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Analysis of Classical Routing Algorithms on Different Contention Based MAC Protocols for Wireless Sensor Networks

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Abstract. *W*ireless sensor networks (WSNs), many constraints of nodes. A variety of classical routing algorithms have been developed for data gathering in wireless sensor networks. Sensor extract useful information from environment, this information has to be routed through several intermediate nodes to reach the destination. Information can effectively disseminate to the destination is one of the most important tasks in sensor networks. This paper shows the analysis results of a simulation using ns-2.33 simulator for two classical routing algorithms namely: Flooding and Omniscient. Simulating results shows that the omniscient multicast protocol has good performances in terms of using additional routing metrics remaining energy, routing load and dropped packets, comparison to flooding routing protocol in wireless sensor network.

Keywords: Wireless Sensor Networks, Omniscient, Flooding, Routing Protocol, Energy Efficient.

1. Introduction

A wireless sensor networks (WSNs) with limited computing and wireless communication capabilities are becoming increasingly available for commercial and military applications. In other way, the data may have to travel multiple hops before reaching the sink. Similarly, the query commands issued by users or the sink may have to go through multiple hops through the network to obtain some particular information which is collected by different sensor nodes at different locations. Therefore, it is essential to deploy efficient scheme in the wireless sensor network to select paths going through multiple hops and forward data from source to destination, which is a major functionality of the routing process.

The WSNs have the advantages of fault tolerance, easy deployment and accurate sensing, which can be applied in many fields, such as battlefield surveillance, environment monitoring, industrial sensing and diagnostics, critical infrastructure protection and biological detection [1], [2],[3]. Once deployed, nodes in the network in many current applications of wireless sensor networks are stationary. Energy efficiency is one of the most common concerns to be effectively addressed in the design of routing schemes for WSNs. Many research efforts have been devoted to developing energy-aware routing protocols for WSNs. However, in general, energy consumption is not a concern at all in classical routing protocols. Sensor nodes are constrained in resources such as energy, bandwidth, memory, and computing capability. Such constraints combined with the aforementioned challenging issues necessitate the invention and development of new routing solutions for WSNs. There is extensive research occurring in the area of protocol design for WSNs. Communication in wireless sensor networks is minimize the energy consumed by unattended battery-powered sensor node[5].

As a result of this many different data dissemination protocols have been proposed to solve WSNs challenges [4][5][6][7]. Each design is based on different assumptions and intuitions regarding the application scenarios of the network and its operational behavior. Although each of the protocols claims to solve some of the challenges identified during the development process. In all above mentioned applications, the network consists of tens to millions of tiny devices. Each device carries one or more sensors and has limited signal processing and communication capabilities. Usually, the devices are powered by batteries and can thus only operate for a limited time period. Key to implementing a network with such devices is that energy, computing power and communication bandwidth are scarce. Therefore, lightweight, scalable, energy-conserving communication protocols are essential to the successful operation of the network. Fast deployment of such a network and robustness against device failures require an ad-hoc network that is self-organizing. In general, radio communication (both transmitting and receiving) is generally the operation that consumes the most energy in a device.

In typical sensor applications, the energy consumption is dominated by the node's radio consumption. it can be concluded that power consumption in sleeping mode is negligible to the power consumption in active mode. Since the radio is controlled by the MAC, the MAC is central in optimizing the WSN's lifetime. In addition, note that different node powering mechanisms are available, such as nonrechargeable battery; rechargeable battery with regular recharging (e.g. sunlight); rechargeable battery with irregular recharging (e.g. opportunistic energy scavenging); capacitive/inductive energy provision (e.g. active RFID); etc. This has also an influence on the choice and design of the MAC protocol. In conclusion, the aim of a WSN design is to guarantee its longevity under the given energy and complexity constraints. The MAC plays a central part in this design since it controls the active and sleeping state of each node. The MAC protocols hence needs to trade longevity, reliability, fairness, scalability and latency; throughput is rarely a primary design factor.

As specified, WSNs are characterized by similar networking architecture as ad-hoc networks, and so the ad-hoc MAC concepts are valid in sensor scenarios. The popular IEEE 802.11 Distributed Co-ordination Function (DCF) [8] is a contention-based channel coordination method for ad-hoc scenarios, which can be energy optimized to suit WSN needs. The research in Energy-Aware MAC protocols [9]. In this paper carried purely contention based MAC protocols like: always listening –MAC and energy aware-MAC, below we briefly describe. In conventional ad-hoc address oriented communications protocols, such as IEEE 802.11 [10], generally consume too much energy or poorly support multi-hop networks, next section describe in brief manner.

