore, according to grid construction mechanism in GBDD, the diagonal of a square sized cell is set to 75m. SN changes its transmission power accordingly while switching between high power and low power radio mode.

Links between nodes are considered bidirectional and symmetric i.e. if node A can hear from node B, then node B is also expected to hear from node A. All nodes have same transmission range(s) and there is a link between two nodes if the distance between them is less or equal to high power radio range R_H. This attributes to the fact that low power radio is used only for network management activities like formation of zone ADZ, receiving and maintaining tuples comprising information about residue energy in nodes within ADZ etc, whereas it is high power radio which is responsible for communicating queries and data among nodes. Each query packet used is 36 bytes and each data packet has 64 bytes.

Each node knows its geographical coordinates using low-cost, low-power GPS or other localization algorithms. For simulation purpose coordinates (x,y) within the specified boundaries of sensor field are randomly generated and assigned to nodes during deployment. Each simulation run lasts for 200 seconds. Table I summarizes simulation parameters.

B. Performance Metrics

Following two performance metrics are used to evaluate performance of proposed grid construction and data dissemination scheme.

Overall energy consumption is the first performance metric used and is the energy consumed by all nodes in transmitting and receiving queries and data. This includes energy consumed by DNs on data/query path from SDN to IDN for a particular sink plus energy consumed by active nodes in sensing and transmitting readings to SDN added across all sink-source pairs. Like TTDD, energy consumed by nodes while in idle state is not however included as it does not reflect energy consumed in data packets retrieval.

Average packet delay is another metric used and is defined as the average time between the moments a SDN transmits a packet and the moment a sink receives the packet, averaged across all source–sink pairs. Actually this metric represents average packet delay for packets emanating from all active nodes towards destined sink or sinks in response to a query or queries from that sink.

C. Effect of Number of Sources and Sinks on Overall Energy Savings

Fig. 4(a) and Fig. 4(b) shows overall energy consumption when GBDD and TTDD are respectively used. For comparison, Fig. 4(c) combines both of these results in the form of bar graph. Initially only one event (thereof only one SDN corresponding to that event) is generated in sensor field and number of sinks interested in data about that event are incrementally varied from 1 to 8 in steps of 2. With each different number of sinks, the set up is run for entire simulation period and overall energy consumed by the network is computed. Simulation is then repeated in similar manner each time with different number of sources varied from 1 to 8 in steps of 2 and overall energy is computed after each run. Sinks and events are allowed to move randomly with a maximum speed of 10 m/s. These all simulation runs are repeated for both proposed GBDD and TTDD. Energy consumptions in both schemes are shown in separate graphs to avoid cluttering.

In each approach, overall energy consumption by network increases as number of sinks increase for a given number of sources. Also, as evident from these graphs, overall energy consumption further increases with increasing number of sources. When averaged across all source-sink pairs in each approach, GBDD shows up to 43% overall energy savings as compared to TTDD.

D. Effect of Number of Sources and Sinks on Delay

Similar to computation of overall energy consumed by the network for all simulation runs calculated previously, average packet delay is also computed. Fig. 5(a) shows the impact of varying number of sources and sinks on average packet delay when GBDD is used and Fig. 5(b) shows average packet delay when TTDD is used. For comparison, energy consumption in both cases is plotted in a single bar graph as per Fig. 5(c). Results show that GBDD incurs smaller average packet delay as compared to TTDD. This attributes to the fact that unlike TTDD, in GBDD wherever possible a data packet follows diagonal path right from SDN towards sink if sink's position is quite away from it and not in straight line with its cell side.

If event is in straight or approximate straight line with SDN's cell side, then path is eventually shortest path (not diagonal) as communication between adjacent DNs is direct in single hop.

GBDD shows 30% improvement in average delay computed across all source-sink pairs for a data packet to reach from SDN to sink.

