An efficient protocol for load-balanced multipath routing in mobile ad hoc networks

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by

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Abstract

In this project, we propose a new routing protocol for load-balanced multipath routing in Mobile Ad hoc NETworks (MANETs). First we find k paths from source to destination and the data packets are distributed based on the routing time of the paths and the energy consumed by nodes in routing the data packet from source to destination along the paths.

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Chapter 1

Introduction

A mobile ad-hoc network (MANET) is a network composed of mobile nodes mainly characterized by the absence of any centralized coordination or fixed infrastructure, which makes any node in the network act as a potential router. MANETs are also characterized by a dynamic, random and rapidly changing topology. This makes the classical routing algorithms fail to perform correctly, since they are not robust enough to accommodate such a changing environment. Consequently, more and more research is being conducted to find optimal routing algorithms that would be able to accommodate for such networks.

Ad-hoc On-demand Distance Vector (AODV) [3] is one of the most popular routing protocol for MANET. AODV is a loop-free routing protocol for ad-hoc networks. It is designed to be self-starting in an environment of mobile nodes, withstanding a variety of network behaviors such as node mobility, link failures and packet losses.

Chapter 2

Literature Survey

2.0.1 Ad-hoc on-demand distance vector routing[3]

In AODV, nodes discover routes in request-response cycles. A node requests a route to a destination by broadcasting an RREQ message to all its neighbors. When a node receives an RREQ message but does not have a route to the requested destination, it in turn broadcasts the RREQ message. Also, it remembers a reverse-route to the requesting node which can be used to forward subsequent responses to this RREQ. This process repeats until the RREQ reaches a node that has a valid route to the destination. This node (which can be the destination itself) responds with an RREP message. This RREP is unicast along the reverse-routes of the intermediate nodes until it reaches the original requesting node. Thus, at the end of this request-response cycle a bidirectional route is established between the requesting node and the destination. When a node loses connectivity to its next hop, the node invalidates its route by sending an RERR to all nodes that potentially received its RREP.

2.0.2 . Optimized link state routing protocol (OLSR)[2]

OLSR is a proactive link-state routing protocol, which uses hello and topology control (TC) messages to discover and then disseminate link state information throughout the mobile ad hoc network. Individual nodes use this topology information to compute next hop destinations for all nodes in the network using shortest hop forwarding paths.

2.0.3 Fibonacci sequence based Multipath Load Balancing (FMLB) [4]

The FMLB protocol distributes transmitted packets over multiple paths through the mobile nodes using Fibonacci sequence. Such distribution can increase the delivery ratio since it reduces the congestion. The FMLB protocol's responsibility is balancing the packets transmission over the selected paths and ordering them according to hops count. The shortest path is used more frequently than the other ones.

2.0.4 Least Common Multiple based Routing (LCMR)[1]

The LCMR protocol finds multiple paths between a source to a destination, when those exist, along with the estimates of the time to route a packet along each of these paths. The data packets originating from the source to the destination are then distributed along these multiple paths in such a way that the number of data packets sent along any such path is inversely proportional to the routing time through this path. This distribution strategy keeps the load balanced along all the paths so that the overall routing time for sending the data packets is minimized.

Chapter 3

Problem Statement and Contribution

Multipath routing in Mobile Ad hoc NETworks (MANETs) is based on finding multiple paths from a source to destination and distributing the data packets according to some strategy which can lead to reduced routing time and better Qualtiy of Service(Qos).

3.0.1 Related Works

A routing protocol called Least Common Multiple based Routing (LCMR) [1] finds multiple paths and distribute the data packages along a path in inverse to the routing time of the path. This routing protocol performs better than Fibonacci sequence based Multipath Load Balancing (FMLB) [4] which distributes the data packages according to Fibonacci numbers and doesn't consider the routing times.

3.0.2 Our Contribution

In our protocol we consider routing time of a path along with the energy consumed in routing a packet along the paths. This can lead to reduced routing times and an energy efficient routing protocol and thus will provide better QoS. Our work is still going in as to how we will finally distribute the data packets according to the energy consumption and routing time both.

Chapter 4

Proposed Method

Our method generates a topology table (network graph) for every node based on the Optimized link state routing protocol (OLSR)[2] technique. This protocol generates k different paths from a source to destination using DFS/BFS algorithm on the topology tables. Then it sends packets along every path and measure the routing time and the energy consumption for every node on that path. For measuring the routing time and energy consumption of a path , first we calculate the initial energy on the nodes on that path and also record the time.Then we send the packet along that path, when it reaches the destination , we record the time again and also calculate the final energy. The difference between the two recorded times gives the routing path and the difference between the two energies will give the energy consumption of that path. Based on these two factor the data packages will be routed along these multiple paths.

