Comparative Analysis of Green Algorithm within Active Queue Management for Mobile Ad Hoc Network

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ABSTRACT
The Queue Management Techniques play an important role in improving the Quality of Service in Mobile Ad-hoc Networks. The need of congestion control and Queue management is inevitable in Mobile Ad-hoc Network. Understanding and analyzing the latest AQM Techniques give an insight to improving throughput, packet loss rate, average end to end delay and other parameters that severely affect the performance. The performance of mobile ad-hoc networks is evaluated by varying the Channel Error Rate, Bandwidth and Delay at different fragment sizes of different traffic flows. The proposed method performs the network analysis of new Routing protocols. The work proposes to evaluate various Active Queue Management Techniques in a multi traffic environment i.e., sources generating both TCP and UDP traffic classes. The UDP is propagated via CBR and TCP is propagated via FTP. The implementation of the proposed queue management technique has been done in NS-2. In the proposed work we have make NS-2 compatible with GREEN by integrating source code into the ns-2 installation files and using various AQMs in comparison with GREEN to calculate the throughput at various Bandwidths across network. Using various AQMs in comparison with GREEN we have calculated the throughput at various Delays across the network and we have also calculated the throughput at various channels Error Rate across the network. The proposed method has been compared with other primitive AQM techniques so that a repository of best available results can be obtained for design and research purposes. The proposed method has outperformed the existing queue management techniques in number of scenarios.

Keywords: AQM, MANETs, Throughput, Channel Error Rate, NS-2

INTRODUCTION
Mobile Ad hoc Networks (MANETs) are self organizing networks formed by a collection of autonomous mobile wireless nodes without the support of any fixed infrastructure or central administration. The remote nodes in MANETs communicate directly with the help of the intermediate nodes which operate as routers. As MANETs eliminate the cost and time of infrastructure deployment, setup, and administration, they have numerous applications, especially in the military and emergency services. Although MANETs have unique applications, realizing them is difficult because of several intrinsic constraints. Unlike their wired counterparts, mobile devices usually have limited resources (battery power, memory, CPU) which limit their transmission range. In addition to this, wireless networks have limited bandwidth and are more prone to errors than wired networks which further impose limits on the amount of data that can be sent. Hence, in order to conserve the limited resource, it is highly desirable that transmission should be as efficient as possible (minimal losses and retransmissions).

Fig 1: Mobile Ad hoc Network

The mobile network nodes today use Drop tail queue management where packets are discarded when the queue is full. When multiple packets are dropped due to queue overflow, multiple TCP flows (to which these packets belong) back off. However, as there is a considerable amount of
delay between the packet drop at the queue and the notification at the sender, large number of packets may be dropped as the sender continues sending at its current rate. Multiple flows backing off results in under utilization of the queue (no congestion). When these flows sense this (no congestion), they start increasing their sending rates as a result of which after some time the queue overflows again. This phenomenon of alternating periods of under utilization and over utilization is caused by the Drop Tail queue management policy and is called ‘Global Synchronisation.

**Active Queue Management (AQM)**

1) Random Early Detection (RED) was proposed as a solution to the ‘Global Synchronisation’ problem and this opened up a new area of research called Active Queue Management (AQM). The key aims of AQM are to prevent global synchronisation, reduce queuing delays and improve resource utilization. AQM has been extensively studied in the context of wired networks (to quote a few). A few approaches have also studied the implications of employing AQM in the fixed wireless side (WLANs in particular)[3] with encouraging results. However, to the best of our knowledge no approach has ever studied the implications of AQM in mobile environments. If benefits in terms of improved performance (reduced packet loss) are to be reaped by deploying AQM in MANETs, it is imperative that any such scheme should be Lightweight, Requires less memory, Processing power and energy. There are few AQM Techniques used in MANETs which are REM (Random Exponential Marking) SFQ (Stochastic Fair Queuing), Random exponential marking (REM) is an attractive adaptive queue management algorithm. It uses the quantity known as ‘price’ to measure the congestion in a network. REM can achieve high utilization, small queue length, and low buffer overflow probability.

Fair Queuing is a queuing mechanism that is used to allow multiple packets flow to comparatively share the link capacity. Routers have multiple queues for each output line for every user. When a line as available as idle routers scans the queues through round robin and takes first packet to next queue. FQ also ensure about the maximum throughput of the network.

**Literature Review**

Chung and Claypool et al. (2017) has discussed that in Internet routers, active queue management (AQM) is a technique that consists in dropping or explicit congestion notification (ECN) marking packets before a router’s queue is full. An Internet router typically maintains a set of queues, one per interface, that hold packets scheduled to go out on that interface. Historically, such queues use a drop-tail discipline: a packet is put onto the queue if the queue is shorter than its maximum size (measured in packets or in bytes), and dropped otherwise.

Wydrowski Bartek et al. (2016) explained about an active queue management algorithm for a self managed Internet in the paper. The author introduced a new active queue management (AQM) algorithm called GREEN. GREEN provides high link utilization whilst maintaining low delay and packet loss. GREEN enables low latency interactive applications such as telephony and network games. GREEN is shown to outperform the current AQM algorithms. Certain performance problems with current AQMs are discussed.

Fountanas Fengetal et al. (2011) explained about the challenges with Manet. MANETs present many challenges, especially when real-time traffic must be supported in terms of providing Quality of Service (QoS) guarantees. Providing QoS for real-time traffic over IP-based networks is still an open issue because existing active queue management schemes have been designed for TCP-compatible traffic. MANETs present the worst-case scenario for QoS guarantees due to their distinct characteristics, such as contention from multiple users (when using 802.11) and limited bandwidth. The objective of this thesis is to evaluate various AQM techniques to comparatively analyze the best Queue Management Schemes for different resource constraint networks.