TABLE I
SIMULATION PARAMETERS

Parameter	Value
Size of sensor field	2000 x 2000 m^2
Total number of SNs	200
High power radio transmission range	100*m*
Low power radio transmission range	25*m*
Diagonal of square sized cell of grid (*d*)	75*m* (α=75/√2m)
Transmitting power of primary radio of a node (high power mode)	0.66*W*
Receiving power of primary radio of a node (high power mode)	0.395*W*
Idling power of primary radio of a node (high power mode)	0.035*W*
Transmitting power of secondary radio of a node (low power mode)	0.066*W*
Receiving power of secondary radio of a node (low power mode)	0.0395*W*
Idling power of secondary radio of a node (low power mode)	0.0035*W*
MAC protocol	802.11
Query message size	36 *bytes*
Data packet size	64 *bytes*
Simulation period	200 *seconds*

E. Effect of Sink Speed on Overall Energy Consumed

In many situations sinks are either in direct control of WSN user or if not in direct control can be accessed or relocated, whereas, appearance and disappearance of events are unpredictable in sensor field. For example, nodes with soldiers acting as sinks can be placed or moved strategically at certain locations in battlefield to collect useful data about enemy tanks entering in it. Therefore, we study the impact of sink speed keeping events' behaviour same as in earlier simulations (i.e. maximum speed 10m/s).

Sink speed is varied from 1 to 20m/s. Also, in most scenarios, numbers of sinks are always relatively smaller than SDNs.

Hence, we keep numbers of sinks 2 and numbers of SDNs as 8. Fig. 6(a) shows overall energy consumed with varying sink speed. For low sink speed GBDD consumes less energy as compared to TTDD, but when the speed is very high, GBDD however consumes more energy.

This is due to the reason that as sink moves fast, it crosses boundary of a cell more frequently. Since the size of a cell in GBDD is much smaller than cell used in TTDD, cells changed per unit time in GBDD are more. Hence, more number of times sink has to find new IDN which further resolves either to link with old IDN or some other DN on path closer to it.

F. Effect of Sink Speed on Overall Average Packet Delay

With the same setup as given in previous section, average packet delays are also computed for varying sink speeds. Fig. 6(b) shows the results when setup is run both for GBDD and TTDD separately. In case of lower sink speeds, average packet delay for GBDD is smaller than in TTDD which is again due to the same reason (i.e. shorter path shorter path) as given in previous section. However, at higher speeds due to smaller cell size in GBDD, sink crosses boundary of a cell and enters into new adjoining cell more frequently than in TTDD.

It takes time to appoint new IDN for sink and to set path from this new IDN to SDN(s) from where it requires data. Path can be set by reconnecting to existing (old) path from new IDN and by sharing it or by setting new path (if sharing is not possible). This introduces delay due to path set up time and even at existing IDN packet has to wait before it is delivered to sink through new IDN. Hence, as sink moves more randomly, GBDD starts introducing slightly higher delays in packet delivery to sink and hence more average packet delay.

V. CONCLUSIONS

Tedious and energy consuming process of handling movement of event and sink is simplified and made more energy efficient by using a virtual grid across sensor field. GBDD exploits location awareness and virtual grid structure to designate certain nodes as dissemination nodes only few of which need to be active to provide an optimal path between a source-sink pair. Movement of event or sink to new location does not necessarily warrant path setup every time. Instead, for most of the time either movement is free from path modification or partial modification is required and very infrequently new path setup is required.

In GBDD, first sink appearing in the sensor field triggers grid construction with sufficiently large lifetime and once constructed is utilized by all other sinks appearing during valid period of that grid. Sink constructs new grid only when no valid grid is present. Unlike TTDD, new events appearing in the sensor field do not trigger grid construction, rather it utilizes existing grid.

Movement and multiplicity of sinks and events is efficiently managed through local message passing and path sharing.

Simulation results reveal that GBDD gives significant improvements in overall energy savings compared to TTDD.

Also, for slow sink movements GBDD gives smaller average packet delay than TTDD. However, for higher sink speeds slightly more packet delay is introduced in GBDD than in TTDD.

