Performance Analysis of Routing Protocols in Heterogeneous Wireless Sensor Networks

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Abstract

Wireless sensor nodes are necessary for industrial applications. This paper presents a mathematical framework for the evaluation of the performance of proactive and reactive routing protocols in mobile ad hoc networks (MANETs). Each wireless node has a two customer queue without priority in that network models. Here the two types of customers are unicast and broadcast packets. In the previous method Zigbee protocol can be used. Here to improve the performance of reactive and proactive routing MAC protocols under various network configurations.

Key Terms

MAC protocol, wireless sensor node, reactive and proactive protocol.

1. Introduction

The MAC layer at nodes is as well as simplified as a two customer queuing model, where the packet loss probability and delay at nodes can be effectively computed. When analyzing the performance of the MAC layer, to consider the cases of a scheduled MAC (TDMA) and a contention-based MAC (802.11 DCF MAC). In the combinatorial model, the computed metrics are synthesized along with the routing logic to produce quantitative measures of the routing protocols in terms of end-to-end packet loss probability and delay.

It is important to note that this work does not attempt to model or compare between specific proactive and reactive routing protocols. Rather, the intent is to capture the essential behavior and scalability limits in the network size of both classes of protocols by quantifying their performance within a unified framework. The simulation results in this paper are not intended to provide an exact match with our analysis; they are provided only as a supporting evidence for the conclusions regarding to protocol behavior observed in literature.

Network configurations vary on traffic pattern, mobility and network density. Certain analytical study on routing overhead has been carried out. To Proposed a parametric models for proactive and reactive protocols to evaluate the individual routing control overhead. These studies concentrate on the impact of traffic patterns and they also provide a mathematical and simulation-based framework for quantifying the overhead of reactive routing protocols.

2. Related Works

DESCRIPTION OF PROTOCOLS

A. DSR

The key feature of DSR is the use of source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header.

When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route discovery works by flooding the network with route request (RREQ) packets. Each node receiving a RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply **(**RREP**)** packets that **is** routed back to the original source. RWQ and RREP packets are also Source round. The RREQ builds up the path traversed so far and also RREQ routes itself back to the source by traversing this path backwards. The route carried back by the RREP packet is cached source for future use.

B. AODV

AODV shares DSR on-demand characteristics in that it also discovers routes on an “as needed” basis via a similar route discovery process. However, AODV adopts a very different mechanism to maintain routing information. It uses traditional routing tables, one entry per destination. This is a departure from DSR, which can maintain multiple route cache entries for each destination. These DSR protocol without source routing AODV relics on routing table entries to propagate a RREP back to the source and subsequently, to route data packets to the destination. AODV uses sequence numbers maintained at cache destination to determine freshness of routing information and to prevent routing loops. These sequence numbers are carried by all routing packets.

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An important future of AODV is maintenance of timer based states in each node, regarding utilization of individual routing table entries. A routing label entry is “expired” if not used recently. A set of predecessor nodes is maintained for cache routing table entry, indicating the set of neighboring nodes that use that entry to route data packets. These nodes are notified with RERR packets when the next hop link breaks. Each predecessor node, in turn, forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link.

The recent specification of AODV includes an optimization technique to control the RREQ flood in the route discovery process. It uses an expanding ring search initially to discover routes to an unknown destination. In the expanding ring search, increasingly larger neighborhood’s arc searched to find the destination. The search is controlled by the TTL held in the IP header of the RREQ packets. If the route to a previously known destination is needed, the prior hop-wise distance is used to optimize the search.

C. LOGIC EFFICIENCY

The Behavior with steady traffic, the initial traffic and network setup cost are usually small and negligible. The operation of the traffic flow can then be generally classified into two alternating scenarios: data phase and exception phase.

1. During the data phase, the active path has been setup and data packets are delivered from □ to j along an active route.
2. The exception phase is triggered when a link failure is detected in the active path and an alternative path needs to be discovered. Let □□ and □□ be the mean duration of time for the data phase and the exception phase.

D. OPERATION EFFICIENCY

During the data phase, data packets are unicasted along the active path from source to the destination. From a queuing perspective, nodes along the active path form a tandem network of queues. Since every node takes two kinds of traffic: broadcast packets and unicast packets, every node can be treated as a two-customer queue. Since nodes are modeled as M/G/1 queues, for queues to be stable and functional, we can infer the scalability constrain when data traffic between nodes originates from one same source rather than multiple independent streams. Compute complementary cumulative distribution function (CCDF) (□) characterizing the stability of topology for mean link life time.

