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Distributed Energy Efficient Selective Forwarding Technique for Data Intensive WSN

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Abstract- Energy efficiency in wireless sensor networks (WSNs), routing protocols are engaged in a playful manner suggesting a consciousness of high value. Opportunistic routing, offering relatively efficient and adaptive forwarding in low-duty-cycled sensor networks, generally allows multiple nodes to forward the same packets simultaneously, especially in networks with intensive traffic .Uncoordinated transmissions often incur a number of duplicate packets, which are further forwarded in the network, occupy the limited network resource, and hinder the packet delivery performance. Existing solutions to this issue, e.g. overhearing or coordination based approaches, either cannot scale up with the system size, or suffers high control overhead. We present Duplicate-Detectable Opportunistic Forwarding (DOF), a duplicate free opportunistic forwarding protocol for low-duty-cycled wireless sensor networks. DOF enables senders to obtain the information of all potential forwarders via a slotted acknowledgement scheme, so the data packets can be sent to the deterministic next-hop forwarder. Based on light-weight coordination, DOF explores the opportunities as many as possible and removes duplicate packets from the forwarding process. We implement DOF and evaluate its performance on an indoor test-bed with 20 Telos B nodes. The experimental results show that DOF reduces the average duplicate ratio by 90%, compared to state-of-the art opportunistic protocols, and achieves 61.5% enhancement in network yield and 51.4% saving in energy consumption.

Keywords- opportunistic routing, low-duty cycled, duplicate packet.

1. INTRODUCTION

Wireless sensor networks (WSNs) [1], [2] are mostly battery-powered and thus energy-constrained. In order to save energy, sensor nodes are duty-cycled and rely on multichip forwarding to deliver data to the sink. Design of data forwarding mechanism, which guarantees the packet delivery ratio (PDR) and keeps the energy consumption low, is a crucial and challenging issue in low-duty-cycle WSNs. A widely adopted low-duty-cycle protocol is X-MAC [3], in which sensor nodes sleep and wake up asynchronously. To guarantee transmission of a data packet from sender to receiver, the sender has to keep sending multiple copies of the same packet (called preamble) for a long period that exceeds the sleeping period of the receiver, called Low Power Listening(LPL). As a result, if the forwarder is deterministic, the end-to-end delay is likely high. Obviously, sender energy is wasted on waiting for the forwarder. The duty-cycled communication nature makes the deterministic forwarding schemes inefficient. To shorten the waiting time, an intuitive idea is to take the earliest forwarding opportunity instead of waiting forth deterministic forwarder, like opportunistic routing [7]. Temporally available links may be exploited to reduce the transmission cost in wireless mesh networks. In order to address the above issues, we propose Duplicate Detectable Opportunistic Forwarding (DOF). Instead of direct data transmission in LPL, a sender sends a probe and asks the potential forwarders to acknowledge the probe respectively in different time slots. By utilizing the temporal diversity of multiple acknowledgements, the sender detects the quantity and differentiates the priority of all potential forwarders. The sender then forwards its data in the deterministic way to avoid multiple forwarders hearing the same packets. We develop methods to resolve possible collisions among multiple acknowledgments and exploit temporal long good links for opportunistic forwarding. With the light-weight mechanism to suppress duplicates, DOF can adapt to various traffic loads in duty-cycled sensor networks and enhances the system performance with respect to both network yield and energy efficiency.

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2. RELATED WORK

Routing over Duty-cycled WSNs including i) Opportunistic

Routing (ORW) ii) Deterministic Routing. Opportunistic routing schemes that exploit the broadcast nature of wireless transmissions and dynamically select a next-hop per-packet based on loss conditions at that instant are being actively explored. These protocols exploit the redundancy among nodes by using a node that is available for routing at the time of packet transmission. In traditional deterministic forwarding, continuously sends the data to the predetermined relay node until it wakes up. As to deterministic routing, it includes shortest path routing, minimum-hop routing, on-demand routing (AODV), geographic routing etching 2014 Zhichao Cao proposed Lazy Forwarding that is a node is able to dynamically schedule data forwarding to multiple good parents instead of one deterministic parent. In 2014 Ashfaq Ahmad proposed cluster heads (CHs) with adaptive clustering habit (ACH)2) scheme for WSNs .In DOF ,it enables senders to obtain the information of all potential forwarders via a slotted acknowledgment scheme, so the data packets can be sent to the deterministic next-hop forwarder

3. PROPOSED WORK

In our approach, DOF enables senders to obtain the information of all potential forwarders .With this information, the data packets can be sent to the deterministic next-hop forwarder and finally it reaches the sink**.** This process is performed by the following task as

1) Probe Broadcast
2) Slot Assignment
3) Forwarding Strategy
4) Duty cycle Routing

A) Probe Broadcast:

As Fig. 1(a) shows, sends packets to the intended destination R2 (a destination is the final receiver like the sink node).There are three potential forwardersR1, R3, and R4 (a forwarder is one relay node along the routing path). The links are either reliable or burst, indicated as the solid or dashed lines, respectively. As Fig. 1(d) shows, instead of directly sending data, a sequence of probes is first broadcast by S. The interval of two adjacent probes is divided into multiple time-slots. Each slot is long enough to receive an ACK. When R1,R2, and R3 receive one probe and any of them offers routing progress, each of them independently selects a slot (2, 0, and 4) to send the ACK back. According to the slot information of the received ACKs (0 and 4), S sends the data packet to a forwarder (R2) by adding in the slot information (0).

