

Research Article

QoS Routing for Mobile ADHOC Network Environment

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Abstract: One of the main parameters while accessing a wireless mobile adhoc network is the Quality-of-Service (QoS) routing protocol. Providing QoS is of utmost importance in wired line and wireless ad-hoc networks that abide number of mobile nodes mutually interdependent on multi-hop wireless paths due to multi hop communications, node mobility, channel access conflicts and inadequate central coordination. The main application of QoS is guaranteed in multimedia and error sensitivity. An entirely distributed adaptive algorithm that can provide statistical QoS on the subject of service accessibility in an adhoc network is proposed in this study. Optimization of a new QoS parameter to afford adequate service, keeping the overheads minimal is proposed in this algorithm. So, the lower and upper bounds of service efficiency is theoretically derived based on the unique model and the results depict that our algorithm is competent in achieving better QoS under group mobility.

Keywords: ADHOC network, MANET protocol, quality-of-service

INTRODUCTION

Wireless Local Area Networks (WLANs) are growing rapidly in recent years and IEEE 802.11 has become a standard model (IEEE Standard Association, IEEE Std 802.11-2007, 2007). Adhoc networks have also added on due to the popularity of WLANs. A wireless network that comprises of stations those communicate with each other in a peer-to-peer fashion directly is called as an adhoc network. Thus it is nonaligned with any current network frameworks. Connecting two mobile phones via Bluetooth, two laptops through IEEE 802.11 (operating in ad hoc mode) are some simple examples of adhoc networks. When compared with other networks, the two main challenges that need to be worked out here are: Providing distributed Quality of Service (QoS) and multihop wireless Internet access.

Wireless ad-hoc networks are interconnected by multi-hop wireless paths in a peer-to-peer fashion and are self-created and self-organized by collective number of mobile nodes. Each node serves as a packet-level router for peers in the same network. Such networks have drawn significant interest in research to offer unique benefits and versatility with respect to spatial bandwidth reuse, intrinsic fault tolerance and low cost rapid deployment moreover, commercially available Bluetooth ready wireless interfaces may lead to the actual usage of such networks in reality (Weyland *et al.*, 2006). The topology of adhoc networks may be highly dynamic due to unpredictable node mobility,

which makes QoS provision inherently hard. Narrow bandwidth of wireless channels between nodes further exhibits the situation where the message exchange overheads of any QoS-provisioning algorithms has to be kept at minimum level. This insists that the algorithm should be fully distributed than centralized to small subset of nodes (Wu *et al.*, 2007).

This study on ad-hoc networks has mainly focused on three aspects: general packet routing (Rais *et al.*, 2008; Setiawan *et al.*, 2008), power conservation and topology control and QoS (Park *et al.*, 2007). Due to the lack of sufficient knowledge in instantaneous and predictive QoS, its guarantees may be impossible when the mobile nodes, computational load and propagation difficulties are increased. Users of an adhoc network may not be satisfied with pure best-effort services and may demand guarantee for at least statistical QoS on the other hand. With the following examples, most of the scenarios demonstrate that a certain degree of QoS support beyond the best-effort services (Wu *et al.*, 2008). Let us consider a wireless adhoc network where a source has only the domain name to send packets to one of the destination. Such a name should be converted to the actual address based on a particular addressing scheme for the ad-hoc network (for e.g., vanilla IP address). Such conversions are performed on a server and running similar services are based on the domain name. However, as wireless nodes are mobile, it may be impossible to locate a centralized server since it resides on a different network partition which is unreachable from the source (Ping *et al.*, 2007). So,

QoS-aware mechanisms will be able to assist the scenario of increased service availability (i.e., the probability that a service is accessible when called upon) to mobile nodes. As it is hard to design scalable solutions to address such a problem in an environment where all nodes are on mobility, it is needed to present a model to take the responsibility when a subset of network states is sufficiently accurate (Govindan and Mohapatra, 2012; Bharati and Weihua, 2013).