4.0.1 Calculation of energy consumption

$$\text{Energy Consumption } = \mathrm{P}_t \times \frac{Number of bits transmitted}{Bit Rate}$$

$$\frac{P_t}{P_r} = \frac{(4\pi d)^2}{G_t G_r \lambda^2}$$

$$\mathrm{P}_t = P_r \frac{(4\pi d)^2}{G_t G_r \lambda^2} = P_r \frac{(4\pi d f)^2}{G_t G_r c^2} \approx 17.53 \times 10^{-16} \times P_r (df)^2$$

where, P_t = signal power at the transmitting antenna

P_r = signal power at the receiving antenna

λ = carrier wavelength

f = carrier frequency

G_t = gain of the transmitting antenna

G_r = gain of the receiving antenna

d = propagation distance between antennas

c = speed of light (3×10^8m/s) where d and λ are in the same units (e.g., meters).

Chapter 5

Simulation results

In the simulation, we used ns3 to find the paths between a source and a destination and the routing time of every path and the energy consumed in every path. We generated 25 random nodes and generated 6 paths from 1st node to 25th. The routing time and energy calculated for every path is shown in the table -

Table 5.1: Simulation results

Path no	Routing time	Energy consumption
1	0.064004	0.167602
2	0.037088	0.0931544
3	0.036828	0.0901223
4	0.06749	0.222464
5	0.06013	0.184388
6	0.048838	0.136969