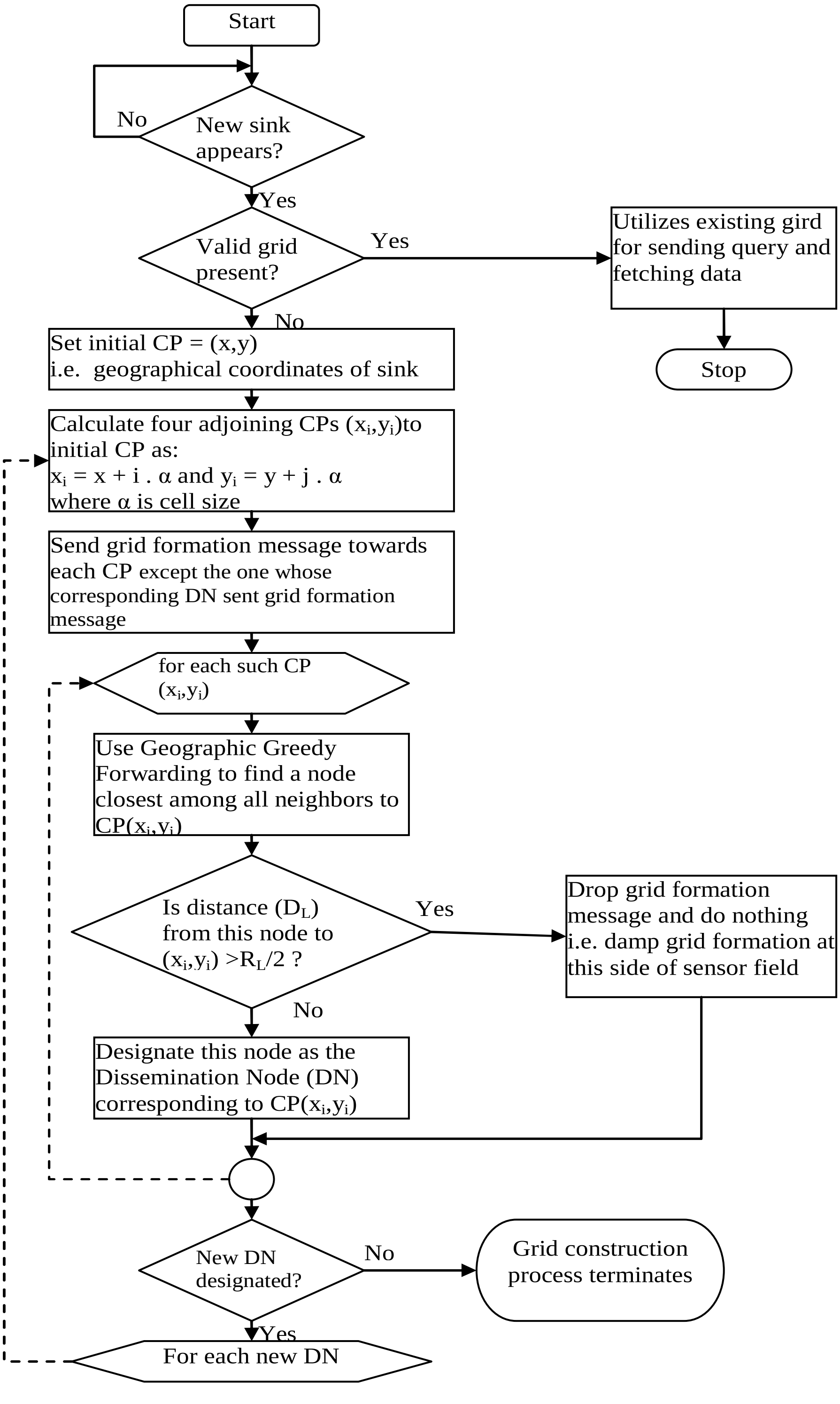

Fig. 1 Grid Construction Flowchart

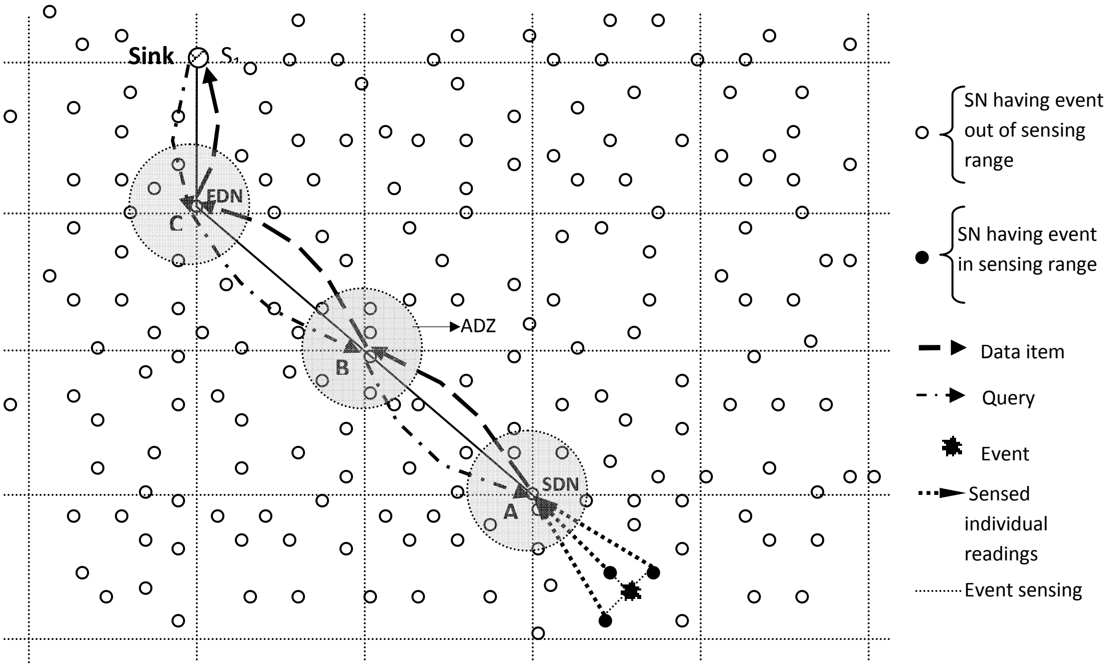

Fig. 2 Setting Query and Data Flow Path

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Algorithm

1.      Until (Event is not Detected)
        i.   SNs remain passive but awakened to observe appearance of an event
        ii.  No path setup is initiated
             // Unnecessary path setup avoided

2.  for (each SN having event in its sensing range)
             //Event appears

        i.   Activate itself to sense the event
        ii.  Send $M_{setup}$ (a path setup message) to its cluster head called SDN
3.  if (this is not the first $M_{setup}$ message received at SDN from any of nodes
    from current cell and a path between SDN-sink pair already exists)
        i.   Send acknowledgement message conveying existence of path and do nothing
             // Path has already been set

4.  else repeat {
        i.   Using high power radio, DN (SDN in first step) broadcasts $M_{setup}$
             message comprising GPS coordinates of its upstream DN towards
             sink (about which it has learned during virtual grid formation) and
             also its own coordinates.
        ii.  Neighboring DN having coordinates as in $M_{setup}$ only receives this
             message and others ignore it.
        iii. Upstream DN sets pointer towards downstream DN by
             memorizing its coordinates also found in $M_{setup}$.}
             until (sink is discovered)

5.  Send acknowledgement of path setup from sink to SDN following
    downstream pointers at each DN including sink.
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Fig. 3 Setting query/data path between event and sink