The routing progress of different forwarders should be distinguished because the forwarder with more routing progress should be used with a higher priority. However, the data ACK loss over these links may lead to undesirable retransmissions due to the burst loss. Thus, the short-term link performance should be considered.

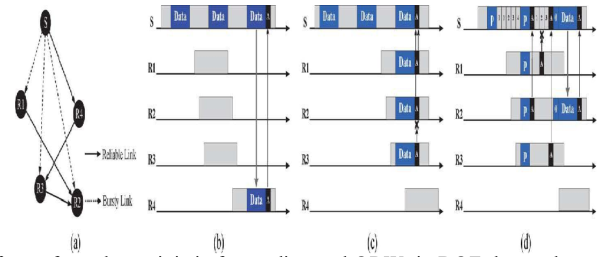

Fig 1 Different from deterministic forwarding and ORW, in DOF the sender distinguishes the multiple waking forwarders by the temporal diversity of ACKs. Then, it sends the data packet to an exclusive forwarder by adding in the ACK slot information. (a) Topology. (b) Deterministic forwarding. (c) ORW. (d) DOF.

B) Slot Assignment:

DOF send data packet to deterministic forwarder via slot assignment. There are two requirements for slot assignments) multiple forwarders should be distributed into different slots .ii) the sender should infer the routing progress of different forwarders by ACK slot distribution. When forwarder receives probe which is sent by S, forwarder sent routing progress along with ACK slot to the S.

Sender maintains priority sequence. The priority sequence is like a ruler to measure the routing progress. The forwarder matches its routing progress to a location on the priority sequence. When forwarder receives the probe sent by S, the routing progress is calculated by (1) is carried in the probe, and is local routing information. If is larger than, we set it as. By (2), the routing progress is mapped to a location in the priority sequence. A forwarder with a larger routing progress is mapped into the head area of the sequence.

TABLE I

DESCRIPTION OF THE SYMBOLS IN THE ACK ASSIGNMENT ALGORITHM

Symbol	Description
W_s	the routing metric value of the source node
Δ_{max}	the maximum routing progress over one hop
N	the total length of the priority sequence
M	The total number of ACK slots
L	the number of priority zone of ACK slots
R	the number of ACK slots in each priority zone

C) Forwarding Strategy:

A forwarder may serve multiple senders during a short period. Each forwarder maintains a sender table, which records the ACK slot information to trace the potential senders. Each entry of the sender table includes the following: the sender's address, expected data sequence number (DSN), and the selected ACK slot. When a probe is received, the forwarder first checks the attached routing metric of the sender S. If the forwarder can provide routing progress, it selects an

ACK slot to acknowledge the sender. Then, if there is a record of the same sender, the forwarder updates the corresponding record in the sender table. Otherwise, the forwarder adds a new entry into the table. Upon the acknowledged probe, the sender attaches the DSN and the selected ACK slot number as the virtual intended forwarder address. When the forwarder receives a data packet, it queries the sender table. If there is no matched entry, the forwarder drops the packet and does nothing. Otherwise, it will take the responsibility to forward the data packet. When the sender prepares to send a batch of packets, the intended forwarder will keep awake during the batched sending. Besides the probes of the first packet, the probes of the rest of the packets are not needed. Thus, to save the extra overhead of the probe Transmission, the sender directly sends the rest of the packets with the connection (called Tunnel) found by the probes of the first packet until either the loss of data ACK or there are no pending data packets.

D) Duty-Cycle Routing:

In DOF, a packet is sent to one of the waking neighbors, which provides certain routing progress. As a result, the routing topology toward the sink is not fixed. A packet may be forwarded to the sink along different paths. Moreover, considering the unsynchronized sleep schedule in LPL, DOF drives two requirements on routing. First, the routing metric should reflect the waiting time of the link-layer transmissions. Second, each node should adaptively choose a set of forwarders from all neighbors to determine the local routing metric. Expected duty cycle process is considered as the local metric. EDC estimates the Expected Transmission count (ETX) based on the number of wake up events observed from each of the forwarders.

4. Experimental Result

We implement DOF on TelosB nodes in TinyOS 2.1.1. The RAM and ROM consumption of the program are 6268 and 39714 B, respectively. We compare the network yield, energy consumption, duplicate ratio of DOF to two unsynchronized low-duty-cycled forwarding protocols such as ORW and CTP-XMAC. PRR as the indicator of the network yield. The PRR of DOF is still higher than 90% and 70% when the IPI is 2 and 1s, respectively. When the IPI is 1 and 2 s, the network yield of DOF is about 46.5% and 61.5% higher than the best of ORW, CTP-AMAC, and CTP-XMAC. DOF can keep the energy consumption low for various traffic loads. DOF utilizes the probe to detect potential forwarders so that it induces a low communication overhead. DOF always keeps the duplicate ratio low, which is close to the duplicate ratio of CTP-XMAC in different traffic loads.

5. CONCLUSION

Developing an adaptive and efficient forwarding protocol is urgent for a duty-cycled wireless sensor network. We propose DOF, a duplicate-detectable unsynchronized low-power opportunistic forwarding that is adaptive to various traffic loads. Based on the slotted acknowledgment, DOF mainly solves the channel degradation problem incurred by the large amount of duplicates in traditional opportunistic forwarding and retains the benefits of the opportunistic routing as much as possible.

6. FUTURE WORK

Duplicate Detectable Opportunistic Forwarding (DOF) is used to remove duplicate packets from being forwarded. DOF overcomes duplication using opportunistic forwarding scheme. DOF is suitable for small scale network. Developing a DOF for large scale network is future enhancement.

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