RELIABLE DYNAMIC SOURCE ROUTING PROTOCOL (RDSRP) FOR ENERGY HARVESTING WIRELESS SENSOR NETWORKS

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Abstract

Wireless sensor networks (WSNs) carry noteworthy pros over traditional communication. Though, unkind and composite environments fake great challenges in the reliability of WSN communications. It is more vital to develop a reliable unipath dynamic source routing protocol (RDSRP)l for WSN to provide better quality of service (QoS) in energy harvesting wireless sensor networks (EH-WSN). This paper proposes a dynamic source routing approach for attaining the most reliable route in EH-WSNs. Performance evaluation is carried out using NS-2 and throughput and packet delivery ratio are chosen as the metrics.

Keywords:

Energy Harvesting Wireless Sensor Networks (EH-WSN), Routing, Reliability

1. INTRODUCTION

The use of wireless sensor networks (WSN) has given a key to a wide range of communication issues. The application of sensor networks has the energy capacity limitation. Hence making the sensor nodes with non-rechargeable batteries has the scope to rationalize the high cost of WSN deployment for low consumption applications. An energy-harvesting wireless sensor network (EH-WSN) is a kind of sensor network that offers a solution to this energy problem by allowing sensor nodes to harness environmental energy to power the nodes.

In WSNs, sensor node observes the surroundings, collect sensed data, and deliver the collected data to sink node/destination node. Among the application areas of WSN, unkind and multifaceted environments have reliability issue. As in [1]-[3], wireless links in real networking environments can unreliable. Also when the sensor nodes are not within the transmission range of the sink node, then the other sensor nodes operate as relay nodes and carry sensed data from the source sensor node to the sink sensor node. This operation can be performed either using a single path or multiple paths. Thus attain reliable wireless communications within WSNs; it is foremost to encompass a reliable routing protocol.

2. RELATED WORKS

Many research works have been carried out on energy-harvesting routing protocols. In [10], the author introduced one of the first routing protocols to integrate solar energy harvest into the route selection by simply classifying nodes as either harvesting or non-harvesting. Also in [10] the non-harvesting nodes are mostly avoided. In [11]-[13], the authors correlated the cost metrics envoy of a node's available energy with the available links. Routes are then found using Bellman-Ford, Directed Diffusion (DD), or other applicable shortest-path or least-cost algorithms applied on these metrics.

Geographic routing protocols make use of the location information of sensor nodes. SPEED (Stateless Protocol for End-to-End Delay) [4] is the geographic information used to assess the delay of the retransmitted packets. The location information got through a self-configuring localization mechanism such as GPS (Global Positioning System), or infrastructure-based and ad-hoc localization systems as discussed in [5]-[9]. Such geographic protocols consume less overhead, minimum state stored to forward data along with reasonable flexibility. Also, the protocols consume less energy and bandwidth since discovery packets floods are not required beyond a single hop [14], [15]. In [16] a proactive routing protocol DTRP was proposed that offers reliability through scalable multi-path redundant per-packet source-tuneable capability.

3. RELIABLE DYNAMIC SOURCE ROUTING PROTOCOL

3.1 EH-WSN AND LINK FAILURE MODEL

EHWSN is capable enough to harvest energy from the nearby environment where it is existing or from the other energy sources and convert it in the form of electrical energy. The lifetime of EHWSN is connected to the failure of any constituent in the energy flow. The reliability of energy flow of EHWSN consists of MEMS (Microelectromechanical systems) energy harvesting denoted as *meh*, power conditioning denoted as *pwrc*, energy storage denoted as *ens*, energy flow denoted as *enf* radio denoted as *r*, microcontroller *µc*, MEMS sensor as *mems* and along with power management *pwrm*. Hence the reliability of EHSN is denoted as

$$R_{EHSN}(t)=R_{enf}(t)\times R_{mems}(t)\times R_r(t)\times R_{\mu c}(t)$$

The reliability of each component is modelled by failure distribution which is redrafted as

$$R_{EHSN}(t)=e^{-(\lambda_{enf}+\lambda_{mems}+\lambda_r+\lambda_{\mu c})t}=e^{-\lambda EHSNt}$$

where, $e^{-\lambda EHSN}$ in failures per hour (fph) denotes failure rate of EHSN.

The widely used radio model for link failures in wireless sensor networks depends on the lognormal shadowing radio propagation model as referred in [17].

$$P_{rx}=P_{tx}-RTLP-10\eta\log10\left(\frac{d}{tr}\right)-\chi dB-P_N$$

where, P_{rx} denotes received power, P_{tx} denotes transmitted power, RTLP denotes received transmission link power, d denotes distance between transmitter cum receiver and χ denotes zero-mean normal distributed random variable in decibels (dB) and PN denotes noise.

Another important characteristic of WSNs is uncertainty. That is due to nature of WSNs such as constraints of the sensing devices and location finding, the varying environments, changing network topologies, unreliable communications, irregular radio patterns, etc.