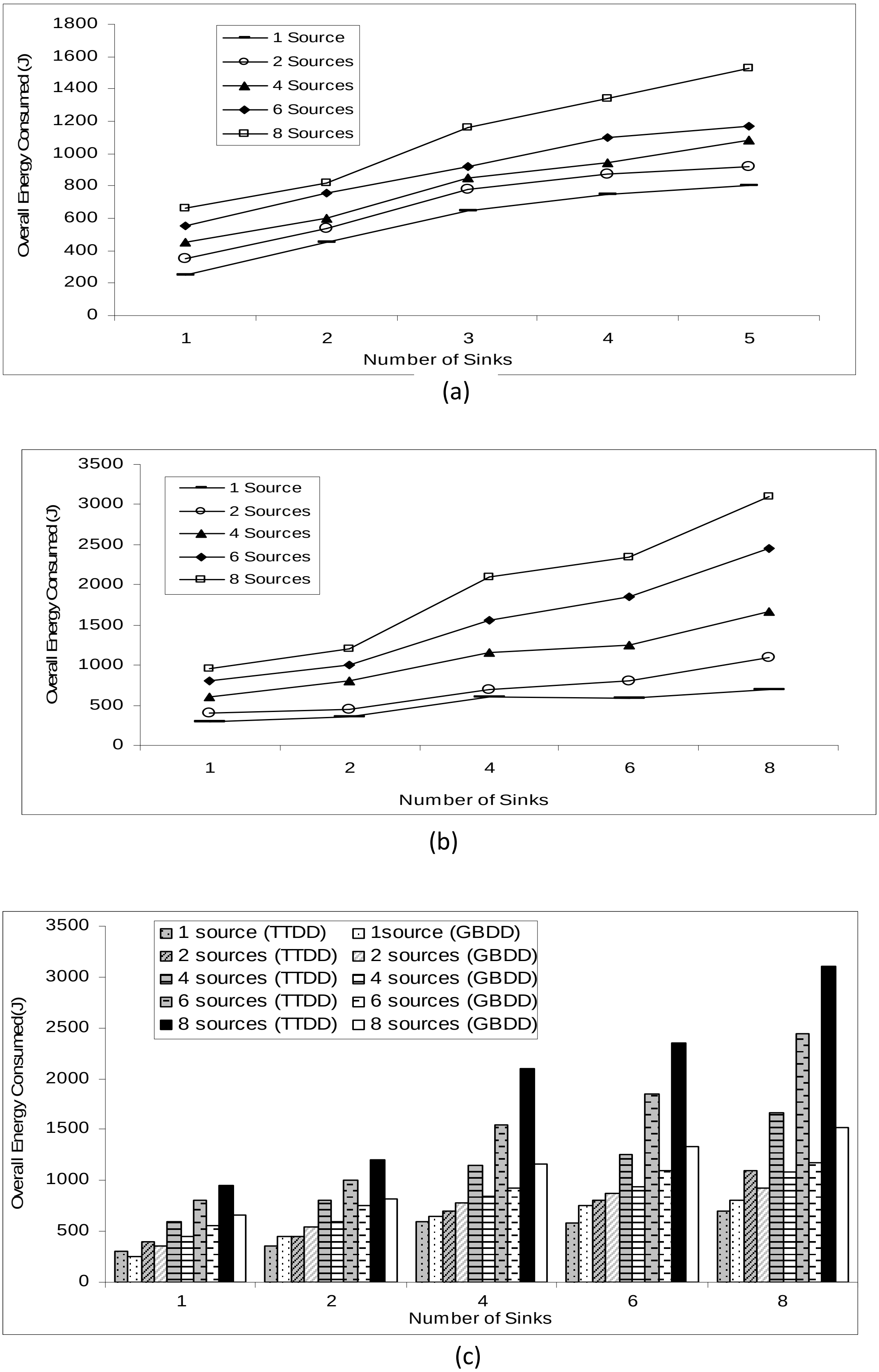
