International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Load Balanced Algorithm for Location Based Routing Around Dead Nodes in Wireless Sensor Networks

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Abstract: ***Adaptive load balancing algorithm is a protocol for converge casting in wireless sensor networks.Converge casting is the process of collection of data information in the network towards the base station. ALBA-R features the cross-layer integration of geographic routing with contention-based MAC for, relay selection and load balancing (ALBA), as well as a mechanism to detect and route around dead node. ALBA and Rainbow (ALBA-R) together solve the problem of routing around a dead end without overhead-intensive techniques such as graph planarization and face routing. The protocol is localized and distributed, and adapts efficiently to varying traffic and node deployments. Through extensive ns2 based simulations, we show that ALBA-R significantly outperforms other converge casting protocols and solutions for dealing with dead nodes, especially in critical traffic conditions and low-density networks. Our results show that ALBA-R is an energy-efficient protocol that achieves remarkable performance in terms of packet delivery ratio and end-to-end latency in different scenarios, thus being suitable for real network deployments.***

Keywords: Wireless sensor network; converge casting; geographic routing; graph planarization; face routing

1. Introduction

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

Many researches happening on protocol design for WSNs has focused on MAC relay selection and routing solutions. An important class of protocols is represents geographic or location based routing schemes, where a relay is greedily chosen based on the advancement it provides towards the destination.

Many geographic routing schemes fails fully address important design challenges, including 1.efficient relay selection, 2.routing around dead nodes, and 3.resilience to localization errors. Dead nodes are inherently related to the greedy forwarding mechanism even these are fully connected topology these are fully connected topology these may exist nodes (called as connectivity holes)these that they have no neighbors that provides packet advancement towards the destination (the sink). The busy node and dead ends are unable to forward the packet to the sink and the packets get discarded. Many of the protocols have been proposed to alleviate the impact of dead nodes, but these are fails in the energy efficiency, packet delivery ratio (PDR) and end-to-end delay. In this paper we present a new approach to route the packet routing around dead ends that works in any connected topology without overhead occurs based on topology planarization. The proposed protocol is named as ALBA (Adaptive load balancing algorithm) whose main approach is based on geographic routing , contention based relay selection and load balancing are blended with to route packet out and around dead nodes. The combination of ALBA and Rainbow called as ALBA-R these results the converge casting in WSNs. This paper contributes the WSN research this includes the following:

1) The geographic forwarding happens by consideration of congestion nodes to making routing decisions .This protocol achieves the performance in packet delivery ratio (PDR), latency, and energy efficiency.
2) Energy efficient load balancing algorithm uses the rainbow mechanism in WSN to route the packets around dead ends and guarantees the packet delivery efficiently. The metrics

of packet delivery ratio and latency are investigated through experiment by using 40 sensor nodes. This is done by using ns-2 based simulations. ALBA-R shows that it is the superiority with respect to previous geographic and topology based on converge casting.

3) Using NS2 based simulation the work further enhanced to reduce the energy consumption when increase in the load intensity, the data packets is transmitted successfully form source to sink node within a short period of time. The simulated result shows that modified ALBA-R protocol is an energy efficient protocol.

2. Related Work

A number of ideas have been proposed to address the problem of routing around dead nodes. Geographic routing over planarized WSNs is then obtained by employing greedy routing as long as possible, resorting to planar routing only when required, for example, to get around dead nodes. Heuristic rules are then defined for returning to greedy forwarding as soon as next-hop relays can be found greedily. Solutions based on planarization have several drawbacks. First of all, a spanner graph of the network topology needs to be built (and maintained in the presence of node dynamics), and this incurs nonnegligible overhead. Planar routing may then require the exploration of large spanners before being able to switch back to the more efficient greedy forwarding, thus imposing higher latencies. Moreover, in realistic settings, localization errors and Non ideal signal propagation may lead to disconnected planar graphs or to topology graphs that are nonplanar. This is because spanner formation protocols assume that the network topology is modeled by a UDG, and the correctness of the approach cannot be guaranteed when this is not the case, as in most realistic situations. To make planarization work on real networks, a form of periodic signaling must be implemented to check that no links cross, as performed by the Cross-Link Detection Protocol (CLDP). However, this is a transmission intense solution for WSNs, which eventually affects the network performance. A different class of solutions for handling dead ends is based on embedding the network topology into coordinate spaces that decrease the probability of dead nodes. The GERAF and IRIS protocol are designed for converge casting in wireless sensor network. But these protocols are fails to achieve the performance in packet delivery ratio, end to end delay and energy efficiency. The ALBA-R protocol is designed to avoid the packet dropping around dead end or busy node. This proposed protocol achieves the better performance in packet delivery ratio and energy consumption when compared to IRIS and GERAF protocol. But this protocol requires more time to transmit packet from source to destination without packet dropping.