3.2 RELIABLE SOURCE ROUTING

Reactive or on-demand routing protocols determine routes only on-demand. This can be beneficial when there is high variability in the sensor network's energy state as like in the case of EH-WSNs. It is also applicable when sources only need to initiate packets at uneven events. Hence in this research work on-demand routing mechanism is implemented. During the route discovery stage in the on-demand routing fashion, a Route Request (RREQ) is flooded towards the destination/sink node. Upon receiving RREQ packet, the destination/sink node sends back a Route Reply (RREP) message to the source node in order to set up routes for data packets.

3.3 FORWARDING FASHION OF ROUTE REQUEST (RREQ)

Every RREQ packet is linked with a two-tuple identifier [Source node address, Request ID] that is commonly referred as the RREQID. In default dynamic source routing (DSR) implementation, each forwarding sensor node preserves a record of RREQIDs in a Request Table (RT). By conferring with the RT, RREQs of a given RREQID is forwarded almost once in a time. On the other hand, this can show the way to alternate routes with possibly lower costs being ignored. On top, checking for cyclic and over-length paths as in traditional DSR, the additional rule of dropping routes that has poor link quality has been added.

3.4 TIMER AT DESTINATION

For a wireless sensor network that consists of more number of nodes, gathers all off-path information is not viable. So, a timer with duration T_{newrq} is started at the destination when a new RREQ is received. Preferably, T_{newrq} is small and will not make major route acquisition latency. Presently, T_{newrq} is simply set to a constant value that implies not all the sensor nodes in the network are crossed by the RREQ.

When the timer expires, the destination chooses the best route and then carries out the unicast operation on a route reply RREP to the source node and the RREQID is noticeable as processed in the RT.

3.5 EXPIRATION OF ROUTE

The chosen route gets invalidated after a time T_{rexp} has passed by. A new route discovery is started when the source node needs a route to the destination node but the cached route expired.

4. SIMULATION SETTINGS AND RESULTS

The total number of wireless sensor nodes is set up to 100 with transmission range of 25-100 meters in the terrain region of 750 meters × 750 meters. The constant bit rate (CBR) fashion is followed with 128 kilo bits per second. The initial energy of each sensor node is set up to 1 joule. The performance metrics throughput and packet delivery ratio is taken up for simulation with the above mentioned settings as depicted in Table.1. Simulation has been carried out using NS2 for 100 seconds based on pause time and varying transmission range between 25 to 100 meters. The conventional dynamic source routing (DSR) is taken for comparison and the simulation results prove that the proposed routing mechanism attains better reliability in terms of throughput as shown in Table.2 and packet delivery ratio as shown in Table.3. From the Fig.1, Fig.3 it can be clearly understood that the proposed RDSRP attains better throughput than that of DSR and the Fig.2 and Fig.4 illustrates packet delivery ratio is better in RDSRP.

Table.1. Simulation Settings

Terrain Size	750 × 750 meters
Pausetime	20, 40, 60, 80 and 100 seconds
Bit Rate	128 Kbps, CBR
Number of Nodes	100
Initial Energy	1.0 joules
Transmission Range	25, 50, 75 and 100 meters

Table.2. Simulation Results - Throughput

Pausetime (Seconds)	**Throughput (Packets)**		**Transmission Range (Meters)**	**Throughput (Packets)**	
	DSR	**RDSRP**		**DSR**	**RDSRP**
20	2278	2381	25	8704	9601
40	4403	4710	50	9088	10112
60	6528	6989	75	10112	10624
80	8602	9216	100	10624	11392
100	10624	11392			

Table.3. Simulation Results–Packet Delivery Ratio

Pause time (Seconds)	**Throughput (Packets)**		**Transmission Range (Meters)**	**Throughput (Packets)**	
	DSR	**RDSRP**		**DSR**	**RDSRP**
20	0.89	0.93	25	0.68	0.75
40	0.86	0.92	50	0.71	0.79
60	0.85	0.91	75	0.79	0.83
80	0.84	0.90	100	0.83	0.89
100	0.83	0.89			

