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Adaptive Load-Balancing Algorithm with Rainbow Mechanism to Avoid Connectivity Holes in Wireless Sensor Networks

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Abstract: The majority of the research on protocol design for WSNs has focused on MAC and routing provision. An important class of protocols is represented by geographic or location-based routing schemes, where a relay is greedily selected based on the progression it provides toward the sink. ALBA-R is a protocol for converge casting in wireless sensor networks and features cross-layer integration of geographic routing with contention-based MAC for relay selection, load balancing (ALBA) as well as a mechanism to identify and route around connectivity holes (Rainbow). ALBA and Rainbow (ALBA-R) serve together to 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 disseminated and adapts proficiently to unstable traffic and node deployments. Extensive NS2-based simulations is used to reveal ALBA-R considerably outperforms other converge casting protocols and solutions for dealing with connectivity holes, critical traffic conditions as well as low density networks. Our results show that ALBA-R is an energy-efficient protocol that achieves remarkable presentation in terms of packet delivery ratio and end-to-end latency in different scenarios, thus being fitting for real network deployments. Further the results show performance improvement achieved in ALBA-R protocol in terms of improved throughput, greater packet delivery ratio as well as reduced delay and energy consumption.

Key words: Wireless sensor networks · Cross-layer routing · Connectivity holes · Geographic routing · Localization errors

INTRODUCTION

Wireless sensor networks are a very capable enabling technology for future information retrieval and ambient–interactive networking. Typical wireless sensor nodes are relatively contemptible and are expected to become even cheaper in the near future, making it feasible to quickly deploy wireless networks formed by hundreds or thousands of nodes. Data aggregated through the sensor nodes in the form of data packets are transmitted to the sink through multihop wireless routes (WSN routing or converge casting) utilizing which can be implemented with a small code size and memory necessities and thus being tolerant to changing radio frequency and networking conditions. Research on protocol design for WSNs is mainly for MAC and routing solutions. Geographic or location-based routing schemes, where a relay is greedily selected based on the improvement it provides toward the sink. Geographic routing, being almost stateless, disseminated and localized requires little division and storage resources at the nodes and widely used for WSN applications.

The design and challenges are faced by geographic routing schemes with regard to 1) connectivity holes, 2) resilience to localization errors and 3) efficient relay selection. These problems are solved by ALBA-R routing protocol. Connectivity holes are essentially related to the way greedy forwarding mechanism. Even in a entirely connected topology, there may exist nodes (called dead ends) that have no neighbors that provide packet innovation toward the sink. Dead ends are incapable to forward the packets they create or collect.

So packets will never reach their destination and will finally be redundant. Many solutions have been proposed to improve the force of dead ends. In particular, those that propose packet delivery assurance are frequently based on making the network topology graph planar and on the use of face routing [1]. However, planarization does not

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work well in the presence of localization errors and sensible radio dissemination effects [2], as it depends on unrealistic representations of the network, such as a unit disk graph [3].

The contributions we provide WSN research with this paper include the following [4]:

Achieving data security during the routing process, develop greedy geographic forwarding by considering congestion and packet expansion jointly when making routing decisions. The new relay selection format, which implements MAC and routing functions in a cross-layer manner, achieves performance better to existing protocols in terms of energy efficiency, packet delivery ratio (PDR) and latency.