The IEEE 802.11 [11] is the standard MAC layer which is proposed for wireless local area networks. This scheme is a contention-based protocol which can be operated in ad-hoc mode. In IEEE 802.11 specifies the Distributed Coordination Function (DCF) which is based on CSMA/CA. A transmitter must wait for a channel to be idle for Distributed InterFrame Space (DIFS) amount of time before it can start to transmit. If the channel is sensed busy, either immediately or during the DIFS, it backs off its transmission by a random amount of time to avoid collisions. The time after the DIFS period is slotted and a node is allowed to transmit only at the start of a time slot. The backoff scheme is exponential. The backoff time is uniformly chosen in the range (0, W), where W is the contention window (CW). W is variable in nature and its initial value (the first time a node has to backoff) is CWmin. Each time a node has to backoff for the same frame after the first backoff, it doubles the contention window. There is a CWmax, beyond which the window is not incremented. DCF uses ACKs sent by the destination to judge whether a frame was successfully received or not. A maximum of 8 retries are allowed after which the frame is dropped from the interface queue.

Here describe other variant of MAC is known as energy aware contention based protocol, name is Sensor-MAC (S-MAC) [12] - It has been designed for sensor networks where energy consumption is a major criteria. In S-MAC, a node sleeps for a certain period of time and is awake for a certain period of time. These periods repeat in cycles and the total time is the time taken to complete one cycle. Otherwise the protocol is very similar to the DCF protocol as described above as it uses RTS/CTS for hidden terminals, RTS/CTS/DATA/ACK cycle, randomized backoff time and carrier sensing. The basis of this protocol is not to overhear frames which are not destined for it. It does this by going to sleep. A node co-operates with its neighbours so as it knows when it can sleep and when it should be in the listening mode.

The rest of the paper is organized as follows. A brief overview of the each protocol that is included in this work is given in Section II. Section III is devoted to an explanation of the simulation environment. The results of the comparisons are located in Section IV. Finally Section V sets out to conclude this work.

2. Classical Routing Algorithms in WSNs

This section describes two classical routing data dissemination algorithms namely: Omniscient Multicast and Flooding. In [5] [13] the authors use traditional protocols namely: Omniscient and Flooding for dissemination of data in sensor networks and compare to directed diffusion. However these protocols still operate in and address-oriented fashion. This work concentrates on the direct comparison of two classical data dissemination schemes on continuous sensing and energy aware MAC protocols.

2.1.Flooding Protocol

In the flooding algorithm every incoming packet is sent through every outgoing link. In flooding each node acts as both transmitter and receiver. When a node needs to send a packet it will send the packet through all links except the source node. Since the node sends a packet through every outgoing link the packets will be delivered indisputably. In these algorithms have two problems comes out like: *Implosion:* If

Sensor node sends data through multiple links duplicate messages may be retrieved (implosion). And overlapping. Other one *Overlap:* When the two sensor nodes sense the same information, it sends the overlapped data to the same node. Eventually, Flooding wastes the available energy and bandwidth by sending duplicate copies

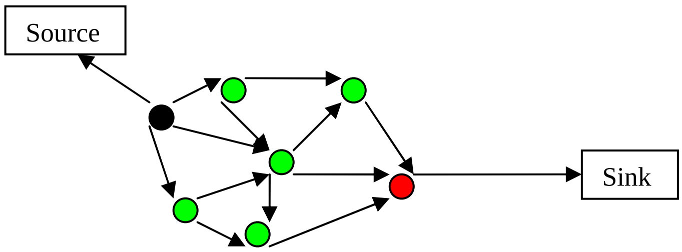

Fig.1. Flooding Protocol

2.2.Omniscient Multicast Protocol

In the omniscient multicast scheme, each source transmits its events along a shortest path multicast tree to all sinks. Analysis of omniscient multicast, as well as do not account for the cost of tree construction protocols. Rather centrally compute the distribution trees and do not assign energy costs to this computation. Omniscient multicast instead indicates the best possible performance achievable in an IP-based sensor network without considering overhead. Omniscient multicast offers the advantage that it is not dependent on fixed multicast trees, as could be defined in fixed, wired topologies, but routes packets based on definition of information sinks. At each node, when the router layer receives a packet, it decides whether to pass the packet up the stack based on the sink table it maintains. Omniscient multicast is unrealistic in that it assumes all route information is available at no cost.

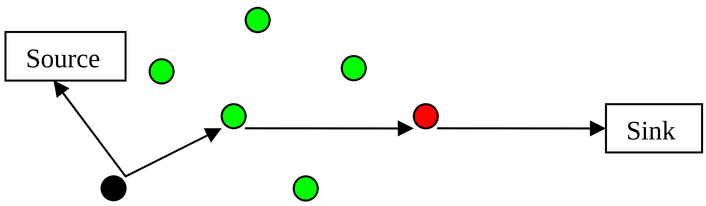

Fig. 2. Omniscient Multicast Protocol

3. Simulation Methodology

This section describes the simulation methodology and the performance metrics used for the comparison of two classical routing algorithms using contention based approaches for WSNs. Ns-2.33[14] used for the simulation of protocols. Both classical protocols comparison has done the same topology scenarios.

