Load Balancing Geographic Routing in Wireless Sensor Networks

R. Cleita Katharine, K. Jagadeeswari, R. Sathish, Aida Jones

Abstract— **This paper presents a protocol ALBA-R that uses converge-casting for wireless sensor networks. ALBA-R is a cross-layer integration of geographic routing and load balancing (ALBA), along with a mechanism for detecting and routing around connectivity holes (Rainbow).[1] This mechanism together solves the problem of routing around dead ends without overhead-intensive techniques. This protocol efficiently adapts to varying traffic and node deployments, as it is localized and distributed. [6] ALBA-R outperforms other protocols dealing with connectivity holes, especially in low-density networks and critical traffic conditions through extensive ns2-based simulations. Experiments in an outdoor test-bed of TinyOS motes, shows the performance of the protocol as an energy-efficient protocol. This is suitable for real network deployments as it achieves a remarkable performance in terms of end-to-end latency and packet delivery ratio.**

Index Terms— **Rainbow mechanism, ALBA, sleep and awake schedule**

I. INTRODUTION

A wireless sensor network (WSN) has 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 wireless sensor networks development 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. [4]

The WSN is built of nodes from a few to several hundreds or even thousands. Here 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 sensors and an energy source, usually a battery or an embedded form of energy harvesting. [3][5] The main characteristics of a WSN include Power consumption constraints for node using batteries or energy harvesting, Ability to cope with node failures(resilience), Mobility of nodes, Heterogeneity of nodes, Scalability to large scale of deployment, Ability to withstand harsh environmental conditions, Ease of use, Cross layer design.

An important studying area for wireless communications is Cross-layer. The optimal modulation to improve the transmission performance, such as data rate, energy efficiency, quality of service can be made by cross layer. Sensor nodes can be imagined as small computers in terms of their interfaces and components. The usual components are a processing unit with limited computational power and limited memory, sensors or MEMS (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and power source usually in the form of a battery. Secondary communication interface and energy harvesting modules are other possible inclusions.

To produce low cost and tiny sensor nodes are one of the major challenge for WSN. Still many of the nodes are in the research and development stage. [8]

II. RAINBOW MECHANISM

ALBA-R has been introduced to identify the packets. It is based on Rainbow mechanism which selects a node for packet forwarding. The packets needed for transmission is divided into positive and negative. The even colors are given to positive packets and odd colors are given to negative packets. The negative packets are once again retransmitted and packets are achieved. The Rainbow mechanism is mainly used to route packets.

III. ALBA

In WSN, convergecasting is used to provide a cross-layer solution that integrates awake/asleep schedules, MAC, traffic load balancing, routing and back-to-back packet transmissions. According to independent wake-up schedules with fixed duty cycle *d* nodes alternate between awake/asleep modes.

Packet forwarding is implemented by having the sender polling for availability its awake neighbors by broadcasting a Request-to-Send (RTS) packet for jointly performing channel access and communicating relevant routing information (cross layer approach). Available neighboring nodes respond with Clear-to-Send (CTS) packet carrying information through which the sender can choose the best relay. Relay selection is performed by preferring neighbors offering “good performance” in forwarding packets. Positive geographic advancement toward the sink (the main relay selection criterion in many previous solutions) is used to discriminate among relays that have the same forwarding performance. [1]

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IV. MODULES

A. Creating the Network Scenario and Node:

In communication networks, a topology is a usually schematic description of the arrangement of a network, including its nodes and connecting lines. There are two ways of defining network geometry: the physical topology and the logical (or signal) topology. The physical topology of a network is the actual geometric layout of workstations. Logical (or signal) topology refers to the nature of the paths the signals follow from node to node. The number nodes is going to participate in the simulation is decided. We hence use only a logical topology as it is wireless environment.

Node creation is nothing but the creation of the wireless nodes in the network scenario that is decided. Node configuration essentially consists of defining the different node characteristics before creating them. They may consist of the type of addressing structure used in the simulation, defining the network components for mobile nodes, turning on or off the trace options at Agent/Router/MAC levels, selecting the type of adhoc routing protocol for wireless nodes or defining their energy model. [2] Simulator::node-config accommodates flexible and modular construction of different node definitions within the same base Node class. For instance, to create a mobile node capable of wireless communication, one no longer needs a specialized node creation command.