This study focuses on the new QoS parameter that forms service which is efficiently based on the definition of group mobility. Theoretically, lower and upper bounds of service efficiency are derived to measure the effectiveness of providing adaptive services in adhoc networks and propose a fully distributed algorithm which is referred to as an adaptive service provisioning algorithm. This is executed in each of the mobile nodes, so that:

- The group membership of nodes are identified.
- Service instances are created and terminated dynamically.
- Message exchange overheads incurred by the algorithm are reduced considerably.

Finally, different scenarios have been used to enrich the discussion and the extensive collection of simulation results ensure that QoS provisioning is very effective on the proposed algorithm.

METHODOLOGY

Theoretical analysis: The motivation behind the group mobility model is to identify groups of nodes showing similar mobility pattern and maintain a stable structure over time. Therefore, it is with high probability that nodes within the same group tends to be mutually reachable. It is beneficial for an adaptive service that includes multiple identical service instances running on individual nodes to improve service accessibility with minimum resources. Omar *et al.* (2013) But the ideal case should have an algorithm to capture grouping information with perfect accuracy at any given time so that it is placed on one service instance in each of the groups and trivially achieve the best service accessibility with minimum resource overheads.

However, in reality, the difficulties that prevent us to achieve the ideal scenario are:

- Groups are detected on the fly with distributed algorithm that is based on local states so that they may not be identified with perfect accuracy.
- With dynamic group membership, service instances may need to be created and terminated with a perfect grouping algorithm (Goyal *et al.*, 2012).

To address such problems, a realistic approach that quantitatively defines a QoS parameter as the optimization goal with regards to the adaptive service, derive the upper and lower bounds of that QoS parameter theoretically and finally design the best possible algorithm in a realistic scenario.

Service efficiency: First define the parameters to analyze the aspects of QoS quantitatively in service provisioning so that for any given time t , let N be the total number of nodes in the network, $N_s(t)$ be the number of service instances and $N_a(t)$ be the number of nodes that are reachable from at least one of the nodes that run a service instance thus having adaptive service access. The next step is to define service coverage S_{cover} and service cost S_{cost} as:

$$S_{cover}(t) = \frac{N_a(t)}{N} \text{ and } S_{cost}(t) = \frac{N_s(t)}{N} \quad (1)$$

The main objective is to have maximum service coverage while incurring lowest possible service cost. This is characterized by the new QoS parameter, service efficiency S defined as:

$$S(t) = \frac{S_{cover}(t)}{S_{cost}(t)} = \frac{N_a(t)}{N_s(t)} \quad (2)$$

The primary goal of an adaptive service is to reach as many nodes as possible. However, (2) treats $S_{cover}(t)$ and $S_{cost}(t)$ with equal weights. To maximize $S(t)$ in (2), we have to place one service instance in a larger group that performs at a higher service efficiency of $2N/3$ rather than placing two service instances in both groups. Therefore, while we assume $K(t)$ groups at time t , we need to rectify the definition of $S(t)$ as:

$$S(t) = \frac{S_{cover}(t)}{S_{cost}(t)} = \frac{N_a(t)}{N_s(t)}, \quad \text{While satisfying } N_s(t) \geq K(t) \quad (3)$$

We can then proceed with the optimization objective for maximizing the service efficiency $S(t)$.

RESULT ANALYSIS

The simulation results and discussions when different perspectives are given to enable a better understanding of the results are elaborated here. The result for each simulated scenario along with the flow are shown in Fig. 1. Here, it is also possible to compare the performance used in different schemes and then concurrent flows are put together to show the overall results of a scenario. Average jitter and end-to-end delay are shown separately by flow, scenario and scheme.