3. Proposed Algorithm

3.1 Computation of QPI and GPI Values

In this paper we proposed ALBA protocol, it is a cross layer solution for converge casting in WSNs that integrates awake/asleep schedules, routing and traffic load balancing takes place in the case of back to back packet transmission. Data packet transmission happens when the sender broadcast the request to send (RTS) packet to its neighbor nodes, the available neighbor nodes respond the clear to send (CTS) packet to the sender this is used for best relay selection. This relay selection is good for efficient transmission of data packet. This relay selection depends on the two parameters: Geographic priority index (GPI) and queue priority index (QPI). The GPI is the distance between the nodes it is calculated by using the formula is

$$GPI=\sqrt{((x2-x1)2+(y2-y1)^2)}$$

Where, X2= node 2 distance in x direction, X1= node 1 distance in x direction, Y2= node 2 distance in y direction, Y1= node 1 distance in y direction. The QPI value is calculated by using the formula is

$$QPI= \{(Q+Nb)/M\}$$

Where, Nb= Requested number of packets to be transmitted back to back, Q=Total number of packets in the queue of an eligible relay, M= The average number of packets it was able to transmit back to back without errors.

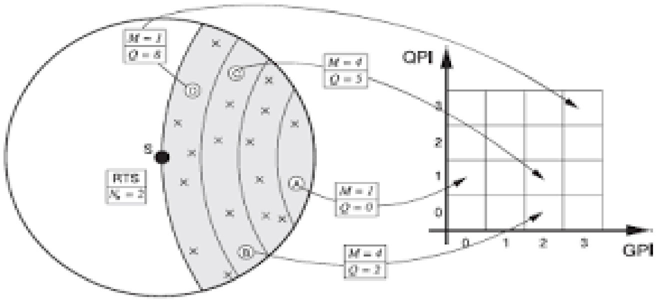


Figure 1: Computation of QPI and GPI Values

The figure 1 shows the computation of QPI and GPI value. The white circles represent the awake and asleep mode. The black color represents the source node and arcs represent the GPI region centered at sink. The gray color represents the forwarding area. The source node is denoted as S it wants to send a 2 packets that is NB=2. Among awake node A has empty queue with bad forwarders records M=1 hence QPI becomes 2. Nodes B and C has same M=4, B contains smaller queue hence QPI is 1 and C becomes 2. The sender has sense the channel with low QPI value.

In ALBA protocol source node broadcast the RTS for eligible forwarders to calculate their QPI and GPI values and it inviting answer from the node whose QPI is 1. The RTS having complete information required for relay to calculate their QPI and GPI values, that is location of the source and sink node, and requested number of data packet transmitted in a burst NB. The source node broadcast first RTS with QPI1 only nodes which has QPI is 1 they are allowed to answer with CTS packet to the source node. If anyone node answer with CTS packet immediately the data packet sent to the destination, and source node gets the ACK from the sink. If no node answering for first RTS packet with QPI 1 and source node broadcast other RTS packet with higher QPI. If in the case two are more node respond with same requested

QPI then it's broken via GPI. According to GPI value the best node is selected by broadcasting new RTS packet calling the answer from node whose GPI is 0 and it provide the high advancement. If no node find awake with GPI value 0, the source node broadcasting the RTS packet with higher GPI value. If in the case the multiple nodes are replying with same (QPI, GPI) values they are broken according to the binary splitting tree collision mechanism.