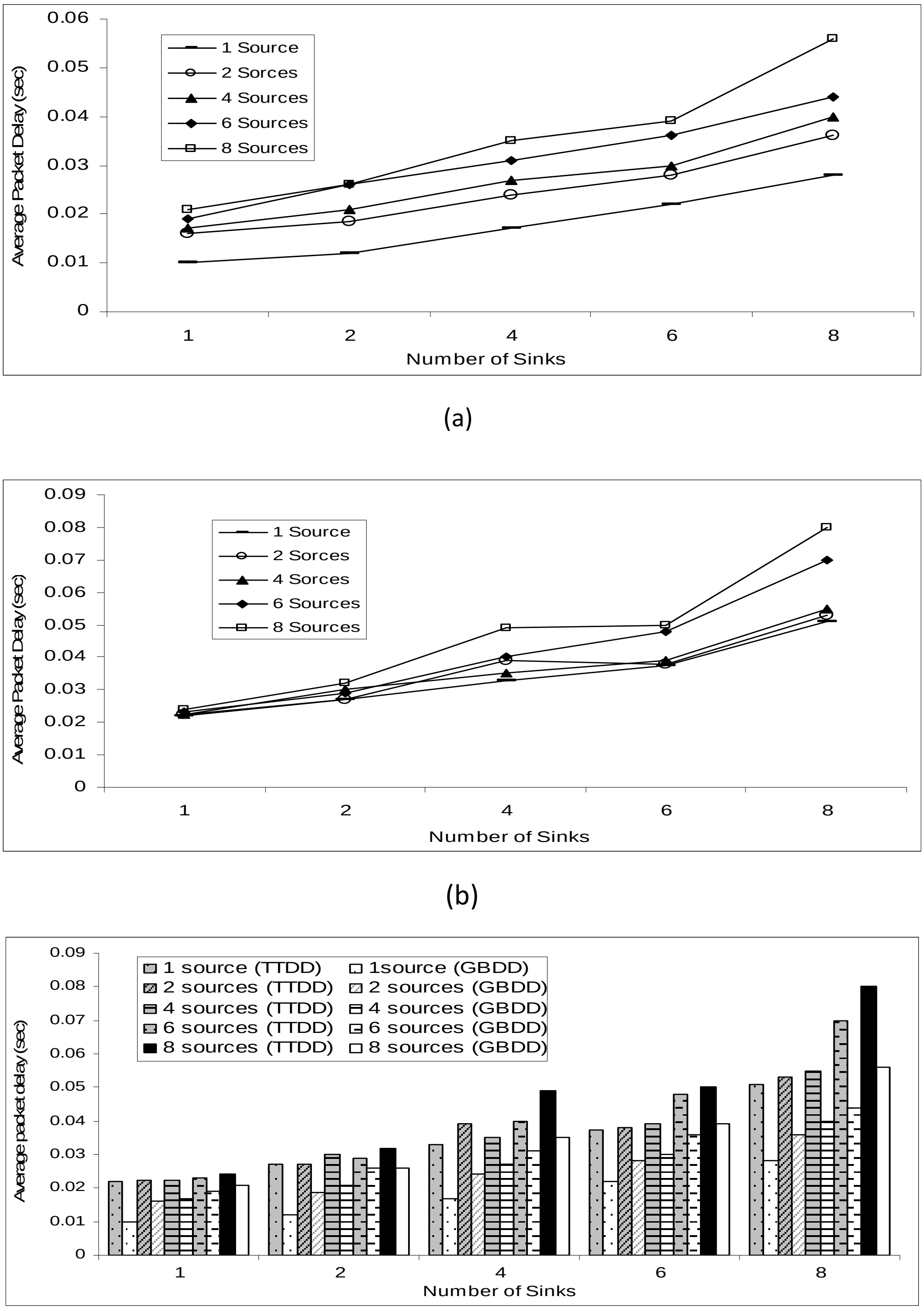


