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Optimal Performance of Multicasting in Mobile AD HOC Network in Synchronization of Distributed Systems

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Abstract

In current distributed systems several functions are offered by some dedicated process in the system. One might think of address assignment and registration, query co- ordination in a distributed system, clock synchronization, token generation after token loss, and so forth. Usually many processes in the system are capable to offer such functionality. However, at any time only one process is allowed to actually offer the function. Sometimes it suffices to elect an arbitrary process, but for other functions it is important to elect the process, which is best in this dissertation work, we consider a distributed leader election (LE) protocol which elects the most favorable process. Each process has a fixed unique identity and a total ordering exists on these identities, known to all nodes. We assume a finite number of nodes. The leader is defined as the process with the smallest identity among all participating nodes. Realistic distributed systems are subjected to failures. The problem of leader election thus becomes of practical interest when failures are anticipated. Thus, a leader has to be elected from a set of processes whose elements may change continuously. Nodes communicate with each other by exchanging messages via a broadcast network. This network is considered to be fully reliable. All nodes except the sending node itself receive a broadcast message. Communication is asynchronous and order preserving.

Leader election is a special case of distributed consensus problems. For instance, in conventional routing protocols, a number of characteristics are identified by which the existence of a solution for the distributed consensus problem is determined. In mobile ad-hoc network, the problem of electing a node as leader is solvable since we consider order-preserving message delivery, broadcast communication and atomic send and receive.

Due to the complexity of the design of a fault-tolerant LE protocol a step-wise refinement is adopted. That is, we develop a fault-tolerant protocol in three steps, each step resulting in a LE protocol. We start with rather strong and unrealistic assumptions about process and system behavior. In each subsequent step these assumptions are weakened and a protocol is constructed starting from the protocol derived in the previous step. In our initial design processes are considered to be perfect and a leader is assumed to be present initially (destination, towards which all messages are directed is considered as leader according to TORA). A node may participate spontaneously, but it does not crash.

1. Introduction

In the first step, instead of having a single destination-oriented DAG, it is ensured that each component eventually forms a leader-oriented DAG. In the second step, when a partition from the current leader is detected (using TORA mechanism), a new leader is elected and its id is propagated throughout the component. And when two components merge, a contest takes place between the leaders so that the winner's id is propagated and wipes out the loser's id.

Finally, in the last step, when multiple changes occur, additional complications arise. This is due to the fact that while a new leader's id is being propagated changes could occur in the component and the process of electing a leader may be repeated.

As efficiency plays an important role in the design of leader election protocols. We focus our analysis on the worst case message complexity which indicates the maximum number of messages needed to elect a leader.

Existing designs are mainly focused on reducing message and time complexity, scarcely paying attention to protocol verification, let alone providing a formal approach to verification. However, for the design of complex communication protocols formal methods are indispensable.

2. Literature survey.

The problem of leader election was originally coined by in the late seventies and various LE protocols have been developed since then. A broad range of solutions exists varying in network topology, mesh, complete network, communication mechanism (asynchronous, synchronous), available topology information at processes and so forth.

3.1 Leader Election Algorithms.

A possible straightforward solution to a broadcast network is to superimpose a topology-like a ring –on it and to adopt a well- known solution for this topology. However, existing solutions are aimed at distributed systems that are assumed to behave perfectly- no failures are anticipated and a fixed number of participating processes is assumed. Moreover, the specific characteristics of broadcasting are not exploited.

Realistic distributed systems were subject to failures. A few LE protocols are known that tolerate either communication link failures or node failures or process failures. In the LE problem with a similar failure model and using broadcast communication is considered, however, no ordering between nodes is considered.

In Mobile Ad hoc Networks, topology is instantly changing and prone to link failures. In such situations many parameters have to be kept track of such as number of nodes, mobility of the nodes, communication range etc. In such contexts, electing a leader becomes difficult. We consider that the links may fail or form at any time. Here a LE protocol is constructed which tolerates transient link failures. This protocol belongs to the category of self-stabilizing protocols.

4. Protocol Simulation and Implementation

The system provides a platform for the simulation of mobile Ad hoc networks. The system is designed with the following goals in mind.

- **Object Oriented Design.**

This system is built in terms of self contained modules that can be easily replaced, modified and reused. It has a higher level of abstraction, thus providing a seamless transition among different phases of development.

- **Generic Simulation Environment.**

The designed system should model a mobile Ad hoc network in general sense. It should facilitate the creation and manipulation of state of several network entities such as nodes, network area etc. it should facilitate the plugging in of several protocols that manage the network.

- **Parallel execution.**

The system should allow the activities of the various network entities to be performed in parallel. A parallel model when compared to a sequential one provides higher flexibility and makes the system closer to the real scenario.

- **Statistical Evaluation.**

The system should provide for the collection of various performance metrics of the network. The data for evaluation should be collected at regular intervals and this process should not affect the normal functioning of the other network entities.

