Testing, Detection and Possible solutions for the Bufferbloat phenomenon on Networks [1]

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[1] Tema para optar al Título de Ingeniero Civíl Informático

Outline

1. Introduction
2. The Recipe for Bufferbloat
   - The Transport Layer Protocol
   - Router's Buffers Effect
   - Active Queue Management
   - Hidden Flaws and Bufferbloat
3. Experimental Work & Results
   - Test Setup
   - Results
4. Conclusions & Discussion

The Routers

- The traffic in a network is inherently bursty
  - The role of the buffers in the router is to smooth the flow of traffic.
- Bottleneck Routers
  - Each packet is squeezed down in bandwidth, it must stretch out in time since its size stays constant.

What is Bufferbloat?

- As stated by *Jim Gettys*
  - Todays networks are suffering from unnecessary latency and poor system performance.
  - Large buffers damage or defeat the fundamental congestion-avoidance algorithms of the Internets most common transport protocol.

Bufferbloat

"The existence of excessively large and frequently full buffers inside the network".

General Objectives

- To define the Bufferbloat phenomenon, and explain the impact that it could have on latency and Throughput(related to System Throughput) in Internet.

- To detect its presence by measurements of the latency and throughput in a TCP/IP Network.

- To propose solutions in the implementation of a network where the existence of excessively large and frequently buffers are detected.

Secondary Objectives

- Develop appropriate tests to be able to prove the existence of Bufferbloat.
- To test and differentiate the possible causes of the excessive latency and throughput reduction in a TCP/IP LAN and check how much is generated by Bufferbloat or by a miss-configuration.
- To propose configuration of the TCP parameters in a Linux based machine or an algorithm that can help to minimize the phenomenon.

TCP 101

Packet Conservation Principle

"A new packet isn't put into the network until an old packet leaves".

TCP's Phases

1. Slow Start
   - Exponentially increase of the sending rate.
   - Increase ***cwin*** until ***ssthrsh***.
2. Congestion Avoidance
   - Optimal utilization preventing congestion.
   - Most common: Cubic & CTCP.
3. Fast Retransmit & Recovery
   - Recover from lost without much hurt.
   - Continuous transmitting of new data on subsequent duplicate acknowledgments.

Router's Impact

Main Functions

- To absorb bursts of traffic coming from the hosts.
- To ensure that links are used to their maximum capacity.

- The presence of buffers is necessary to help reduce data loss.
- The absence of timely notification triggers the presence of full buffers and increased communication latency.

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Full Buffers

Packets at bottleneck queue

The packet is squeezed down in bandwidth but must stretch out in time since its size stays constant.

Standing Queue

if rate @*packets* are received $>>$ delay to process and remove a package from the buffer.

"This standing queue is the essence of Bufferbloat only creating long delays in communication."

Other Factors

High Latency

- Large buffers only increase latency.
- It is quite common to find these high-latency queues in the last mile.

Sizing Router's Buffers

- Unmanaged buffers are more critical today
- Buffers sizes are larger, delay-sensitive applications are more prevalent, and large downloads common
- Rule-of-Thumb ***B = RTT*C***

Queue management

Tail-Drop Drawbacks

1. lockout.
2. full queue that impact with a high queue delay.

Queue management

Active Queue Management

"FIFO based queue management mechanisms to support end-to-end congestion control"

Objectives

- Reduce the average queue length.
- Decrease the end-to-end delay.
- Reduce packet losses $\rightarrow$ more efficient resource allocation.

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Algorithms

1. Random Early Detection - RED
   - Can provide high throughput and low average delay, but it's complex to configure properly .
2. BLUE
   - Based directly on packet loss and link utilization, can reduce the buffer size and the end-to-end delay.
3. Control Delay - CoDel
   - Based on the idea of a threshold. Beside the minimum packet sojourn, CoDel needs the target and interval time.

Evolution of Components

- Use's Evolution
- "The more is better" mentallity.
- Flows synchronization.
- Packet lost seen as a problem.

Test Description

Hypothesis

"The networks that we use every day, have the necessary characteristics to generate the Bufferbloat phenomenon whether under low loads and if does exists, the how serious are the effects ?"

Test Description

Test Context

1. Twice on the same day in one network to determine if does exist a considerable variance in latency for different times in a day.
2. Select different public and private networks with different "speeds".
3. Use the Ethernet cable in order to compare the results with those previo1usly obtained using Wireless.

