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Anycast Scheduler For Ad Hoc Networks

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ABSTRACT

Area anycast is a very specialized operation in scalable wireless ad hoc networks. In this operation a group of nodes belonging to a pre-specified network region, are capable of receiving Area anycast message. Here anycast source communicates with most eligible destination within the anycast region. By most eligible destination we mean the one that has higher probability in residing within anycast region for a long time, hopefully till the end of anycast communication session. This requires clustering where a node outperforms another by its merit. All the cluterheads send route-reply packet to the anycast source and based on number of hops travelled by these route-reply packets, only one eligible destination is elected by the source. As far as scheduling of packets is concerned, we schedule unicast, multicast, broadcast and anycast packets separately. In this article, we have illustrated scheduling scheme for anycast packets only. The scheme has been compared with first-come-first-served or FCFS and longest hop-length first or LHLF. Simulation results demonstrate that our scheme anycast-scheduler or ANSCHED performs much better than FCFS and LHLF.

Key words: Ad hoc networks; Energy efficiency; Fuzzy Sets: Anycasting.

1. INTRODUCTION

A mobile ad hoc network is an infrastructure less network where the nodes are free to move independently in any directions. It is a collection of mobile devices or nodes that collaborate with each other to bridge the gap between a given pair of source and destination nodes where the destination is outside radio range of source. These networks are extremely important for rescue services in battle field and natural disasters like flood, earthquake etc, where quick deployment and mitigation are necessary.

The routing protocols proposed for ad hoc networks, can be broadly divided in to proactive and reactive routing protocols. In proactive routing protocols nodes proactively store route information to every other node of the network, in a table.

This is not practical for large and scalable networks where number of nodes is huge. This will lead to huge storage overhead, because information is stored about both active and inactive routes.

Reactive protocols reduce this overhead by inculcating the energy cost of route discovery. In these protocols route request packets are broadcast in the network and as soon as one reaches the designed destination, it generates route reply and sends that back to source. This network wide flooding is very costly and therefore, we need to implement ad hoc networks in energy efficient manner. Energy save means increase in lifetime of routers and higher network throughput.

Anycast is an operation where source intends to deliver a set of message packets to any one node within a predefined region. A router might have to schedule multiple anycast packets if more than one anycast packets arrive at it. The scheduler is fuzzy controlled with priorities based on distance from selected destination, amount of pending work that is, number of packets yet to be forwarded and distance between current router and nearest node in anycast region. Please note that the nearest node in anycast region may or may not be equal to the elected destination.

The article is organized as follows. Section 2 specifies related work. Formulation of input parameters of fuzzy controller ANSCHED appears in section 3. Section 4 demonstrates fuzzy rule bases of it while simulation results are shown in section 5. Section 6 concludes the paper.

2. RELATED WORK

Please note that there is no scheduler in literature of ad hoc networks that focus on particularly anycast operation. Therefore, we discuss scheduling algorithms in general. There are different scheduling policies for different network scenarios. Different routing protocols use different methods of scheduling. Among them, FCFS (first-come-first-served) is quite heavily used. The drop-tail policy is used as a queue management algorithm in various scheduling algorithms for buffer management [1]. Except for the no-priority scheduling algorithm, all other scheduling algorithms give higher priority to control packets than to data packets. In no priority scheduling algorithm both control and data packets are served in FIFO (first-in-first-out) order. Priority scheduler requires internal or external priority to be associated with a process. But these do not consider typical natures of different kinds of communication (unicast, multicast, broadcast, anycast) of ad hoc networks.

Certain scheduling schemes depend on the size of the message and number of hops to traverse. In smallest message first (SMF) [2] algorithm, the packets are scheduled in ascending order of the size of messages of which they are a part. Packets belonging to smaller messages receive higher priority over the packets belonging to larger messages. In order to implement this scheme the total message size must be attached to each packet so that the scheduler can access this information while putting the packets in queue. In smallest remaining message first scheme (SRMF) [3], [4] packets are ordered on the basis of the amount of message packets remaining to be sent after the current packet. On the other hand, in shortest hop length first (SHLF) scheduling [5], [6] the distance between the source and destination, measured in terms of the number of hops.