- The Rainbow mechanism allows ALBA-R to efficiently route packets out of and approximately dead ends. It is resilient to localization errors and to channel propagation impairments. Rainbow not needs to network topology planar also it able to promise packet delivery in realistic deployments.
- Even though the load balancing and quality of service is assured, it does not mention the need for data security during the routing process. A simple key exchange mechanism or a cryptographic method incorporated with the existing ALBA-R mechanism can make it good enough to consider the protocol it for experimental and real time implementations. In this research work, we use polynomial bivariate key generation as a key exchange mechanism and one way hash chain algorithm for data security. We use this increase the throughput of the system[5].
- Extensive ns2-based simulation experiments are performed that show how the unique features of ALBA-R determine the overall performance and that show its superiority with respect to earlier exemplary solutions for geographic-based and topology-based converge casting such as GeRaF [6] and IRIS [7]. We have also investigated the performance of Rainbow in sparse networks where dead ends are likely to occur as well as with and without localization errors. We show that Rainbow is an successful distributed scheme for learning how to route packets around connectivity holes, achieving remarkable delivery ratio and latency performance. Our simulation results also show better performance than that of two recent proposals for routing around dead ends by Stojmenovic [8].
- The critical metrics of packet delivery ratio and end to- end (E2E) latency are further investigated through experiments in an outdoor 40-node test bed of TinyOS-based sensor nodes. Besides validating our simulation model, the obtained results verify the effectiveness of ALBA-R in supporting long-lived and reliable wireless sensor networking in performs [9].

Related Work: The need for designing power efficient and scalable networks provided justification for applying position-based routing methods in ad hoc networks. Routing protocols have two modes: greedy mode (when the forwarding node is able to advance the message toward the destination) and recovery mode (applied until return to greedy mode is possible). In the absence of location errors, geographic routing - using a combination of greedy forwarding and face routing has been shown to work correctly and efficiently. The micro-level behavioral analysis the possible protocol error scenarios are identified along with their conditions and bounds. This extensive simulation study of GPSR and GHT revealed that even small location errors (of 10% of the radio range or less) can in fact lead to incorrect (non-recoverable) geographic routing with noticeable performance degradation. Thus a simple modification for face routing is made to eliminate probable errors and leads to near perfect performance [10]. Moreover, in realistic settings, localization errors and non ideal signal propagation may lead to disconnected planar graphs or to topology graphs that are non planar. This is because spanner formation protocols assume that the network topology is modeled by a UDG and the accuracy of the advance cannot be guaranteed when this is not the case, as in the majority reasonable situations. To make planarization work on valid networks, a form of interrupted signaling must be implemented to verify that no relations cross, as performed by the Cross-Link Detection Protocol (CLDP) [11].

Location-based routing used to achieve scalability in large mobile ad hoc networks, is difficult when there are holes in the network topology or when nodes are mobile or frequently disconnected to save battery. Terminode routing using a combination of location-based routing (Terminode Remote Routing, TRR) is used when the destination is far and link state routing (Terminode Local Routing, TLR), used when the destination is secure. The simulation results show that terminode routing performs well in networks of different sizes. In slighter networks, the presentation is equivalent to MANET routing protocols. In superior networks that are not homogeneously occupied with nodes, terminode routing break existing location-based or MANET routing protocols [11].

In the former case, the coordinates of each node are the vector of the hop space between the node and each of a set of beacons. Greedy forwarding is typically performed over the virtual coordinate's space. This decreases the rate of dead ends, but does not remove them. Topology warp system is based on iteratively updating the coordinates of each node based on the coordinates of its neighbours, so that greedy paths are more likely to exist. These approaches are referred to as "geographic routing without location information,as they do not require exact initial position estimates. Both methods, though, present a non-negligible probability that packets get stuck in dead ends.

RS is a recent contention-based protocol to route packets around connectivity holes without requiring planarization. The protocol is planned to complement any greedy forwarding algorithm (including ALBA) by determining a next hop relay through a timer-based disputation. The relay is selected so that a traversal path is found that ensures progress after a greedy failure. Upon receiving a request-to-send (RTS), each possible candidate relay starts a timer whose value (called the delay function) is computed based on the relative position of the contender, the sender and the ancestor of the sender, i.e., the node that particular the sender as relay. RS is based on two delay functions, namely, removes circle and winding triangle (TT), providing different lengths for traverse paths and is shown to reach guaranteed freedom in UDGs. As such, conversely, it is not commonly relevant and it can be destructively precious by localization errors [12].