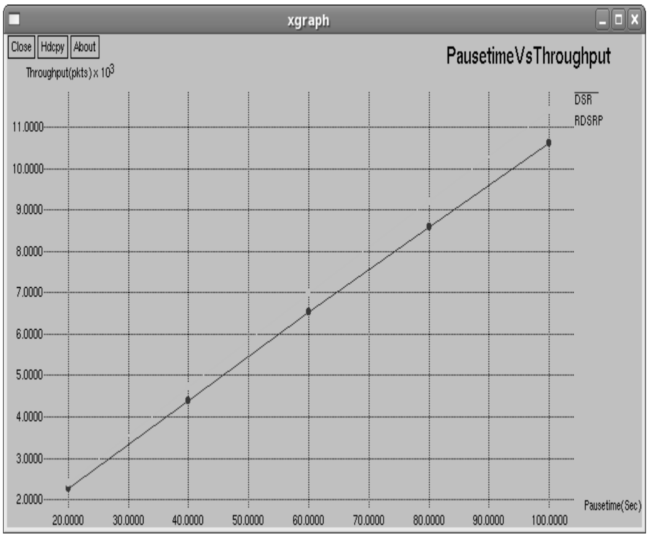

Fig.1. Pause time Vs Throughput

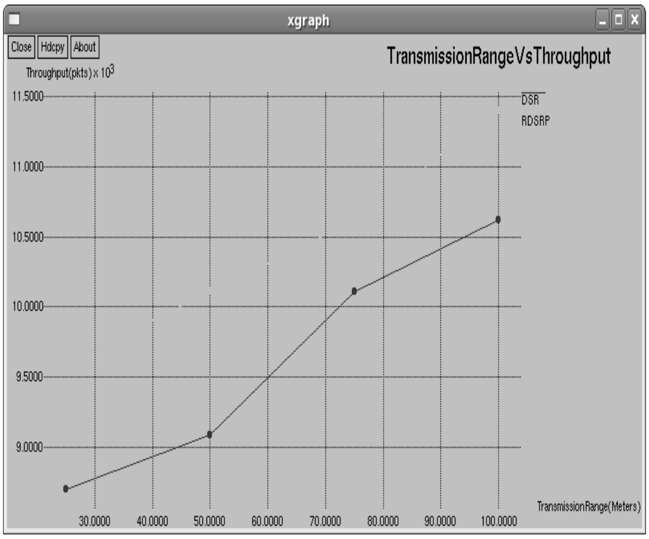

Fig.2. Transmission Range Vs Throughput

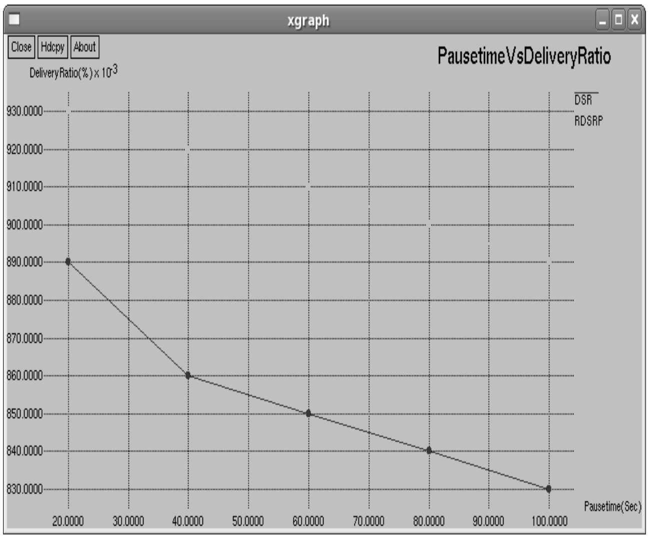

Fig.3. Pause time Vs Packet Delivery Ratio

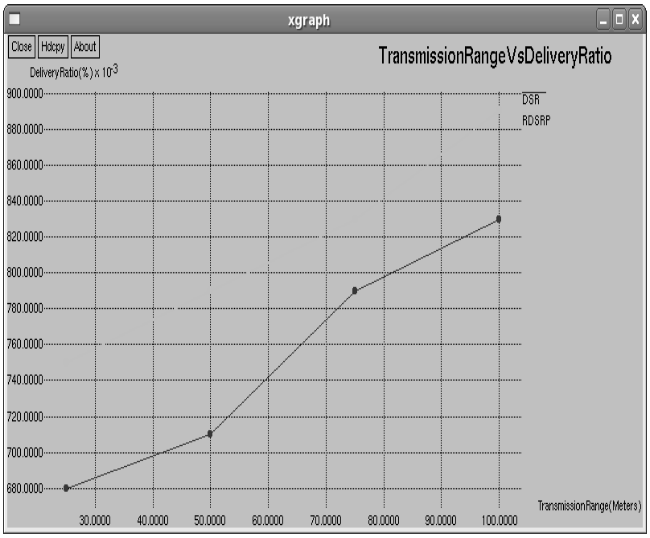

Fig.4. Transmission Range Vs Packet Delivery Ratio

5. CONCLUSION

Wireless sensor networks (WSNs) holds remarkable advantages over traditional communication. It is more imperative to develop a reliable dynamic source routing protocol for WSN to provide better quality of service (QoS) in energy harvesting wireless sensor networks (EH-WSN). This paper proposed a dynamic source routing approach for attaining the most reliable route in EH-WSNs. Performance evaluation is carried out using NS-2 and throughput and packet delivery ratio are chosen as the metrics. Simulation results proved that the proposed routing protocol RDSRP performs better in terms of throughput and packet delivery ratio.

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