3. INPUT PARAMETERS OF ANSCHED

i) dist_priorityi(j) = ・{(1-per(・i(j)) dist(ni, dest(・i(j))) / (H・Rmax)} (1)

・i(j) is the packet that is presently staying at j-th position of message queue of router ni. So, 1・j・m(i) where m(i) is size of message queue of ni. Assume that per(・i(j)) is performance of the path through which ni will propagate packet ・i(j) to destination. per(・i(j)) is less than or equal to 1, as per reference [6], irrespective of the values of i and j. If dest(・i(j)) specify the destination of ・i(j) and dist(na, nb) denote the distance between nodes na and nb, priority of ・i(j) will increase if per(・i(j)) is low and dist(ni, dest(・i(j))) is high, because it is better to propagate a packet faster that has to travel a long distance through a fragile path. Maximum value of this distance is (H・Rmax) where H is maximum possible hop count in the network and Rmax is highest radio-range in the network.

ii) work_priorityi(j) = 1-pac(sesi(j)) / tot_pac(sesi(j)) (2)

where sesi(j) is session of ・i(j). pac(sesi(j)) denotes number of packets yet to be delivered in the session sesi(j) and tot_pac(sesi(j)) indicates total number of packets in this session. If a large fraction of packets are yet to be delivered i.e. work_ priorityi(j) is low, then the packet should be forwarded fast.

iii) nearest_priorityi(j) = dist(ni, ・(・i(j))) / (H・Rmax)

・(・i(j)) is nearest anycast destination in the path from ns to dest(・i(j)). If ・(・i(j)) is very far then the packet needs to be served with high priority.

3.1 Fuzzy Rule base

Table 1 combines dist_priority and work_priority to generate a temporary output t1. t1 is combined with nearest_priority in Table 2 and Table 3 to produce packet_merit which is the ultimate output of FUZZ-SCHD. All parameters of FUZZ-SCHD are uniformly divided into 4 ranges - 0-0.25 is denoted by fuzzy variable a, 0.25-0.5 by b, 0.5-0.75 by c and 0.75-1 by d. As dist_priority becomes high, it means that performance of the path is not good and a small distance needs to be covered. So, if the packet is delayed, then another route discovery session might have to be initiated for not covering a small distance in time [7], [10]. Therefore priority increases in journey of dist_priority from a to d. For a given dist_priority, if work_priority increases then processing priority of the packet will go down because only a few numbers of packets are to be forwarded now. t1 is combined with nearest_priority in Table 2. High value of nearest_priority means that the nearest node in anycast region is very far from anycast source [8], [9]. Therefore, priority of the packet increases with rising of nearest_priority for a given t1.

Table 1: dist_priority and work_priority are combined to produce t1

dist_priority → / **work_priority ↓**	**a**	**b**	**c**	**d**
a	**b**	**c**	**d**	**d**
b	**b**	**b**	**c**	**c**
c	**a**	**b**	**b**	**b**
d	**a**	**a**	**a**	**a**

Table 2: t1 is combined with nearest_priority to produce packet_merit

t1 → / **nearest_priority ↓**	**a**	**b**	**c**	**d**
a	**a**	**a**	**b**	**c**
b	**a**	**a**	**b**	**c**
c	**a**	**b**	**c**	**d**
d	**a**	**b**	**c**	**d**

Table 3: t1 is combined with work_priority to produce packet_merit

t1 → / **work_priority ↓**	**a**	**b**	**c**	**d**
a	**a**	**a**	**a**	**c**
b	**a**	**c**	**a**	**c**
c	**b**	**c**	**c**	**b**
d	**b**	**b**	**c**	**b**

4. EXPERIMENTAL RESULTS

Experiment is performed in ns-2 framework and the communication protocol is IEEE 802.15.4. Total number of simulation runs is 10. Total number of nodes in the network is 100, 150, 200, 250, 300, 350, 400, 450 and 500 in various simulation runs where network area is a square with length of each side being 500 m. Radio-range of each node varies from 10 m – 50m whereas initial energy ranges from 10 J to 30 J. Size of each data packet is 512 bytes. Duration of each simulation run is 1000 seconds. Nodes move according to random waypoint mobility model. Performance of our proposed Area anycast scheduler is compared with FCFS and LHLF [11], [12].

Simulation metrics are

i) Cost of messages – It indicates the total message cost in the network throughout the simulation period.

ii) Energy consumption - It indicates the total energy consumption in the network throughout the simulation period.

iii) Packet delivery ratio – It is the ratio of the number of packets received successfully and total number of messages transmitted as shown in Fig 1.

