Optimal Buffer Size for Wireless Mesh Networks

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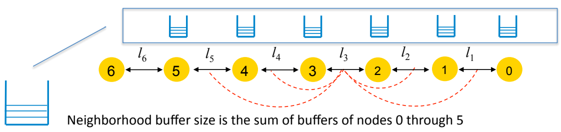
INTRODUCTION

Buffers are used to absorb transient traffic bursts. Very large buffers, which are common nowadays, lead to long queuing delays. On the other hand, very small buffers may result in network under-utilization. Our goal is to determine buffer size that balance throughput and delay trade-off in WMNs.

NETWORK BOTTLENECK AND DISTRIBUTED BUFFERS

According to the two-hop interference model, the collision domain of the link l_3 in the figure below is composed of links l_1, l_2, l_4 and l_5. The bottleneck for any flow is the fully utilized collision domain that has the maximal rate.



Neighborhood buffer size is the sum of buffers of nodes 0 through 5

The problem is divided into two parts:

1st step: determine the size of neighborhood buffer according to:

$$B \ge RTT \bullet \lambda$$

Where λ is the maximum carrying capacity and RTT is the sum of all transmission delays for bottleneck collision domain nodes.

2nd step: distribute the calculated buffer on the bottleneck nodes. Since queue drops closer to source is preferable to drops near to destination, the distribution of the buffer will be as follows:

$$b_1 : b_2 : \cdots : b_M = 1 : \sqrt{2} : \cdots : \sqrt{M}$$

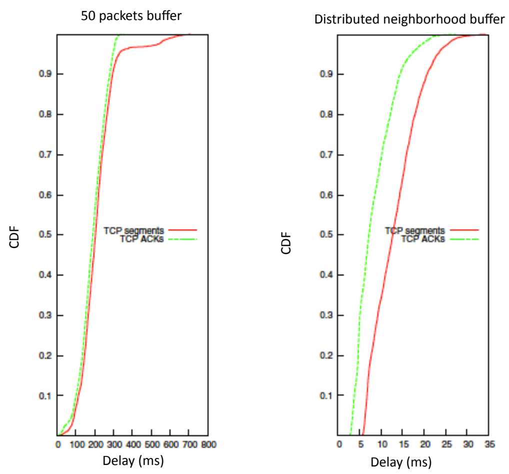
Assuming that cost of packet drop increases linearly with hop count.

WHICH BUFFER TO TUNE?

For ns-2 simulation, the interface queue (IFQ) is modified as per the framework requirements during runtime. In our Linux based testebed, the device driver Tx ring buffer is set to a small value, and the kernel transmit queue (txqueue) is altered as per our proposed framework.

PERFORMANCE ANALYSIS – SIMULATION

Below is a comparison between delay distribution of the proposed approach and the default ns-2 buffer size using a single flow 4-hop chain topology.



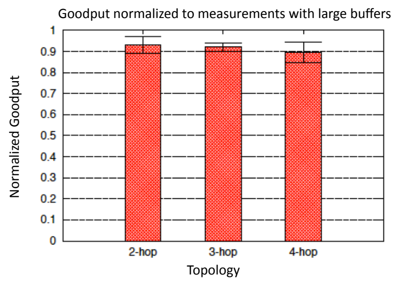
Scheme (Parking Lot Topology)	FTP		VoIP	
	Mean Goodput (S.D.) Kbps	Mean RTT (S.D.) ms	Mean Bit Rate Kbps	Mean Delay (Jitter) ms
Default, 50 packets buffer	261 (58)	388 (32)	7.8	239 (8)
Distributed neighborhood buffer	250 (33)	87 (6)	8	40 (6)

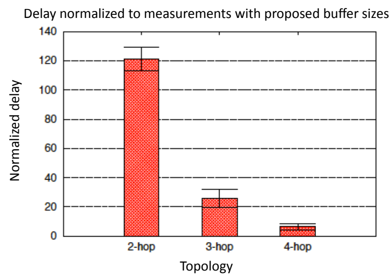
Scheme (Cross Topology)	FTP		VoIP	
	Mean Goodput (S.D.) Kbps	Mean RTT (S.D.) ms	Mean Bit Rate Kbps	Mean Delay (Jitter) ms
Default, 50 packets buffer	382 (17)	309 (72)	7.8	187 (30)
Distributed neighborhood buffer	368 (5)	71 (8)	7.9	35 (4)

The proposed approach is also evaluated under two multi-flow scenarios. The tables above represent results under parking lot and cross topologies.

PERFORMANCE ANALYSIS - TESTBED

Distributed neighborhood buffer is validated on a 10-node WMN testbed. The wireless link rates are fixed to 11 Mbps and 1500 bytes TCP segment is used. Test traffic is generated using iperf. Results are as follows:





Several experiments are done using a multi-flow network. The results are summarized in the table below:

Scheme	Avg. Goodput (S.D.) Kbps	Mean RTT (S.D.) ms
Default, large buffers	786 (45)	1653 (327)
Distributed neighborhood buffer	712 (6)	91 (19)

LESSON LEARNED

Collectively sizing buffers in WMNs nodes lead to buffers as small as 1-3 packets at most mesh nodes.

CONCLUSION

The goal of this work is to carefully size buffers in WMN nodes to maintain high throughput while having low queuing delays. We propose distributed neighborhood buffer where the optimal buffer size will be distributed smartly over several contending nodes.