3.1. Simulation Parameters

Following simulation parameters are used in the simulation process.

Table 1. Simulation Parameters

Parameters	Values
No of nodes	30
No of Source/Sink	1
Network dimension	800*800m
Size of data packets are	64 bytes
Interval time	0.167s
Radio transmission range	40 meters
Simulation time	30 seconds
MAC protocols	IEEE802.11/SimpleMac/SMac
Idle power dissipation	0.035W
Receive power dissipation	0.395W
Transmit power dissipation	0.66W
Node initial energy	10 joules

3.2. Metrics Used

Following performance metrics are used to evaluate and analyze the performance of classical routing algorithm:

- Average Dissipated Energy measures the ratio of total dissipated energy per node in the network to the number of distinct events seen by sink.
- Remaining Energy is different changes of the entire network remaining energy measures with the time changing in algorithm. The entire network remaining energy can indicate the lifetime of the sensor networks.
- Routing Load is ratio of the number of routing messages propagated by every node in the network and the number of data packets successfully delivered to all destination nodes.
- Dropped Packets is number of data packets that are not successfully sent to the destination during the transmission.

4. Simulation Results

This section presents detailed simulation results for two classical data dissemination routing algorithms namely: Omniscient Multicast and Flooding routing algorithms in wireless sensor networks.

4.1. Average Dissipated Energy

After simulation we got the value shown in Table2. These values show the average dissipated energy for Omniscient Multicast and Flooding protocols on various contention based MAC protocols. The values present that Omniscient Multicast using simpleMac contention based protocol has noticeably better energy efficiency than other approaches in wireless sensor networks.

Table 2. Average Dissipated Energy

Routing Algorithms	MAC Protocols	Time(Seconds)	Average Dissipated Energy(joule)
Flodding	IEEE802.11	30	2.645
Omniscient	IEEE802.11	30	1.372
Flodding	SimpleMac	30	1.698
Omniscient	SimpleMac	30	1.204
Flooding	SensorMac	30	3.455
Omniscient	SensorMac	30	6.362

4.2. Remaining Energy

Table 3 presents the different changes of the entire networks, remaining energy with respect to simulation time, and the results are showing that the entire network remaining energy in Omniscient Multicast using SMac protocol is much more than other protocols wireless sensor networks.

Table 3. Remaining Energy

Routing Algorithms	Using MAC Protocols	Time(Seconds)	Remaining Energy(joule)
Flodding	IEEE802.11	30	7.70
Omniscient	IEEE802.11	30	9.87
Flodding	SimpleMac	30	8.64
Omniscient	SimpleMac	30	9.89
Flooding	SensorMac	11	7.08
Omniscient	SensorMac	30	9.05

4.3. Routing Load

In table 4 presents the routing load of the entire networks with respect to simulation time for Omniscient Multicast and Flooding algorithms on using different contention based protocols. The entire network routing load in Omniscient Multicast using IEEE-802.11 is lower than other approaches. It means using other MAC variant is not good compare to IEEE-802.11.

Table 4. Routing Load

Routing Algorithms	Using MAC Protocols	Time(Seconds)	Routing Load
Flodding	IEEE-802.11	30	4.35
Omniscient	IEEE-802.11	30	0.25
Flodding	SimpleMac	30	3.69
Omniscient	SimpleMac	30	0.60
Flooding	SensorMac	11	3.86
Omniscient	SensorMac	30	0.33

4.4. Dropped Packets

Below table shows the packet dropped for omniscient multicast and flooding protocols with respect to simulation time. Flooding is much more dropped packets than Omniscient Multicast. It means omniscient multicast is gives better performance than flooding protocol.

Table 5. Dropped packets

Routing Algorithms	Using MAC Protocols	Time(Seconds)	Dropped Packets
Flodding	IEEE-802.11	30	471
Omniscient	IEEE-802.11	30	00
Flodding	SimpleMac	30	64104
Omniscient	SimpleMac	30	00
Flooding	SensorMac	11	00
Omniscient	SensorMac	30	00

5. Conclusion

This paper presented the comparative analysis on different routing metrics for two classical algorithms using different contention based MAC protocols for wireless sensor network. In this paper preliminary evaluation of performance, results shown that the performance of omniscient multicast algorithm using Sensor-MAC is better in terms of, remaining energy, routing load and dropped packets.

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