- **Scalability.**

The system should scale easily in terms of the network area, number of network entities etc., without high overhead on the rest of the system.

4.2 Simulation Model

We have considered the ad hoc network confined to an environment of 500 X 500 units. The number of nodes was chosen to be 10 nodes for different simulation runs. The simulator generates initial locations (x and y coordinates) of n nodes using uniform distribution. The node identifiers are fixed during the simulation. We assume that no node fails during the simulation.

We assume that all nodes have same transmission range R and this transmission range is specified during the start of the simulation. If the distance between two nodes is less than or equal to R then the two nodes are neighbors (i.e. connected by an edge in the ad hoc network) otherwise they are considered to be disconnected. For the simulations, transmission range values 75, 100, 200 units were used. We assume that each node moves in the fixed environment of 500 X 500 units by pausing for a constant time. This pausing time is fixed during the start of the simulation. The direction of the movement is chosen randomly. Also, each node moves with an average speed v. The average speed is fixed during the start of the simulation. For the simulations, average speed values 5, 10, 15, 20, 25 units/unit times were considered. When a node hits the wall of the 500 X 500 region, the node bounces back and continues to move. Each node maintains a routing table to route the packets generated or relayed and a buffer to queue packets. For the simulation, the source and the destination is chosen randomly. The source node generates C data packets per unit time using a uniform distribution. For the simulation, the C value 10 was used.

In our simulations, we do not model the situation where multiple nodes attempt to send packets simultaneously and its delay introduction. Transmission errors are also not considered.

5. EXPERIMENTS AND RESULT

5.1 Simulation Design

A design goal of our simulations was to evaluate the effect of varying the following three network characteristics.

- Network size
- Rate of topological change
- Network connectivity.

A well-designed series of tests can provide insight into TORA’s applicability for mobile wireless networks. Due to topological changes, TORA was expected to outperform other On-Demand Routing Protocols. TORA was expected to perform better in densityconnected networks, since this would tend to further minimize and localize its failure reactions.

The relative performance of the routing protocol simulated herein was based on measurement of the following parameters.

- ✓ Bandwidth utilization efficiency
- ✓ Number of data bits transmitted per message bit delivered
- ✓ Number of control overhead bits transmitted per message bit delivered
- ✓ Total message packet delay
- ✓ Message packet throughput (Fraction of packets delivered.)
- ✓ Mean message packet delay
- ✓ Message packet throughput (fraction of packets delivered)

These measures were intended to provide insight into the ability of the protocols to route packets to their intended destination, and efficiency of the protocol in electing a leader.

4.2 Results

Executing several sequences of simulations on each given network topology completed testing. In each sequence, one input parameter (e.g. link mean-time-to-failure or average network connectivity) was varied while the other parameters were kept constant. For each set of input parameters, all of the routing protocols were subjected to an identical sequence of random events. Foe each network topology (e.g. 10 nodes, 15 nodes, and 25 nodes), a suitable message traffic load was selected as follows:

A common, mean inter arrival rate for message packet generation in all nodes was selected just above the threshold where broadcasting message packets caused significant queuing delay. This corresponded to an environment where a more efficient routing algorithm than broadcasting could provide a lower, average packet delay. The traffic loads for the three networks were as follows: 4.0 packets/node/second for the 10 node network, 1.5 packets/node/second for the 15 node network and 0.6 packets/node/second for the 25 node network.

5. Network Size and Rate of Topological Change.

Running a similar sequence of simulations (over varying rates of topological change) on each of the different network topologies, provided insight into the effects of network size and rate of topological change on routing performance.

5.2 Network size : 10 nodes.

The first sequence of simulations was run on the 10-node network over varying rates of topological change, while the average network connectivity was held constant at 90%. The link mean-time-to- failure was initially set to 32 seconds, and reduced by one half for each successive simulation to one minute.

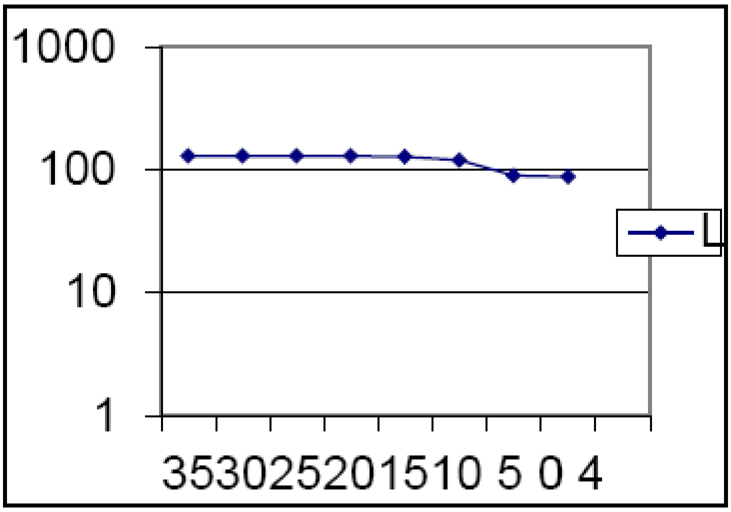

Fig. 1. Mean message packet delay as a function of rate of topological change-10 nodes with 90% connectivity.