Figure 2 shows that source node broadcast the RTS packet with QPI 1, only node C is in awake mode with QPI value 1 and all other neighbor nodes are in asleep state. Node C replies to source node S with the CTS packet and it select the relay. The node S sends the data packet to the node C, after receiving the data packet at node C it sends the ACK to the source node. The node C is in asleep mode all other nodes are in awake mode. The node S broadcast the RTS packet with QPI 1, no node answer for the first RTS because no node with QPI 1. The node S broadcast second RTS packet with QPI 2, the node A and B both answered with CTS packet for the second RTS. In this case the GPI computation takes place to choose the best relay. The node S again broadcast the RTS packet with QPI 2 and GPI 1, the node A responds with CTS packet for GPI After choose the best relay node S sends the burst of data packets to the destination node A and it is acknowledged individually. If the ACK for any one of the packet is missing, the node S stops the data packet transmission of the burst, rescheduling the unacknowledged packet in the burst. In this ALBA handshake we observed that one or more forwarders answer for the same RTS, the GPI value used for the best relay selection. The relay selection fails only in the case of no node with any QPI found and the nodes which as the same QPI and GPI values this is not resolved with a maximum number of attempts. In both the situation causes the sender to back off. The packet get discarded when the sender back off more than NBoff times.

Let us assume that node B is awake and that it is the only available relay whose QPI is 1 after the first RTS (upper part of Fig. 2; all other neighbors are asleep). Node B replies to S with a CTS and is selected as a relay. In the case when B is asleep (lower part of Fig. 2), only A, C, and D would be available. In this case, no node with QPI equal to 1 exists, so that the first RTS is not answered. Both A and C answer the second RTS, as both have the QPI equal to 2. The second phase (best GPI search) is then started, which terminates with the selection of node A, whose GPI is equal to 0. Once a relay is selected, a burst of data packets is sent (as many as the relay can queue, up to NB), and each packet is individually acknowledged.2 If the ACK for one of the packets is missing, the sender stops the transmission of the burst, rescheduling the unacknowledged packet and the following ones in the burst for a later time, after a back off period.

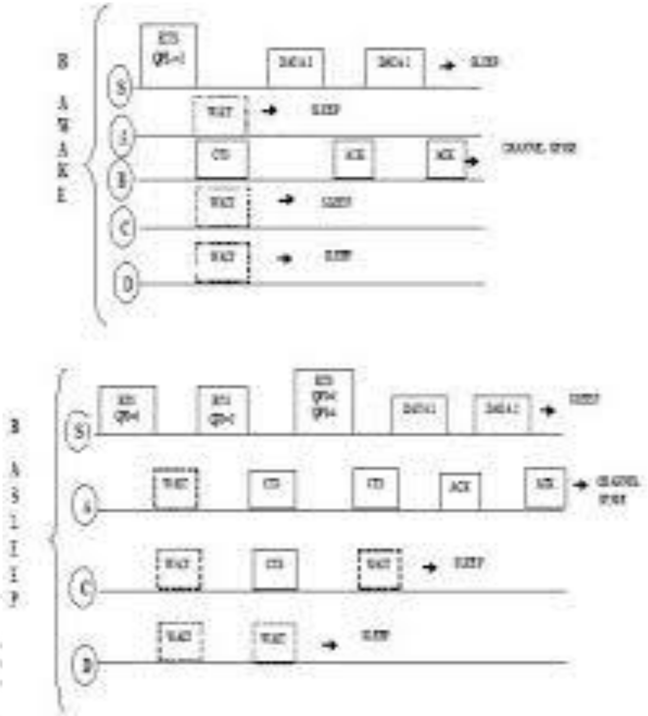


Figure 2: ALBA Hand shakes

The sender updates its expected maximum burst length M, by taking into account the number of correct packets that have been received (if errors occurred), or by optimistically assuming that a certain burst of length MB packets was received correctly, even if NB <M B (in case of no errors). MB is a tunable protocol parameter limiting the maximum number of packets that can be transmitted back to-back in a burst. Nodes that lost the contention overhear data transmissions, understand from the header that they have not been selected as relays, and go back to sleep. Similarly, the nodes that during a handshake realize that they will not be selected as relays go to sleep immediately. We have observed that significant performance improvements can be obtained by allowing awaking nodes to join a relay selection phase that has already started. Upon waking up, nodes enter the QPI search phase and can answer an RTS packet with CTS, provided their QPI index is lower than or equal to the one that is currently being searched for. When a nonempty QPI region is queried and one or more eligible forwarders answer the RTS, the best GPI search starts, and the set of eligible forwarders is frozen (no node that wakes up after this time can enter the contention). This choice has been made to favor a fast relay selection once a region with active neighbors has been found.