3. System Scenerio

1. MOBILITY MODEL

Nodes are mobile and initially they are distributed equally over the network. The movement of each node is independent and unrestricted, i.e., the trajectories of nodes can lead to anywhere in the network. For node i € V = {1, 2. . . N} let {Ti (t), t ≥ 0} be the random process representing its trajectory and take values in Y, where Y denotes the domain across which the given node moves. To simplify the model, we make the following assumption on the trajectory processes.

Assumption: [Stationarity**]** each of the trajectory processes (Ti (t)) is stationary, i.e., the spatial node distribution reaches its steady-state distribution irrespective of the initial location. The N trajectory processes are jointly stationary, i.e., the whole network eventually reaches the same steady state from any initial node placements, within which the statistical spatial nodes’ distribution of the network remains the same over time.

The above assumption is quite fundamental in the sense that it lays the foundation for the modeling of node movement. Most existing models, (e.g., random direction mobility models random waypoint mobility models and random trip mobility model) clearly satisfy our assumption. In other words, our assumption ensures that, on the long run, the network converges to its steady state and the stationary spatial nodes’ distribution can be used in the performance analysis of the network.

2. Routing Protocols Model

To provide descriptions of generic proactive and reactive routing protocols, which we believe capture the essential behavior of many designs and implementations of existing routing protocols. However, this analysis, and hence the generic protocols below, does not consider any protocol specific techniques, such as multi-point relay, local repairs and route caching mechanisms.

2.1 Proactive Routing Protocol

In proactive routing protocols, every node maintains a list of destinations and updates its routes to them by analyzing periodic topology broadcasts from other nodes. When a packet arrives, the node checks its routing table and forwards the packet accordingly. Every node monitors its neighboring links and every change in its neighbour results in a topology broadcast packet. That is flooded over the entire network. Other nodes update their routing tables accordingly upon receiving the update packet. In a well-connected network, the same topology broadcast packet could reach nodes multiple times and therefore enjoy a good packet reception probability. In this paper to assume that every node reliably receives topology packets from other nodes.

2.2 Reactive Routing Protocol

In reactive routing protocols, nodes maintain their routing tables on a needed basis. This implies that when a new traffic session arrives, nodes have to set up the paths between sources and destinations before starting to deliver data packets. The process of path setup is called route discovery. Complementarily, another process called route maintenance is necessary to find an alternative path if a former path was broken.

1) Route Discovery

A mechanism initiated by a node i upon the arrival of a “new traffic session” in order to discover a new path to a node j. Node i floods the whole network with route request (RREQ) packets. Upon receiving the RREQ packet, node j sends out a route reply packet (RREP) along the reverse path to i. As a result, node i usually gets a shortest path to node j.

2) Route Maintenance

A mechanism by which a node □ is notified that a link along an active path has broken, such that it can no longer reach the destination node j through that route. Upon reception of a notification of route failure, node i can initiate a route discovery again to find a new route for the remaining packets destined to j.

In reactive routing protocols, each node does not maintain routing tables before a routing task is triggered. They only find a route on demand by flooding the network with RREQs before sending data packets sender broadcasts router request and initiates a route discovery process. If a link breakage is detected during packet delivery, a new RREQ is generated. The main disadvantages of such algorithms are high latency time in finding routes and excessive flooding when traffic load is high.

4. MAC PERFORMANCE

One is global time division multiple access (GTDMA), serving as a lower achievable bound. The second one is still a TDMA scheme, but the scheduler is optimally designed (LTDMA). In practice, there is none of such schedulers because it needs instant global topology information and a design of such schedulers is known as NP problem. However, we still consider such schemes, serving the purpose of an upper performance bound for scheduled MAC. Finally, we consider the widely deployed contention-based MAC scheme, 802.11 DCF MAC, targeting at more practical protocol analysis.