Heuristic rules are then defined for relentless to greedy forwarding as soon as next-hop relays can be found greedily. Examples of this approach include [13-19] 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 [10]. To make planarization work on real networks, a form of periodic signalling must be implement to verify that no links cross, as perform by the Cross-Link Detection Protocol (CLDP) [13].

Proposed Work

Adaptive Load Balancing Algorithm: The protocol propose in this paper, ALBA, is a cross layer solution for converge casting in WSNs that integrate awake/asleep schedules, MAC, routing, interchange load balancing and back-to back packet transmission. Nodes exchange between awake/asleep modes according to independent wake-up schedules with permanent duty cycle d. Packet forwarding is implement by have the sender polling for convenience its awake neighbors by broadcasting an RTS packet for jointly performing channel access and communicating relevant routing information (cross-layer approach). Existing neighboring nodes reply with clear-to-send (CTS) packet carrying information through which the sender can choose the best relay. Relay collection is performed by prefer neighbors offering "good performance" in forwarding packets. Optimistic geographic advancement in the direction of the sink (the main relay selection criterion in many previous solutions) is used to discriminate among relays that have the equal forwarding presentation. Every probable relay is characterized by two parameters: the queue priority index (QPI) and the geographic priority index (GPI).

Queue Priority Index (QPI): The queue priority index is calculated based on the burst size of the packet transmission and their moving average and the number of packets in an eligible relay queue.

$$QPI = \min\{\left\lceil (Q + N_B)/M \right\rceil, N_q\} \quad (1)$$

where,
Q is the number of packets queue of the nodes eligible for relaying
M is the moving average of the packets
NB is the Burst (packet transmission)

Geographic Priority Index (GPI): The geographic priority index is assigned by the range of the distance of each node from the sink. Based on positioning in order (as provide to a node by GPS, or compute through various localization protocol) and on the information of the location of the sink, every node also computes its GPI, which is the amount of the geographic region of the forwarding area of the sender where a latent relay is located. The numbering of GPI regions array from 0 to Nr - 1. Numbers are assigned so that, the higher the number of the region, the further the sink is the nodes it contains, as shown in the Figure 1.

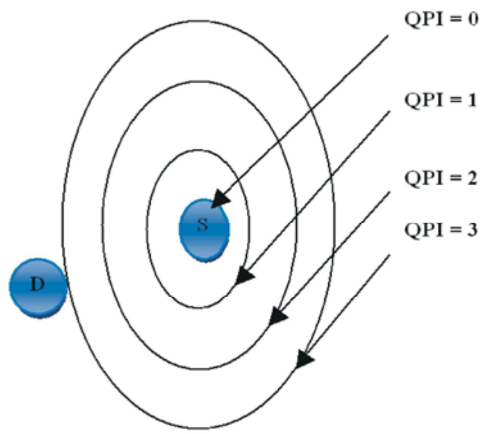

Fig. 1: Geographic Priority Index regions

Rainbow Mechanism: In the mechanism used to avoid the dead end problem and connecting hole. Here labeling color to the nodes. The basic idea for avoiding connectivity holes is that of allowing the nodes to forward packets away from the sink when a relay offering development toward the sink cannot be found. To memorize whether to seek for relays in the direction of the sink or in the opposite direction, each node is labeled by a color selected among an ordered list of colors and searches for relays among nodes with its own color or the color immediately previous to in the list. Rainbow determines the color of every node so that a viable route to the sink is always found. We partition the transmission area of x into two regions, called F and FC that consist of all neighbors of source offering a positive or a negative advancement toward the sink. Based on the reply from the region the source finds the path to forwarding the data.

Sleep & Awake Schedule: Nodes alternate between awake/asleep modes according to self-sufficient wake-up schedules with fixed duty cycle d. Packet forwarding is implemented by having the sender polling for availability its awake neighbors by broad- casting an RTS packet for jointly performing channel access and communicating relevant routing information (cross-layer approach). Presented neighboring nodes respond with clear-to-send (CTS) packet carrying information through which the sender can choose the best relay.