3.2 The Rainbow Mechanism

In this section, we describe Rainbow, the mechanism used by ALBA to deal with dead ends. The basic idea for avoiding dead nodes is that of allowing the nodes to forward packets away from the sink when a relay offering advancement toward the sink cannot be found. To remember whether to seek for relays in the direction of the sink or in the opposite direction, each node is labeled by a color chosen among an ordered list of colors and searches for relays among nodes with its own color or the color immediately before in the list. Rainbow determines the color of each node so that a viable route to the sink is always found. Hop-by-hop forwarding then follows the rules established by ALBA.

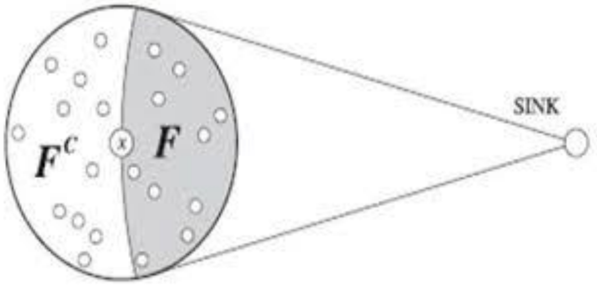


Figure 3: The F and FC regions.

More formally, let x be a node engaged in packet forwarding. We partition the transmission area of x into two regions, called F and FC, that include all neighbors of x offering a positive or a negative advancement toward the sink, respectively (see Fig. 3). When x has a packet to transmit it seeks a relay either in F or FC according to its color Ck, selected from the set of colorsfC0;C1;C2;C3.Nodes with even colors C0;C2;... search for neighbors in F (positive advancement). Nodes with odd color C1; C3;... search for neighbors in FC (negative advancement). Nodes with color Ck, k=0, can volunteer as relays only for nodes with color Ck orCkþ1.Nodes with color Ck, k>0, can only look for relays with color Ck1 or Ck. Finally, nodes with color C0 can only look for relays with color C0.3 The nodes assume their color as follows: Initially, all nodes are colored C0 and function according to the standard ALBA rules (see Section 3). If no dead nodes are encountered, all nodes remain colored C0 and always perform greedy forwarding. Since the nodes on the boundary of a hole cannot find relays offering positive advancement, after a fixed number Nhsk of failed attempts, they infer that they may actually be dead ends and correspondingly increase their color to C1.4 Rainbow; C1 nodes will send the packet away from the sink by searching for C0 or C1 nodes in region FC. If aC1 node cannot find C1 or C0 nodes in FC, it changes its color again (after Nhsk failed forwarding attempts), becoming a C2 node. Therefore, it will now look for C2 or C1 relays in F. Similarly, a C2 node that cannot find C2 or C1 relays in F turns C3 and starts searching for C3 or C2 nodes in FC. This process continues until all nodes have converged to their final color. Note that, at this point, any node that still has color C0 can find a greedy route to the sink, i.e., a route in which all nodes offer a positive advancement toward the sink. In other words, once a packet reaches a C0 node, its path to the sink is made up only of C0 nodes. Similarly, packets generated or relayed by Ck nodes follow routes that first traverse Ck nodes, then go through Ck1 nodes, then Ck2 nodes, and so on, finally reaching a C0 node. As soon as a C0 node is reached, routing is performed according to ALBA greedy forwarding.

3.3 Relay Node Selection

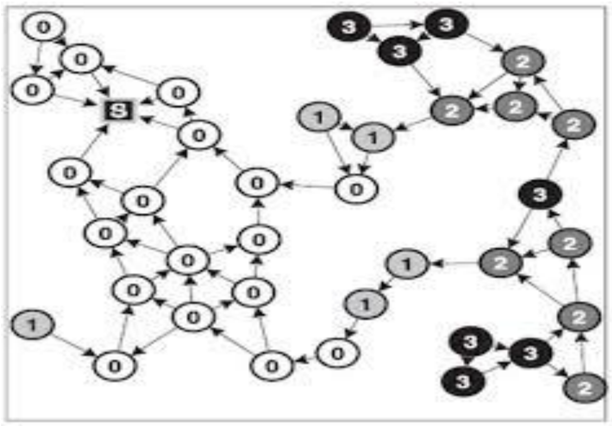


Figure 4: Rainbow Coloring.