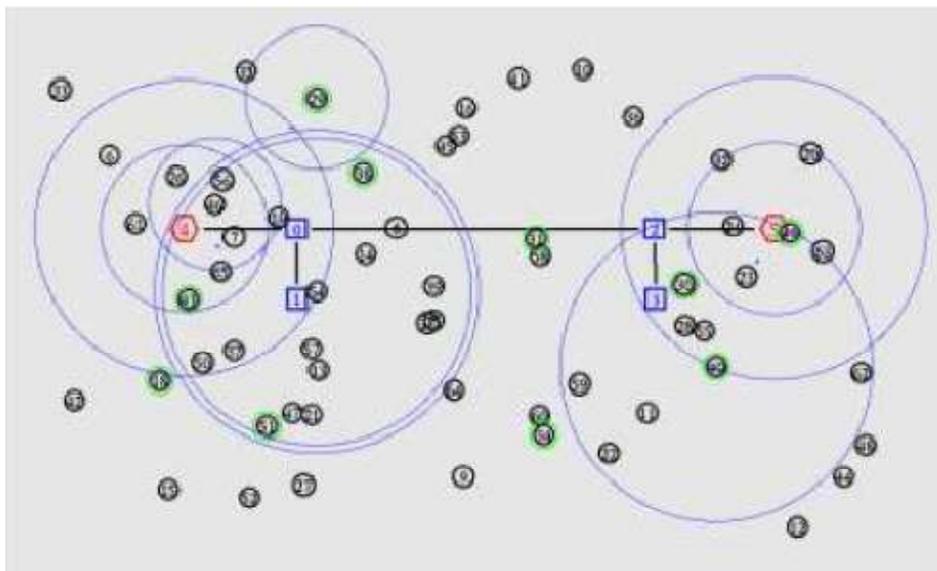


Fig. 1: Screenshot of the simulation scenario

Table 1: Simulation parameter

Parameter	Value
Topology area	1300×800 m
Number of mobile stations	60
Number of traffic sources	10
Number of gateways	2
Packet size	512 bytes
Speed	(Bharati and Weihua, 2013) m/sec
Pause time	5 sec
Data rate	2 Mbps
Transmission range	250 m
Carrier sense range	550 m
Simulation time	1000 sec
Warmup time	100 sec

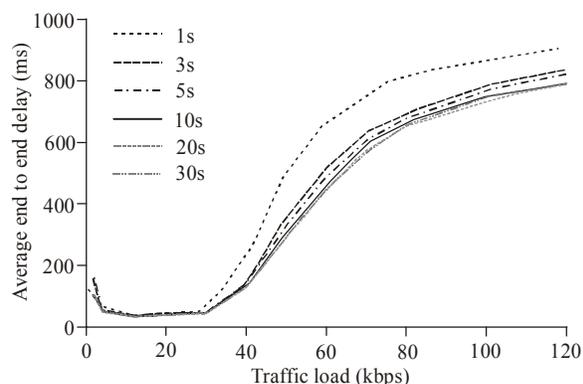


Fig. 2: The impact of advertisement interval

Figure 2 shows the impact of advertisement interval on average end-to-end delay, when the traffic load changes for proactive gateway discovery method. It is observed that, the curve representing the advertisement interval of 1 sec differs from the other curves representing higher advertisement intervals since a very short interval leads to lots of advertisements and thus forms as much overheads followed by as many

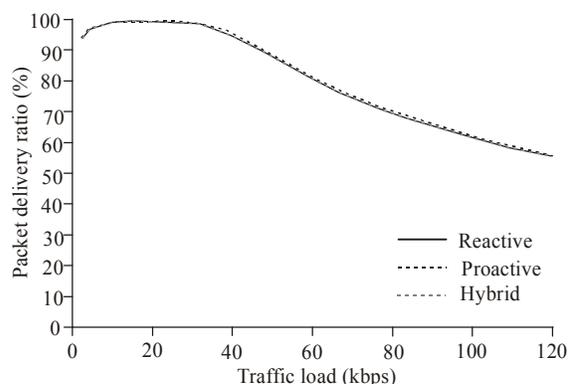


Fig. 3: Packet delivery ratio vs. traffic load

collisions, retransmissions and route discoveries which increases the end to-end delay (Table 1).

Figure 3 to 5 show the packet delivery ratio, average end-to-end delay and the AODV overhead for the three gateway discovery methods respectively when the traffic load increases. Figure 3 shows that the packet delivery ratio is high when traffic load is less but decreases when the traffic increases. This was expected but it can also be seen that while increasing the traffic all three approaches are the same.