B. 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 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. We partition the transmission area of x into two regions, called F and FC that include 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.

C. ALBA:

Every prospective relay is characterized by two parameters:

(i) Queue priority index (QPI),

(ii) Geographic priority index (GPI).

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 = $\min\{\lceil (Q+N_B)/M \rceil, N_q\}$

Where,

Q ⟶ the number of packets queue of the nodes eligible for relaying

M ⟶ moving average of the packets

NB⟶ Burst (packet transmission)

The geographic priority index is assigned by the range of the distance of each node from the sink.

Based on positioning information (as provided to a node by GPS, or computed through some localization protocol), and on the knowledge of the location of the sink, each node also computes its GPI, which is the number of the geographic region of the forwarding area of the sender where a potential relay is located. The numbering of GPI regions ranges from 0 to Nr − 1. [7]

D. Sleep & awake schedule:

Nodes alternate between awake/asleep modes according to independent 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). Available neighboring nodes respond with a clear-to-send (CTS) packet carrying information through which the sender can choose the best relay.

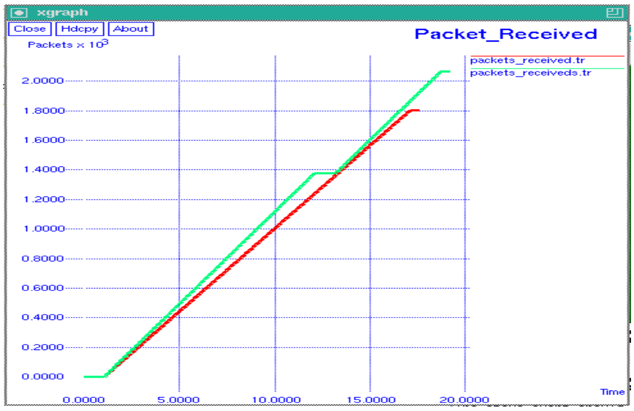

Fig.1. Packet Delivery Ratio

Fig.2. Per Packet Energy Consumption

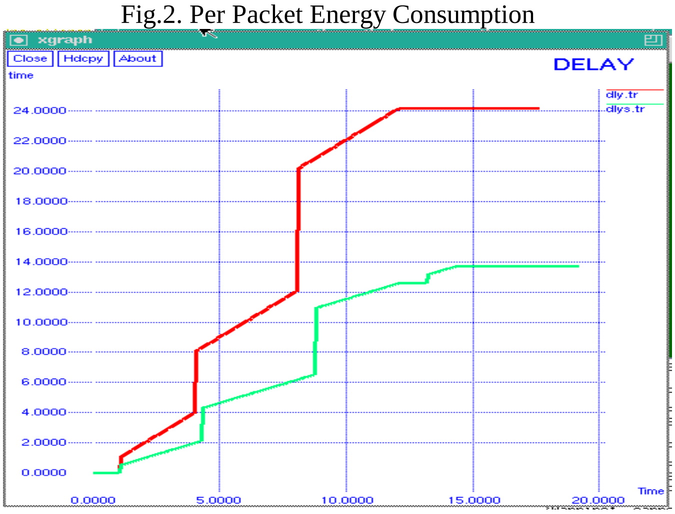

Fig.3. End-to-end Latency

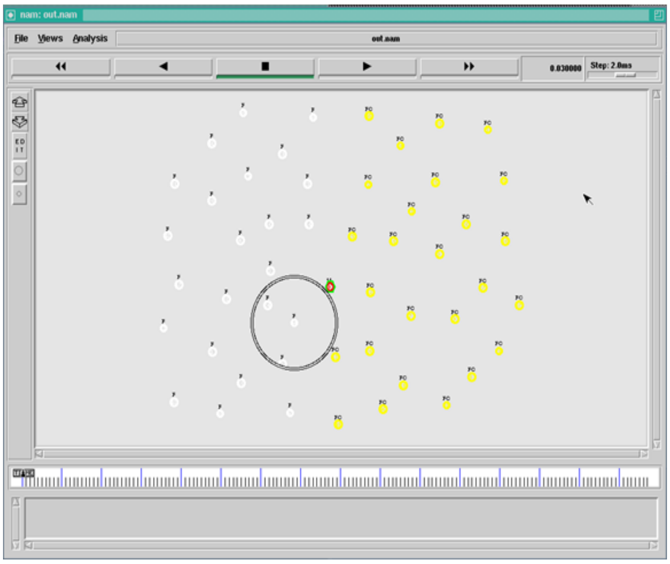

Fig.4. Partitioning the nodes into positive and negative regions

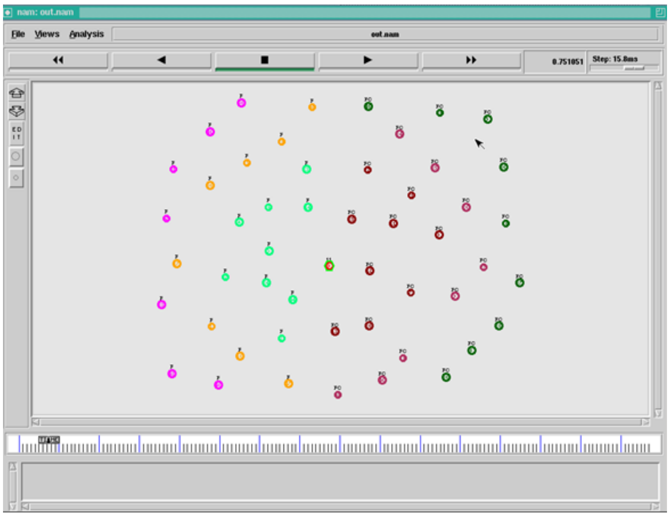

Fig.5. Rainbow Colouring

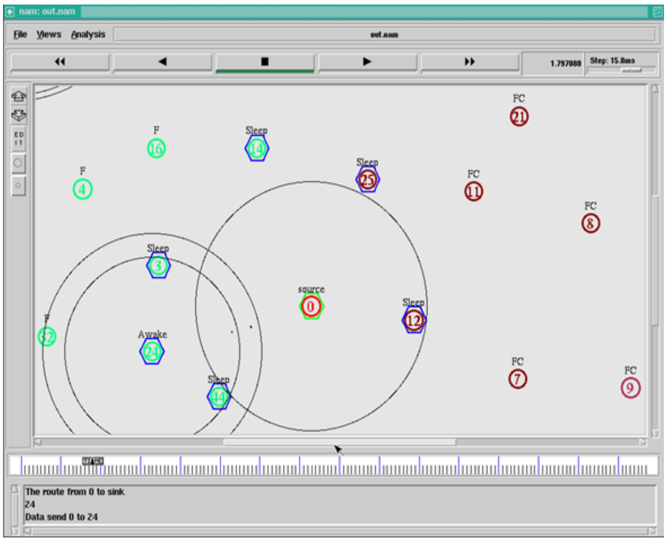

Fig.6. Finding the intermediate nodes using Sleep and Awake Schedule

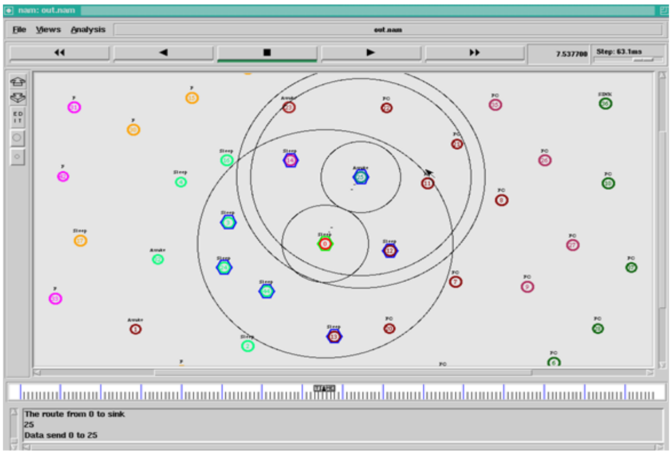

Fig.7. Transfer of packets in broadcasting regions

IV. CONCLUSION AND FUTURE EXTENSION

A. *Conclusion*

In this paper, we have proposed and investigated the performance of ALBA-R, a new cross-layer scheme for convergecasting in WSNs. ALBA-R combines geographic routing, handling 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 previous solutions considered in this study. The scheme designed to handle dead ends, Rainbow, is fully Rainbow is shown to guarantee packet delivery under arbitrary localization errors, at the sole cost of a limited increase in route length

B. *Future extension*

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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