Figure 5-1: Network Graph

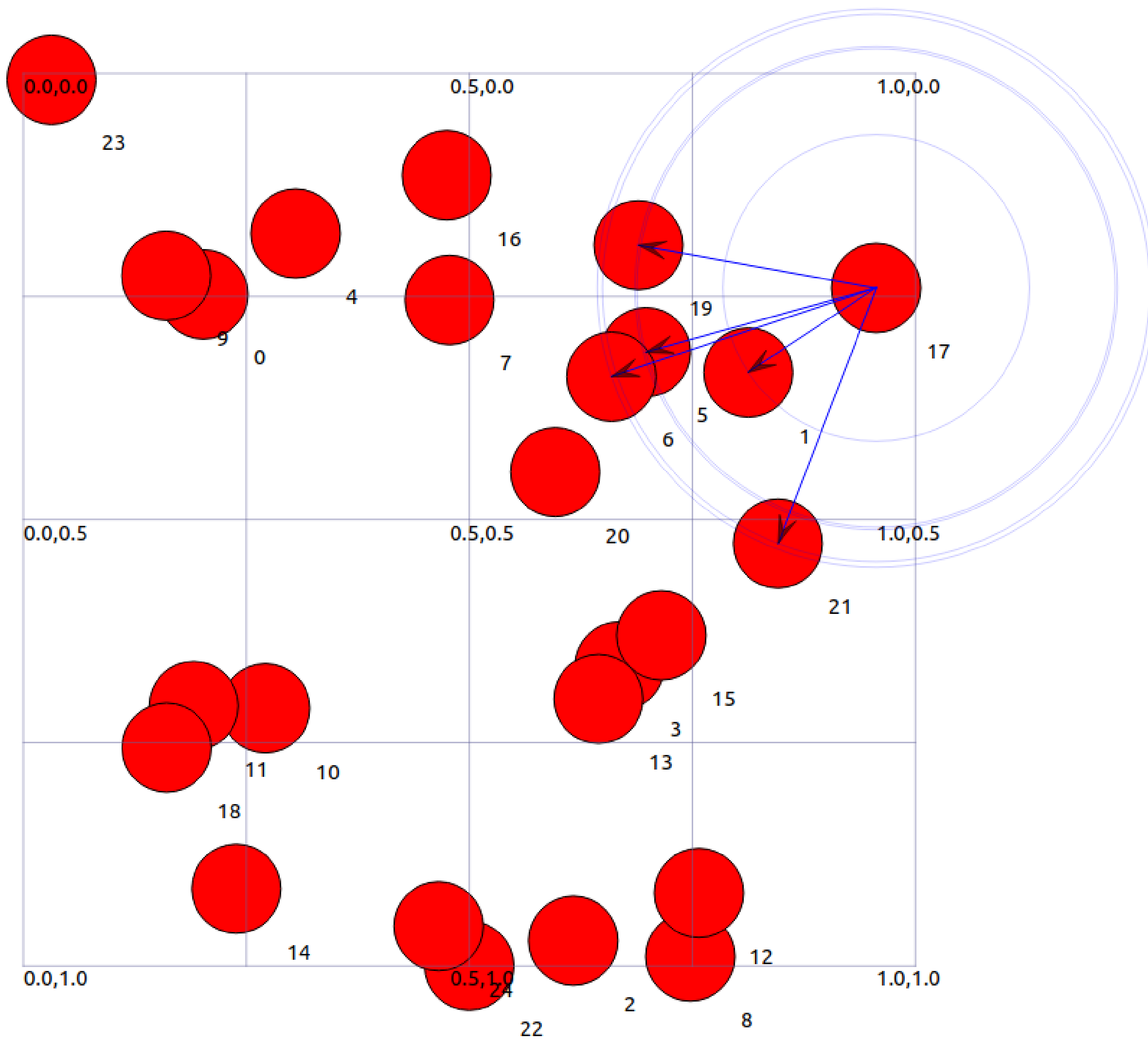
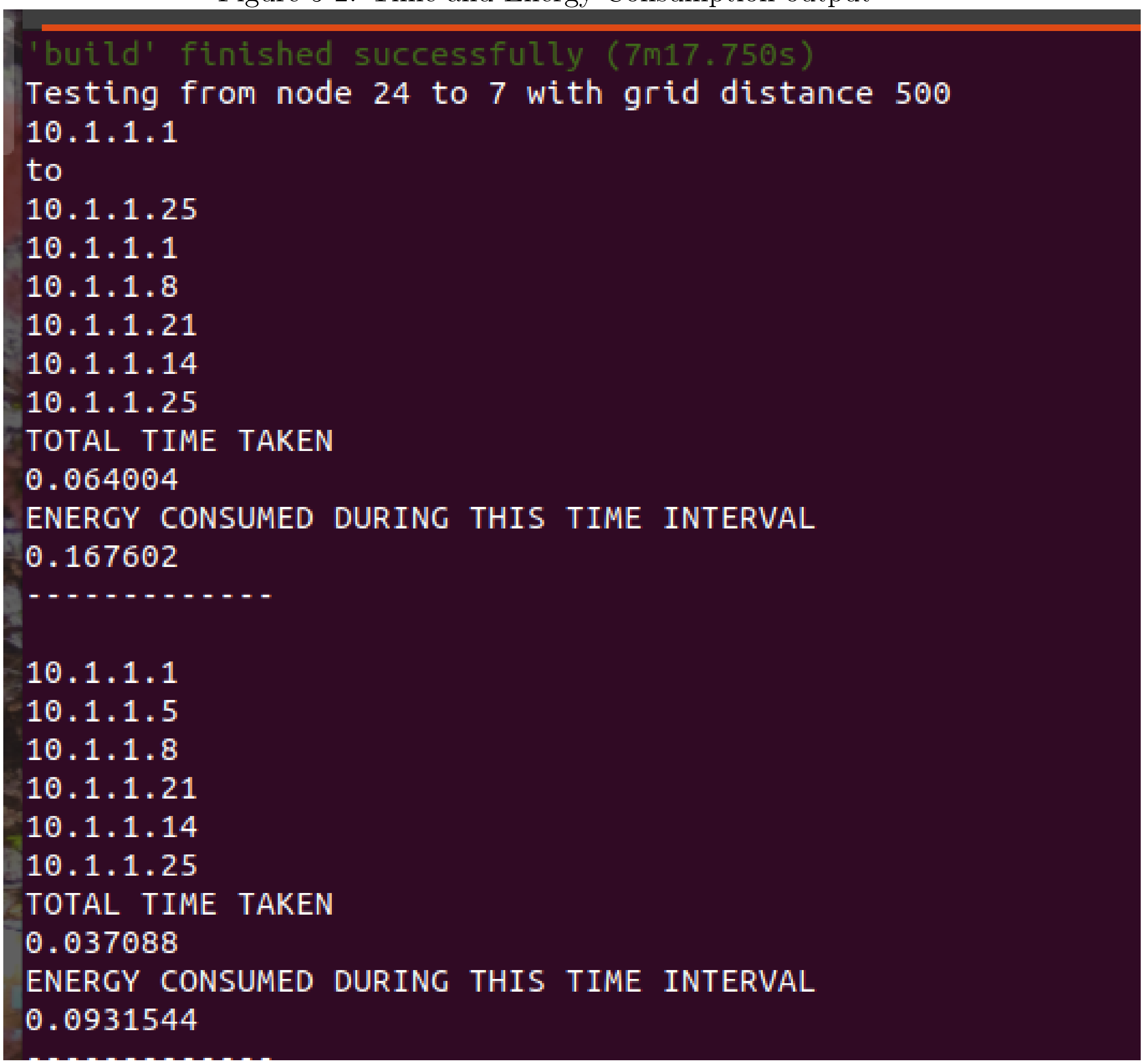