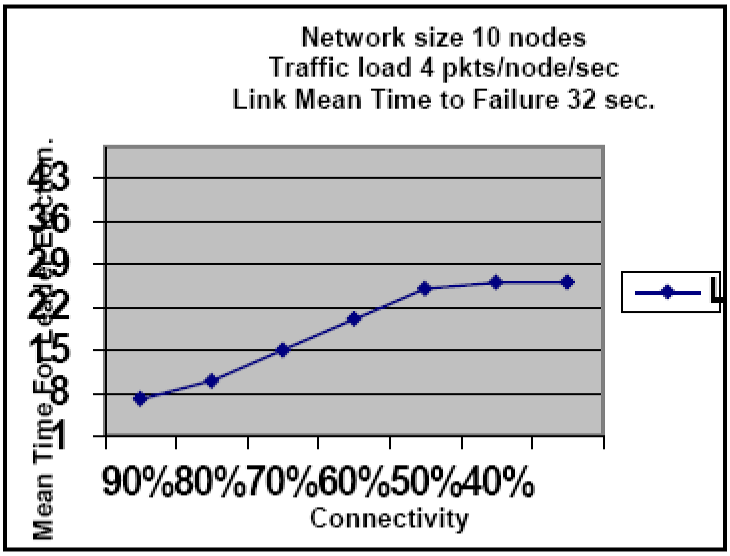

Fig. 2. Mean Time to Leader Election as a Function of Average Network Connectivity.

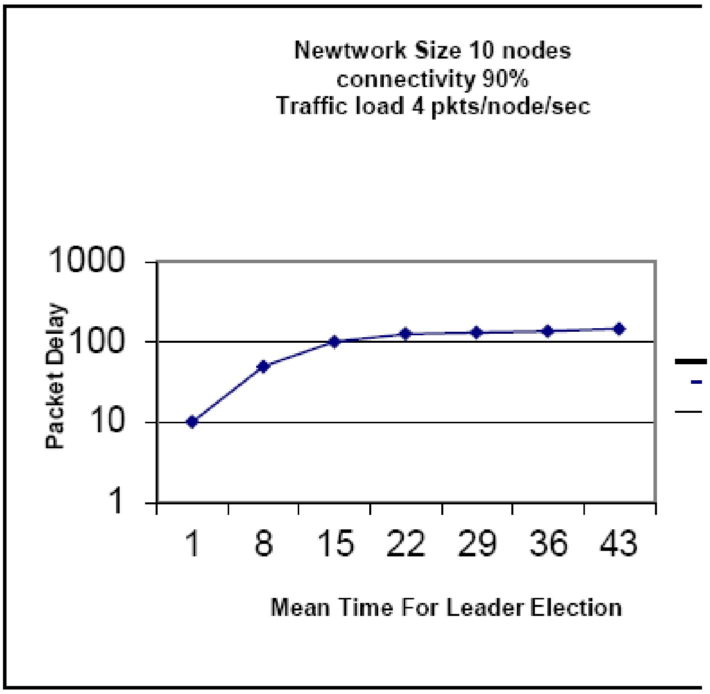

Fig. 3. Packet Delay as Function of Mean Time for Leader Election.

6. Conclusion and Future Work

The Simulations were designed to provide insight in to the effect of varying network size, average rate of topological changes and average network connectivity. While the network connectivity was found not to be significant factor

6.1 Conclusion

We have presented the details of the simulation model, design, implementation and analysis of results of simulation study. We have discussed the results of the simulation with the performance metric (i.e. ratio of “routing packets” and “data packets”) for different values of number of nodes, transmission range and moving speed. There is no clear idea for what these kinds of networks will be used. The suggestion varies from document sharing at conferences to infrastructure enhancement and military applications.

6.2 Future Work

This work designed, implemented and evaluated a wireless multi-hop ad hoc instant messenger with fully implementing the basic features of the TORA protocol along with a few design alternatives. It paves the way for more future work incorporating possibly more nodes and more optimized features of the TORA protocol. Other optimized features can be implemented and their performances can be evaluated, such as reducing route discovery reply packets for route discoveries performed, replying route request using cached routes, and so on.

Furthermore, future work can test performance of other routing protocols, such as AODV, DSDV, OLSR, geographical forwarding, etc. to compare against the TORA protocol. In order to optimize the use of constrained resources in an ad hoc network, mobility prediction and battery power conservation techniques can be developed and experimented to test the effect of these ad hoc routing protocols on a real application, such as the real ad hoc messenger developed in the paper. Moreover, our small-scale network consisting of only 10 to 25 nodes can be extended to a large-scale deployment with more mobile devices included using Bluetooth or IEEE 802.11 technology in the future.

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