We can also sense that the delivery ratio is less for loads of 5 kbps/source range compared to loads of 20 kbps/source. The reason for this is, once a connection is established, it is not fully used when the traffic is very low. Therefore, only few packets are sent before the connection breaks (e.g., due to mobility) and thus a new route must be discovered.

Figure 4 shows that the average end-to-end delay increases when traffic load increases, since it increases the number of collisions, retransmissions and route

Table 2: The average throughput of the VoIP, FTP/HTTP and video traffic

No. of calls	Throughput (kbps)					
	VoIP		FTP/HTTP		Video	
	EDCA	EDCA/RR	EDCA	EDCA/RR	EDCA	EDCA/RR
(a) 0% packet error						
0	0	0	1283	1358	2684	2681
1	128	128	1105	1102	2683	2685
2	256	256	836	841	2681	2685
3	384	384	592	574	2672	2685
4	512	512	414	358	2658	2606
5	576	640	399	300	2507	2211
6	593	768	306	204	2453	1829
(b) 5% packet error						
0	0	0	386	612	2670	2678
1	128	128	255	306	2651	2680
2	255	256	106	171	2591	2680
3	381	384	32	115	2274	2459
4	500	512	14	89	1748	2083
5	531	640	8	77	1247	1702
6	543	768	6	64	1138	1326

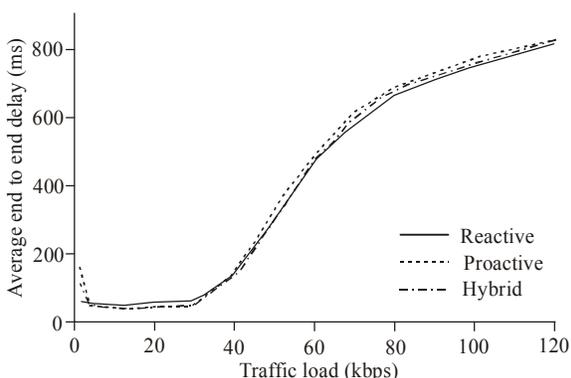


Fig. 4: Average end to end delay vs. traffic load

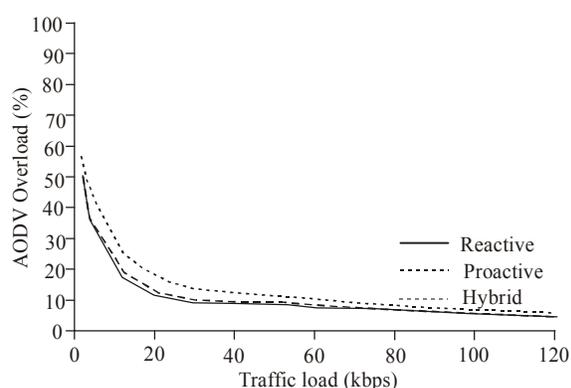


Fig. 5: AODV overhead vs. traffic load

discoveries. We can also see that the differences between the strategies are negligible.

Figure 5 the AODV overhead is dominated by periodically broadcasted GWADV messages. Here, the AODV overhead is significantly larger for the proactive approach than for the reactive approach especially for lower traffic loads. This result is expected since the

proactive approach periodically broadcasts gateway information even if the mobile stations need them or not, whereas the reactive approach broadcasts gateway information only when a mobile station needs it.

Table 2a and b shows the average throughput for FTP/HTTP and video as the number of VoIP calls increases. The VoIP throughput is also there for easier comparison. The general view of the results are: Fig. 6a shows the throughput of FTP/HTTP and video traffic decreases with increasing traffic and error rate for both EDCA and EDCA/RR. Leaving the general view to focus on the FTP/HTTP, Fig. 6b shows the throughput in lossy media drops to lower levels for EDCA when the traffic load is high. Obviously, the TCP-based FTP/HTTP flows are starved by the UDP based VoIP and video streams. For EDCA/RR, on the other hand, the throughput does not decrease as it does for EDCA (64 kbps compared to 6 kbps when there are six VoIP calls). The reason is that, due to the contention-free medium access for VoIP traffic in EDCA/RR, the TCP-based flows have to contend for medium access with UDP-based video streams only, whereas in EDCA, they have to contend with UDP-based VoIP streams as well. The more the streams contending for medium access, higher is the probability for collision and retransmission resulting in low throughput.