Data Transmission: After finding the path the data be send to source to destination in that time any attacker attack the intermediate node our data will be loss or our information is leaked or changed. For that in the paper introduced security use.

Polynomial key pre distribution schemes use the polynomial mathematics in order to generate key team and perform key assignment connecting the involved parties. A key distribution server (KDS) performs off-line distribution of several polynomial shares of degree k to a set of nodes so that any k users are able to calculate a common key that can be used in their communications without any kind of communication. By evaluating its own stored polynomials with the identifiers (ID) of the other (k - 1) parties, each node can determine a common key, separately shared with the other nodes.

Blundo proposed a bivariate polynomial $f(x,y)$ that can be used to compute the key; the parameters (x,y) were defined as the unique ID between the sensors x and y respectively. The polynomial is defined as:

$$f(x,y) = \sum_{i,j=0}^{k} a_{ij} x^i y^j \tag{2}$$

where the coefficients a_{ij} ($0 \leq i, j \leq k$) are randomly chosen from a finite Galois field GF(Q); Q is a prime number that is large enough to accommodate a cryptographic key. The bivariate polynomial has a symmetric property like.

$$f(x,y) = f(y,x) \tag{3}$$

In our specific WSN environment each sensor has a unique ID and, as the first step of network deployment, the KDS first initializes the sensors by giving to each sensor p a polynomial share $g_p(y)$, which is obtained by evaluating $f(x,y)$, with $x = p$,

$$g_p(y) = f(p,y) \tag{4}$$

In other words, each sensor node p stores a number of k coefficients $g_i(0 \leq j \leq k)$ in its memory,

$$g_j = \sum_{i=0}^{k} a_{ij} (p)^i, (0 \leq j \leq k) \tag{5}$$

where p is the node ID of the sensor and g_i is the coefficient of y^i in the polynomial $f(p,y)$.

Simulation Analysis: We have investigated the following metrics, the standardize node energy consumption, defined as the ratio involving the total energy consumed by all nodes over a given time and the energy that the nodes would consume by severely following the duty cycle, if there were no packets to transmit and receive; the

Table I: Simulation Parameters

Parameter	Value
Channel Type	Wireless Channel
Radio Propagation model	TwoRayGround
Network interface type	WirelessPhy
MAC Type	IEEE 802.11
Interface Queue Type	PriQueue
Link Layer Type	LL
Antenna Model	Omni Antenna
Simulation Time	100 ms
Number of Nodes	50
Topology Area	1000 x 1000 m
Routing Protocol	DSDV

every packet energy consumption, defined as the average amount of energy depleted by all nodes to successfully deliver a packet to the sink; the packet delivery ratio, defined as the division of packets that are successfully delivered to the sink; and the end-to-end latency, defined as the time from packet generation to its delivery to the sink. The final metric is computed only for successfully delivered packets [15].

Simulation and analysis of the proposed scheme was performed in NS2. Network simulator is an event driven discrete simulator where all Network Simulator (NS2) is used for analyzing the efficiency of the proposed energy based reliable routing scheme. It is an extensively exercised discrete event simulator used for various test scenario executions using both object oriented tool command language (OTCL) and C++. To test our proposed work, the simulation parameters tabulated in Table 1 were used.

Packet Received Ratio: In this figure show the packet received ratio. In this graph x-axis represents the simulation time period and y-axis represents the no of packet received. Packet received Ratio is the ratio of the total number of packets successfully delivered to the total packets sent. This graph shows the in the routing system the mobile sink collect the data rendezvous at a particular time period. In this Fig. 2 show the ALBA-R is packet received ratio is higher than the existing ALBA-R [16].

Throughput: Quality of Service (QoS) metric to evaluate the performance of network. The packet deliver ratio from the overall packet from the network. In the graph show the performance analysis of our scheme for whole network. The graph X-axis mentions the simulation time period and Y-axis mentions the QoS (packets) delivery ration of whole system. In this Fig. 3 show the ALBA-R quality of system is higher than the existing ALBA-R.