Figure 5-2: Time and Energy Consumption output



```
'build' finished successfully (7m17.750s)
Testing from node 24 to 7 with grid distance 500
10.1.1.1
to
10.1.1.25
10.1.1.1
10.1.1.8
10.1.1.21
10.1.1.14
10.1.1.25
TOTAL TIME TAKEN
0.064004
ENERGY CONSUMED DURING THIS TIME INTERVAL
0.167602
-------------

10.1.1.1
10.1.1.5
10.1.1.8
10.1.1.21
10.1.1.14
10.1.1.25
TOTAL TIME TAKEN
0.037088
ENERGY CONSUMED DURING THIS TIME INTERVAL
0.0931544
-------------
```

Figure 5-3: Time and Energy Consumption output

```
10.1.1.1
10.1.1.8
10.1.1.6
10.1.1.21
10.1.1.14
10.1.1.25
TOTAL TIME TAKEN
0.036828
ENERGY CONSUMED DURING THIS TIME INTERVAL
0.0901223
-------------

10.1.1.1
10.1.1.8
10.1.1.6
10.1.1.22
10.1.1.14
10.1.1.25
TOTAL TIME TAKEN
0.06749
ENERGY CONSUMED DURING THIS TIME INTERVAL
0.222464
-------------

10.1.1.1
10.1.1.8
10.1.1.6
10.1.1.16
10.1.1.13
10.1.1.25
TOTAL TIME TAKEN
0.06013
ENERGY CONSUMED DURING THIS TIME INTERVAL
0.184388
-------------

10.1.1.1
10.1.1.8
10.1.1.6
10.1.1.16
10.1.1.14
10.1.1.25
TOTAL TIME TAKEN
0.048838
ENERGY CONSUMED DURING THIS TIME INTERVAL
0.136969
-------------
```

		Grid Network					Random Network				
	No. of paths	No. of packets sent	Average delay (in msec.)	Throughput (in kbps)	Energy consumed (in J)	Minimum remaining energy (in J)	No. of packets sent	Average delay (in msec.)	Throughput (in kbps)	Energy consumed (in J)	Minimum remaining energy (in J)
Strategy0	1	1965	27.779	75.87	4708.32	116.9	1964	28.32	75.86	4716.95	116.2
	2	1968	33.76	75.97	4709.48	117.0	1967	34.31	75.94	4716.54	116.10
	3	1970	38.35	76.06	4709.6	116.96	1969	38.67	76.03	4716.35	116.13
	4	1972	42.13	76.13	4709.69	117.1	1970	40.32	76.08	4716.31	116.17
	5	1973	43.92	76.17	4709.69	117.09	1971	41.4	76.11	4716.20	116.24
Strategy1	1	1965	27.59	75.87	4710.25	116.53	1965	27.68	75.86	4714.87	116.01
	2	1967	34.36	75.97	4710.5	116.67	1967	34.48	75.95	4715.28	116.08
	3	1970	39.77	76.07	4710.12	116.84	1969	39.00	76.03	4715.44	116.04
	4	1972	43.85	76.13	4710.12	117.04	1970	40.72	76.07	4715.60	116.05
	5	1972	45.16	76.17	4710.15	117.02	1971	41.62	76.10	4715.66	116.16
Strategy2	1	1965	27.21	75.87	4709.90	116.59	1965	27.67	75.86	4715.43	116.1
	2	1967	33.722	75.95	4709.64	116.86	1967	34.25	75.95	4715.97	116.12
	3	1970	39.22	76.05	4710.02	116.97	1969	38.32	76.03	4715.97	116.06
	4	1971	43.20	76.12	4710.16	116.98	1970	39.97	76.07	4715.97	116.12
	5	1972	44.67	76.15	4710.15	116.95	1971	40.98	76.10	4716.0	116.12

Table 1 :

Summary of parameters

number of nodes	25	
Size of network	(50×50) m^2 for random network	
	(40×40) m^2 for regular grid network	
Communication range of a node	15 m for random network	
	10 m for regular grid network	
Size of a packet	1 KB	
Bandwidth of each channel	1 MBps	
Link delay	1 msec	
Random traffic generation	Time of generation	Poisson distribution,
	Source and destination nodes	Uniform random numbers from 1 to 25,
	Mean interarrival time	Varied from 2 s to 20 s
Number of packets generated at each request	Varied from 2,000 to 10,000	

Chapter 6

Conclusion and future works

We have recommended the use of routing time and energy consumption as factors for distributing the data packets along the multiple paths. We have also been able to find routing time and energy consumption for any path. But we have yet to determine a distribution strategy with these two factors and we also have to test the simulations with the routing protocol if it is successful in reducing time and improving Quality of Service.

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