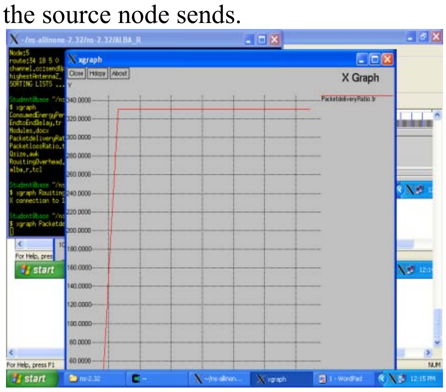
A sample topology where four colors are sufficient to label all nodes is given in Fig. 4. In the figure, the numbers in the nodes indicate the color they assume. Higher colors are rendered with darker shades of gray. A proof of the correctness of the Rainbow mechanism is given in the supplemental material document, available online. That proof, including convergence of the coloring mechanism in finite time and the loop-freedom of the determined routes, is performed through mathematical induction on the number h of changes of color in the route from a node to the sink. ALBA-R correctness is not affected by the presence of localization errors or by the fact that the topology graph is not a UDG, showing that our protocol is robust to localization errors and realistic propagation behaviors.

4. Performance Evolution

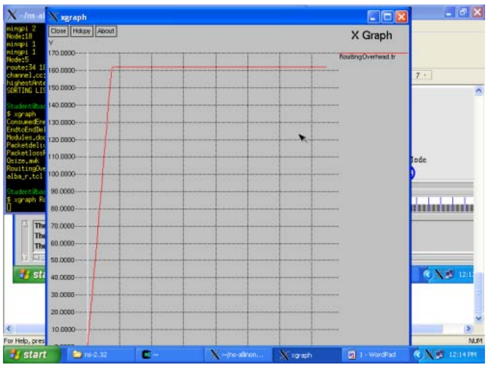
4.1 Simulation Scenarios and Metrics

All sensor nodes are randomly scattered with a uniform distribution. Randomly select one of the deployed nodes as the source node. The location of the sink is randomly determined. We evaluate our proposed method with respect to the following metrics: PDR, Routing Overhead, End to End Delay.

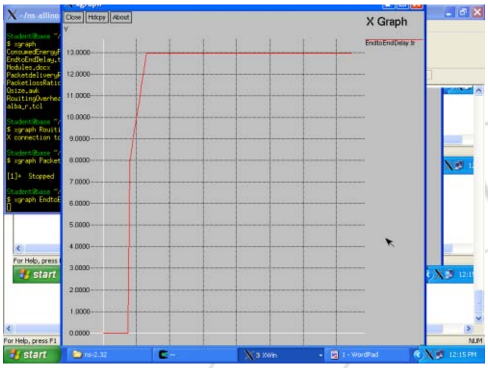
Packet delivery ratio: It is the ratio of the number of report messages the sink receives to the total number of report messages the source node sends.



Routing Overhead: It is due to dissemination of routing control packet.



End to end Delay: It refers to the time taken for a packet to be transmitted across a network from source to destination.



These parameter values are recorded in the trace file during the simulation by using record procedure. The recorded details are stored in the trace file. The trace file is executed by using the Xgraph to get graph as the output.

5. Conclusion

In this paper, we have proposed and investigated the performance of ALBA-R, a cross-layer scheme for converge casting in WSNs. ALBA-R combines geographic routing, handling of dead nodes, MAC, awake-asleep scheduling, and back-to-back data packet transmission for achieving an energy-efficient data gathering mechanism. Results from an extensive performance evaluation comparing ALBA-R, GeRaF, and IRIS show that ALBA-R achieves remarkable delivery ratio and latency and can greatly limit energy consumption, outperforming all previous solutions considered in this study. The scheme designed to handle dead nodes, Rainbow, is fully distributed, has low overhead, and makes it possible to route packets around dead nodes without resorting to the creation and maintenance of planar topology graphs. Rainbow is shown to guarantee packet delivery under arbitrary localization errors, at the sole cost of a limited increase in route length. The comparison with Rotational Sweep, a set of recently proposed mechanisms for avoiding dead nodes, shows that Rainbow provides a more robust way of handling dead ends and better performance in terms of end-to-delay, routing overhead, and packet delivery ratio. Testbed experiments have validated our simulation model and have confirmed ALBA-R to be an energy-efficient protocol with remarkable throughput and limited latency, which makes it suitable for real-world applications.

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