Fig. 4 Effect of numbers of sinks on overall energy consumption with varying numbers of sources using GBDD, GBDD and Comparison of overall energy consumed using GBDD and TTDD with varying sources and sinks



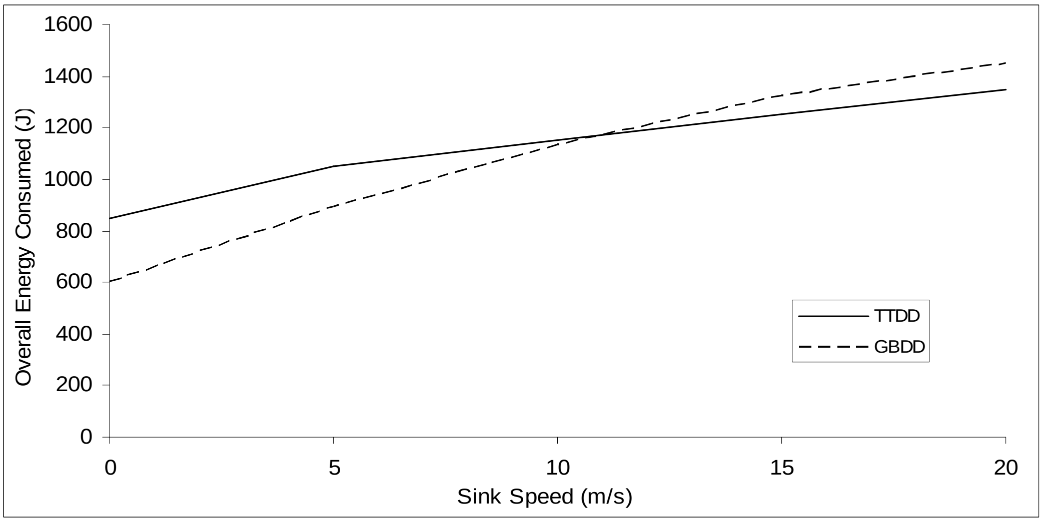
(a)

(b)

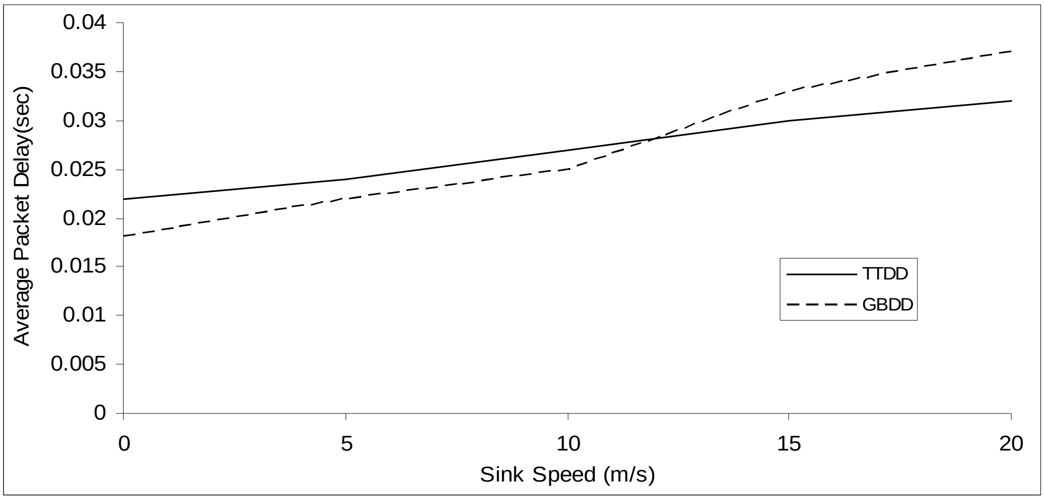
(c)

Fig. 5 Effect of number of sources and sinks on average delay using GBDD, TTDD and comparison of average delays introduced by GBDD and TTDD

Open Science Index, Computer and Information Engineering Vol:6, No:3, 2012 publications.waset.org/7582.pdf



(a)



(b)