Our proposed anycast scheduler assigns high priority to the packets that are i) travelling through fragile paths, to anycast destinations which are very far, ii) with a small number of packets yet to be transmitted in the current session such that iii) anycast region is very far or nearest destination in the anycast region is very far from current router [13]. If a packet travels through a non-stable path and desired anycast destination is very far then that packet should be given priority to increase packet delivery ratio avoiding the message cost and energy consumption of route discovery that would have been otherwise required for delivering that packet to destination. FCFS does not consider any criteria of stability, distance or amount of remaining tasks. Hence its performance is worse than anycast scheduler or LHLF [14]. Full form of LHLF is longest hop length first. It forwards the packet first whose destination is farthest. But it does not consider stability of a path which is extremely important. A packet travelling to a far distance can be delayed if it travels through a stable path. On the other hand, packet travelling to a comparatively close destination may be treated with high priority if its path is fragile. The underlying intention is to avoid route rediscovery as much as possible as shown in Fig 2. That reduces message cost and energy consumption as shown in figures 1 and 2, in favor of our proposed anycast scheduler [15]. If lesser number of route discovery packets are injected in the network, there will be lesser contention and collision faced by data packets [16], [17]. So, anycast scheduler achieves higher packet delivery ratio than its competitors as shown in Fig 3.

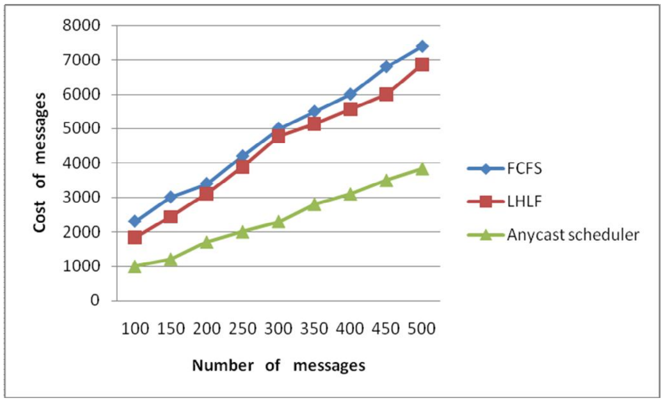

Figure 1: Cost of messages vs number of nodes

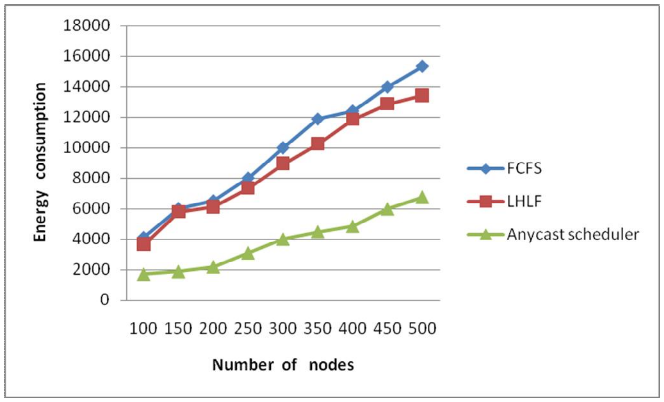

Figure 2: Energy consumption vs number of nodes

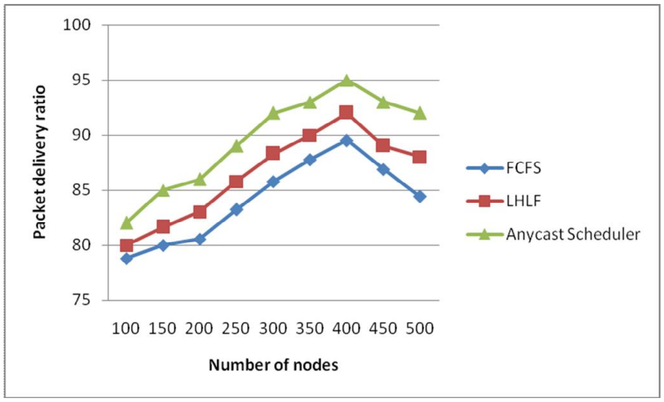

Figure 3: Packet delivery ratio vs number of nodes

5. CONCLUSION

The present article proposes an anycast scheduler which considers many important criteria like performance of a path, amount of work yet to be done and distance from desired anycast destination. Please note that, no scheduler in ad hoc networks is available particularly for anycast operation. All are general i.e. applicable to unicast, multicast, broadcast etc packets. But our scheduler specializes in anycast operation which considers the fact that distance from desired anycast destination is a parameter and along with that distance from closest destination in anycast region are also FCFS and LHLF.

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