Table 3a and b show the packet delivery ratio (or equivalently, one minus the packet loss) experienced by the VoIP, FTP/HTTP and video traffic. The analysis starts by studying the packet delivery ratio for VoIP in error-free and lossy media. The results show that the delivery ratio decreases when EDCA is used. For contention-free EDCA/RR, packet loss is negligible. Once more we can see that EDCA suffers from high traffic load, with up to 29% of the VoIP frames being lost when the medium is lossy.

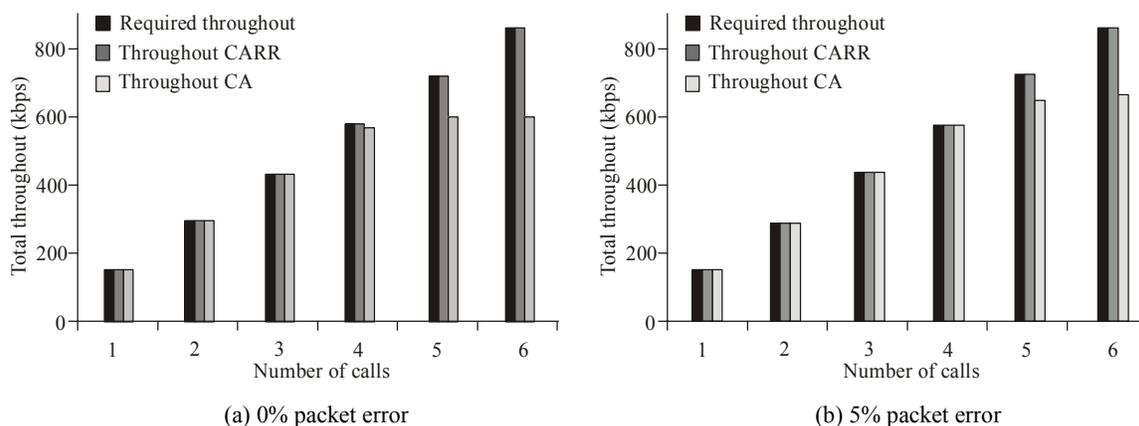


Fig. 6: Average throughput; (a): Error-free; (b): Lossy media

Table 3: The packet delivery ratio of the VoIP, FTP/HTTP and video traffic

No. of calls	Throughput (kbps)					
	VoIP		FTP/HTTP		Video	
	EDCA	EDCA/RR	EDCA	EDCA/RR	EDCA	EDCA/RR
(a) 0% packet error						
0	-	-	99.03	99.08	99.87	99.87
1	100	100	98.78	98.80	99.85	99.88
2	99.99	100	98.50	98.65	99.77	99.80
3	99.98	100	98.59	98.41	99.51	99.91
4	99.95	100	98.76	98.17	98.97	97.01
5	90.48	100	99.07	99.37	93.71	82.32
6	77.91	100	99.99	99.84	94.90	68.12
(b) 5% packet error						
0	-	-	99.28	99.25	99.36	99.64
1	99.92	99.98	99.08	98.87	98.81	99.69
2	99.79	99.97	98.66	98.56	96.73	99.71
3	99.35	99.97	97.25	98.35	85.49	91.54
4	99.01	99.97	94.37	98.10	65.58	77.56
5	83.23	99.96	83.37	98.12	47.19	63.40
6	71.35	99.96	69.91	97.77	43.12	49.40

CONCLUSION

Thus we have presented a solution for Internet access in mobile stations. QoS routing protocol AODV has been extended to route packets between QoS and the wired Internet. To achieve this, we need devices that communicate with both QoS and wired Internet and as all communication between wireless and wired network must pass through these devices, they are referred to as gateways. In this thesis, three methods are presented, implemented and compared for the detection of gateways. These three methods are referred to as reactive, proactive and hybrid gateway discovery. When it comes to end-to-end delay and packet delivery ratio, they show similar behavior and the fact that proactive method shows much higher overhead in terms of control packets than other methods is more obvious.

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