Fig. 6 Overall energy consumed and average packet delay with varying sink speed

REFERENCES

[1] C. Intanagonwiwat, R. Govindan, D. Estrin, J. Heidemann and F. Silva, “Directed Diffusion for Wireless Sensor Networking,” *IEEE/ACM Transactions on Networking*, vol. 11, No. 1, pp. 2 – 16, February 2003.
[2] W. Heinzelman, J. Kulik and H. Balakrishnan, “Adaptive Protocols for Information Dissemination in Wireless Sensor Networks,” in *Proc. 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom_99)*, pp. 174–185, August 1999.
[3] J. Kulik, W.R. Heinzelman and H. Balakrishnan, “Negotiation-Based Protocols for Disseminating Information in Wireless Sensor Networks,” *Wireless Networks,* vol. 8, no. 2/3, pp. 169–85, 2002.
[4] C. Schurgers and M.B. Srivastava, “Energy Efficient Routing in Wireless Sensor Networks,” *IEEE Communications for Network-Centric Operations: Creating the Information Force (MILCOM),* vol. 1, pp. 357-361, 2001.
[5] R. Shah and J. Rabaey, “Energy Aware Routing for Low Energy Ad Hoc Sensor Networks,” in *Proc. IEEE Wireless Communications and Networking Conference (WCNC),* vol. 1, pp. 350-355, March 2002.
[6] F. Ye, A. Chen, S. Lu, L. Zhang, “A Scalable Solution to Minimum Cost Forwarding in Large Sensor Networks,” in *Proc. 10th International. Conference on Computer Communication and Networks,* pp. 304–09, 2001.
[7] D. Braginsky and D. Estrin, “Rumor Routing Algorithm for Sensor Networks,” in *Proc. of the First ACM Workshop on Sensor Networks and Applications (WSNA)*, pp. 22-31, October 2002.
[8] H. Luo, F. Ye, J. Cheng, S. Lu and L. Zhang, “TTDD: Two-Tier Data Dissemination in Large-Scale Wireless Sensor Networks”, *Kluwer Academic Publishers’ Wireless Networks,* vol. 11, no. ½, pp. 161-175, January 2005.
[9] W.B. Heinzelman, A.P. Chandrakasan and H. Balakrishnan, “Application Specific Protocol Architecture for Wireless Microsensor Networks,” *IEEE Transactions on Wireless Communications,* vol. 1, no. 4, pp. 660-670, 2002.
[10] S. Lindsey and C.S. Raghavendra, “PEGASIS: Power Efficient Gathering in Sensor Information Systems,” in *Proc. IEEE Aerospace Conference,* vol. 3, pp. 1125-1130, March 2002.
[11] A. Manjeshwar and D.P. Agarwal, “TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks,” in *Proc. 15th International Parallel and Distributed Processing Symposium,* pp. 2009-2015, April 2001.
[12] J.N. Al-Karaki and A.E. Kamal, “End-to-End Support for Statistical Quality of Service in Heterogeneous Mobile Ad Hoc Networks,” *Computer Communications*, vol. 28, no. 18, pp. 2119-2132, Nov. 2005.
[13] T.P. Sharma, R.C. Joshi, Manoj Misra, “GBDD: Grid Based Data Dissemination in Wireless Sensor Networks,” in *Proc. ACS International Conference on Advanced Computing and Communication (ADCOM 08),* Chennai, pp.234-240, 14-17 December 2008.
[14] Z. Jiang, J. Ma, W. Lou and J. Wu, “An Information Model for Geographic Greedy Forwarding in Wireless Ad-Hoc Sensor Networks,” in *Proc. 27th IEEE conference on Computer Communications (INFOCOM 2008),* pp. 825-833, April 2008.
[15] D. McIntire, K.H. Hing, B. Yip, A. Singh, W. Wu and W. Kaiser, “The Low Power Energy Aware Processing (LEAP) System,” in *Proc. 5th International Conference on Information processing in sensor networks*, pp. 449-457, April 2006.

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