A. Global Time Division Multiple Access

In GTDMA scheme, the channel access of nodes is organized as frames in time and each frame is further organized into N slots. In every frame, every node in the network is assigned a slot for transmission and the duration of slot should allow nodes to transmit the maximum transmission unit (MTU). Let Δg be the duration of a slot and the duration of a framework will be Δf = N Δg. In such fashion, every node will get one slot to send out one packet (either broadcast packet or unicast packet) for every Δf time. During the scheduled access, there will be no collision in packet transmission and thus it is safe to assume that the packet loss probability will be zero, i.e. pe = 0. It is also clear that every node enjoys a deterministic service time as of Δf.

B. Local Geni-TDMA

Contrary to GTDMA, LTDMA is a localized TDMA scheme where the transmissions of nodes are scheduled locally. For node i, if it has Nr − 1 neighbors, the channel access is still grouped as frames but each frame has only Nr slots for all Nr nodes, who are within coverage of node i. However, the design of such a scheduling scheme for all nodes without collisions is sometimes impossible and a NP-hard problem. To assume that there is always one such Geni-scheduler and the obtained results serve as an upper bound on performance. For such a scheme, the packet loss probability is also zero pe = 0.

However, it is clear that because of network mobility the number of nodes within a communication circle, Nr, is a random variable rather than a constant value. By simplifying the analysis and referring our previous analysis for GTDMA, we represent the service time for LTDMA as a random variable $SB = \Delta g$ Nr, with the average and covariance values as follows

$$VB = VU = Var\ (\Delta g Nr) = \Delta 2g$$

$$SB = SU = E\ (\Delta gNr) = \Delta g\ E\ (Nr)$$

Where Δg denotes the time duration of a slot and Var (.) is the variance operator of a random variable.

C. Contention-based MAC

To consider the definition of well-known 802.11 DCF MAC employing carriers sense multiple accesses with collision avoidance (CSMA/CA). In such a scheme, broadcast packets and unicast packets are processed differently and will therefore have different service time. For unicast packets, a rotating back-off mechanism is adopted to resolve contention. For the first trial of transmission of a packet, if the channel is sensed to be idle for an interval greater than Distributed Inter-Frame Space (DIFS), the node initializes a back off timer. And the value of back off timer is uniformly selected within the initial contention window (CW) CWmin.

For broadcast packets, no retransmission is attempted and no ACK is needed. Each broadcast packet is transmitted only once. Therefore, broadcast packets only need to go through the first trial phase of unicast packet transmission, i.e., the phase with the initial contention window of CWmin.

1. First, check which kind of MAC protocol the system employs and derive corresponding MAC parameter values, such as service time and packet loss probability.
2. Second, check which kind of routing protocol it is (proactive or reactive), and then use previously derived MAC parameters and corresponding equations constructed in our analytical model to derive various evaluation metrics, such as protocol efficiency, delivery ratio, delay and so on.
3. Although differences exist between analytical and simulation results for both reactive and proactive protocols, our analytical results provide a satisfactory approximation to the simulated performance. Our model succeeds in capturing the core behavior of routing protocols, which is the main goal of our work.

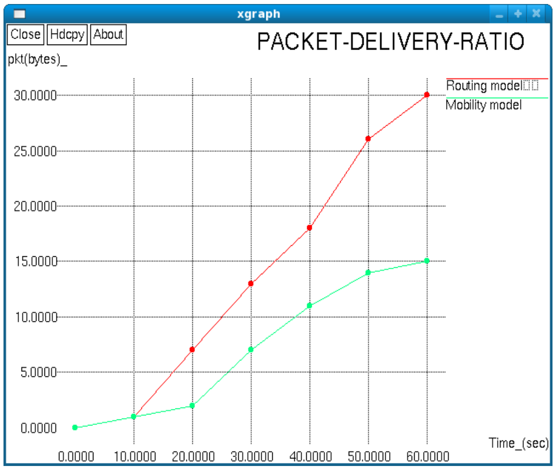
5. simulation results

In this section, we will present simulation environment used to evaluate our scheme and then present our experimental results. Simulation is carried out in NS2 under LINUX (FEDORA) platform for analyzing the controlled packets, used energy, delay and average active time of the nodes.

Parameters

Remaining Energy: In this section, we aim to validate the effectiveness and correctness of our analytical framework in capturing core behaviors of certain kind of routing protocols, rather than providing precise analysis for specific protocol. And also prove that our analytical model is capable of presenting the effect of various parameters on the performance of routing protocols. Similarly, our parametric analytical framework could also capture the essential insights and behaviors of routing protocols in terms of packet delivery delay under various network scenarios.