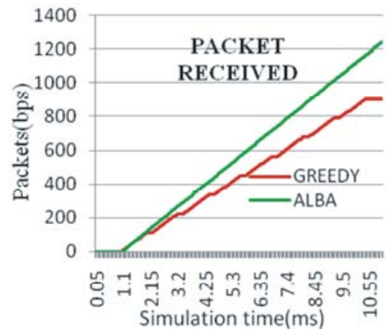

Fig. 2: Packet Received Ratio

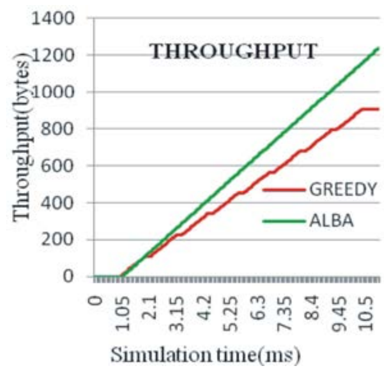

Fig 3. Throughput

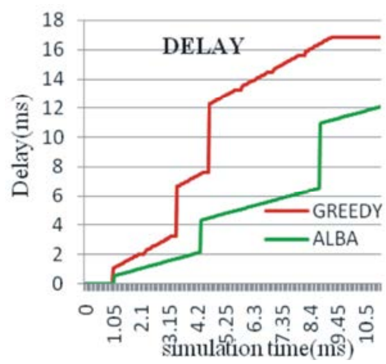

Fig. 4: Delay

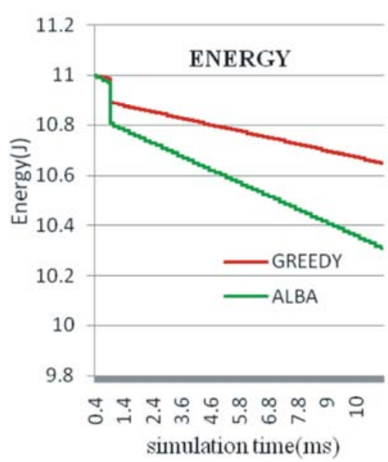

Fig. 5: Residual Energy

Delay: Packet Delay is the delay occurred during data transmission. This graph shows the overall delay of the network. Delay defines the time taken or interval between the data forwarding from one system to another system. In this graph the X-axis mentioned the simulation time (ms) and the Y-axis mention the delay time (ns) between interval times of packets. In this Fig. 4 show the AlBA-R is end to end delay lower than the existing ALBA-R.

Residual Energy: Energy Consumption is monitored using the residual energy plots. The remaining energy defines the sense power, Transmission power, received power subtract from initial energy of the node. The graph shows the energy consumption of our network. The graph X-axis mentions the simulation of the network and the Y-axis mentions the remaining energy of the nodes. In this Fig. 5 show the ALBA-R Energy consumes is lesser then the existing ALBA.

CONCLUSION

In this paper, we have proposed and investigated the performance of ALBA-R, a new cross-layer scheme for converge casting in WSNs. ALBA-R combines geographic routing, conduct of dead ends, 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 of ALBA-R show that ALBA-R achieves remarkable delivery ratio and can greatly limit energy consumption, outperforming all earlier solutions considered in this study. The format designed to handle dead ends, Rainbow, is fully distributed. Rainbow is shown to guarantee packet delivery under arbitrary localization errors, at the sole cost of a partial increase in route length. The evaluation with

Rotational Sweep, a set of newly proposed mechanism for avoiding connectivity holes, shows that Rainbow provides an additional vigorous way of handling dead ends and better performance in terms of end-to-end latency, power Consumption and packet delivery ratio.

Future work can be done on obtaining the test-bed results and scaling the network to a bigger one to analyze the performance of the same.

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