**Methodology**

In order to perform the analysis of AQM techniques for the performance evaluation requires a network to be designed that contains a router to router link on which the parameters can be changed. The multiclass traffic network generating both TCP and UDP traffic, topology of the network created is as follows:

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**Experimental Results**

The simulations are performed on ubuntu 14.14. NS2 is installed with NSG and trace graph to complete the full working model to obtain the results. NSG is used to write TCL scripts from graphical user interface and trace craft is used to analyze the output trace files.
Performance Evaluation of GREEN with other AQMs (Throughput Vs AQM) at varying Bandwidths

| Fragment Size 256kb | AQM | Throughput bps |
|---------------------|-----|----------------|
| Bandwidth           | 0.5 Mbps | 1.0 Mbps | 1.7 Mbps |
| SFQ                 | 232945 | 488854 | 642924 |
| DropTail            | 500462 | 989088 | 978119 |
| GREEN               | 500457 | 983500 | 962756 |
| REM                 | 500462 | 989088 | 978119 |

Table 1: Throughput of UDP traffic in various AQM schemes at fragment size 256 kb at different bandwidth

Performance Evaluation of GREEN with other AQM (Throughput Vs AQM) at varying Bandwidths

| Fragment Size 512 kb | AQM | Throughput bps |
|---------------------|-----|----------------|
| Bandwidth           | 0.5 Mbps | 1.0 Mbps | 1.7 Mbps |
| SFQ                 | 282848 | 572620 | 798883 |
| DropTail            | 500917 | 982102 | 954370 |
| GREEN               | 500916 | 983932 | 927374 |
| REM                 | 500917 | 982102 | 954376 |

Table 2: Throughput of UDP traffic in various AQM schemes at fragment size 512 kb

Performance Evaluation of GREEN with other AQM (Throughput Vs AQM) at varying Delay

In this scenario the bandwidth and the channel error rate of the network link was kept constant [BW = 1.7Mbps and Channel error rate = 0]

| Fragment Size 256 kb | Delay | 10ms | 50ms | 100ms |
|---------------------|-------|------|------|-------|
| AQM                 | Throughput (bps) |
| SFQ                 | 642924 | 689479 | 894320 |
| DropTail            | 978119 | 993948 | 986499 |
| GREEN               | 962756 | 980447 | 994143 |
| REM                 | 978119 | 993948 | 986499 |

Table 3: Throughput of UDP traffic in various AQM schemes at fragment size 256 kb at different delay

Graph 1: Analysis of Throughput vs AQM for different bandwidth at fragment size of 256 kb

Graph 2: Analysis of Throughput vs AQM for different bandwidth at fragment size of 512 kb

Graph 3: Analysis of Throughput vs AQM for different bandwidth at fragment size of 1024 kb

Performance Evaluation of GREEN with other AQM (Throughput Vs AQM) at varying Bandwidths

| Fragment Size 256 kb | AQM | Throughput bps |
|---------------------|-----|----------------|
| Bandwidth           | 0.5 Mbps | 1.0 Mbps | 1.7 Mbps |
| SFQ                 | 340195 | 669993 | 950820 |
| DropTail            | 501767 | 962573 | 967213 |
| GREEN               | 501792 | 966053 | 937213 |
| REM                 | 501767 | 962573 | 967213 |

Table 4: Throughput of UDP traffic in various AQM schemes at fragment size 256 kb at different delay

Graph 4: Analysis of Throughput vs AQM for different bandwidth at fragment size of 256 kb

Graph 5: Analysis of Throughput vs AQM for different bandwidth at fragment size of 512 kb

Graph 6: Analysis of Throughput vs AQM for different bandwidth at fragment size of 1024 kb

Performance Evaluation of GREEN with other AQM (Throughput Vs AQM) at varying Delay

In this scenario the bandwidth and the channel error rate of the network link was kept constant [BW = 1.7Mbps and Channel error rate = 0]

| Fragment Size 512 kb | Delay | 10ms | 50ms | 100ms |
|---------------------|-------|------|------|-------|
| AQM                 | Throughput (bps) |
| SFQ                 | 798883 | 767225 | 986965 |
| DropTail            | 954376 | 989758 | 995345 |
| GREEN               | 927374 | 982309 | 991620 |
| REM                 | 954376 | 989758 | 995345 |

Table 5: Throughput of UDP traffic in various AQM schemes at fragment size 512 kb at different delay.

Graph 7: Analysis of Throughput vs AQM for different bandwidth at fragment size of 512 kb

Graph 8: Analysis of Throughput vs AQM for different bandwidth at fragment size of 1024 kb
| Fragment Size 1024 kb |
|-----------------------|
| **Delay**            | **SFQ** | **DropTail** | **GREEN** | **REM** |
| **10ms**              | 950820  | 925319       | 919923    | 967213  |
| **50ms**              | 936248  | 994536       | 983607    | 967213  |
| **100ms**             | 900000  | 1000000      | 1000000   | 1000000 |

Table 6: Throughput of UDP traffic in various AQM schemes at fragment size 1024 kb at different delay

Graph 6: Analysis of Throughput vs AQM for different bandwidth at fragment size of 1024 kb

**Result Analysis**

During the result analysis following observation has been observed:

- In case of erroneous channels GREEN performs for superior than REN
- Throughput Vs AQM (Varying Bandwidths) from Graph 1 to Graph 3 SFQ has worst throughput for all Bandwidths. GREEN, REM and DropTail have Best throughput for all Bandwidths.
- The Throughput increases as Bandwidth increases for constant fragment sizes.
- The Throughput increases as the fragment size increases for constant Bandwidth.
- The Throughput increases as Delay increases for constant fragment sizes. The Throughput increases as the fragment size increases for constant Bandwidth.

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