For each configuration, the simulation result is obtained from 10 random runs. Each simulation run is conducted with a randomly generated seed with duration of 30 minutes. Since our proposed analytical model includes both MAC and network layer parameters, we can comply two steps to evaluate certain kind of routing protocol under specific network configurations.



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Finally to simulate the remaining energy and delay performance based on the different network configurations.

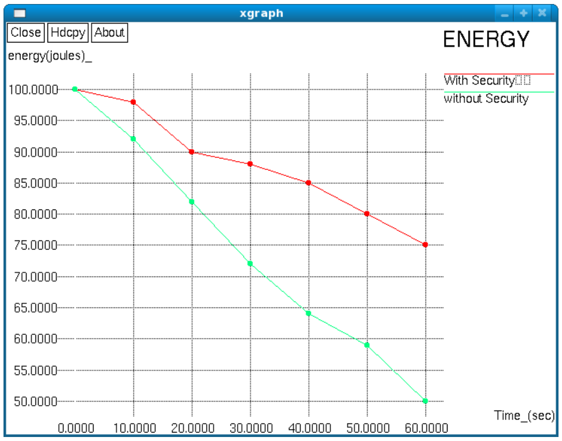

Fig.1. Remaining Energy

End to End Delay: The amount of data that are transmitted form the Transmitter to Receiver should reach with maximum probability of success. The old data can be retransmitted to increase the reliability but will result in delay. Hence a trade- off should be managed between the reliability and delay.

Average Active Time: The nodes should be active only when they are transmitting the message. Otherwise, the nodes will consume more energy.

Delay: Delay is one of the main problems in Wireless Sensor Networks. In general, delay will be high in Wireless Networks while comparing with the Wired Networks. If a message does not reach the controller within the given time, there will be no use. The delay should be reduced in order to increase the efficiency of the network.

Our model succeeds in capturing the core behavior of routing protocols; this is the main goal of our work. Since our analytical model focuses on core behaviors of proactive and reactive protocols while in simulation tool protocols are fully implemented, the difference between analytical and simulation results could be expected and reasonable.

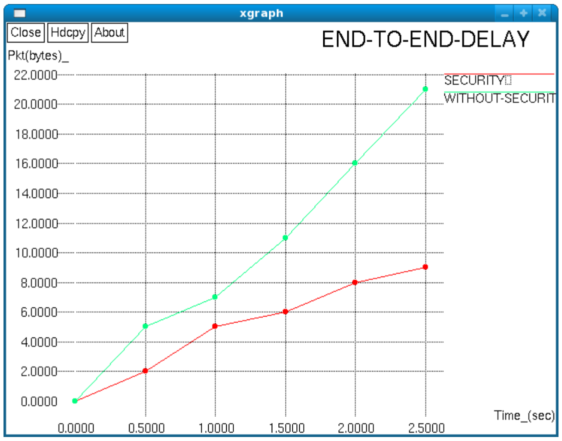

Fig.2.End-to-End Delay

However, for reactive routing protocols obvious difference between them for light traffic exists which is expected and reasonable, since AODV implemented in Ns-2 includes periodical Hello message schemes. To detect link failure which causes the waiting time of routing packets increase for being sent out and in turn causes packet delivery delay larger than that derived from our analytical model which aims to present essential behaviors and does not include Hello message scheme for reactive routing protocols.

6. Conclusion

In that model, the operation of the routing protocol is synthesized with the analysis of the MAC protocol to produce a parametric characterization of protocol performance. The effectiveness and correctness of the model are corroborated with extensive simulations. The model enables in-depth understanding of routing protocol performance, and points out the need to design routing protocols that are capable of confining signaling overhead to those portions of the network where the routing information is needed, in order to operate efficiently under different types of mobility and traffic patterns. our parametric analytical framework could also capture the essential insights and behaviors of routing protocols in terms of packet delivery delay under various network scenarios.

7. Future work

This paper proposes further research into more techniques of Wireless Sensor Networks. Currently it focuses mainly on monitoring applications which can be used in Industrial level. As future work to design a framework for different heterogeneous WISNs and also to improving the energy consumption by using of MAC protocol.

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