Hardware

- Physical Machine (Host Windows 7 OS)
- Virtual Machine (Kali Linux)
- USB Wireless adapter (Zydas) + 8dbi antenna
- Iperf Server / VPSDigital Ocean (NY DC)

Tools/Software

I. Speedtest.net $\rightarrow$ Base
II. Netalyzer $\rightarrow$ Characterization
III. Iperf $\rightarrow$ Full Utilization
IV. Page Benchmark $\rightarrow$ User Experience
V. Smokeping $\rightarrow$ Multiple Objectives

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Speedtest.net

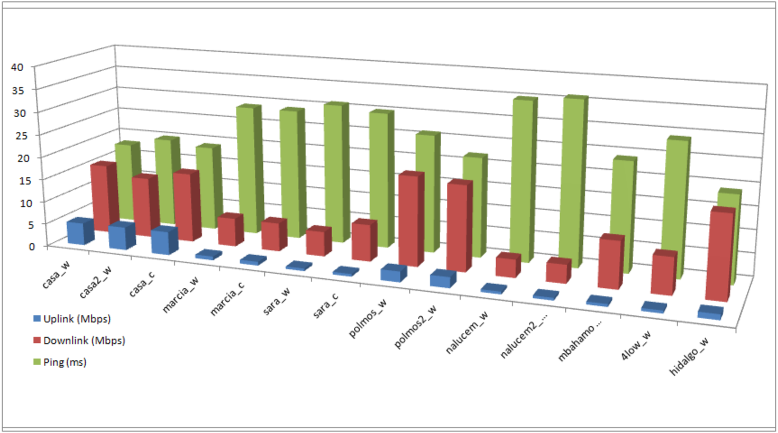


Figure : Speeds and Ping

Results

- The $\sim 12ms$ ping were also not obtained, but the values are still within the acceptable range around the $\sim 26ms$.
- The variation of the ratio between the measured and the bandwidth contracted is of 80%, which is only 6% less than spected.

Page Benchmark

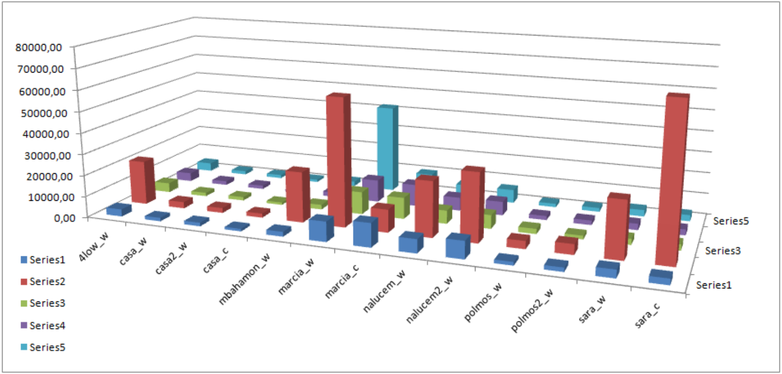
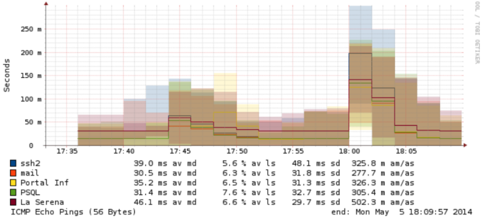


Figure : Total Load Means in ms

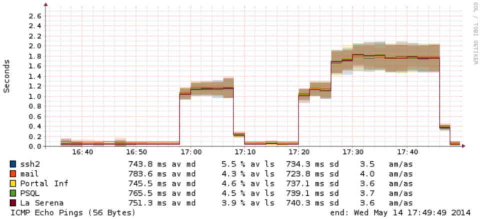
Results Overall

- The average load for a problematic networks was over 9 (max 23) seconds. Normal load is between 1-7 (2) seconds.
- The variation from minimun to maximum load was around 6 to 20 times.

Smokeping



(a) Good performance Network



(b) Bad performance Network

Figure : Ping test to National servers

Smokeping

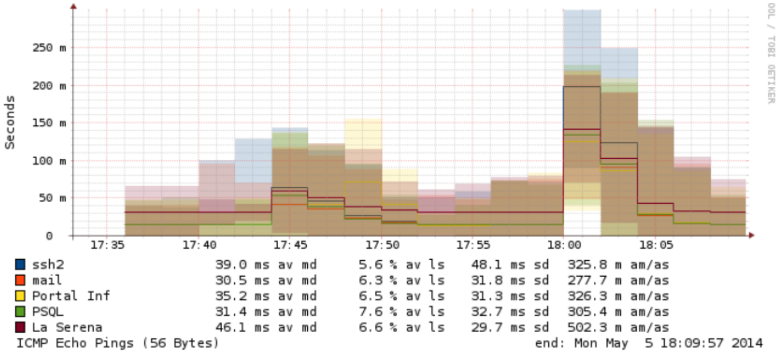
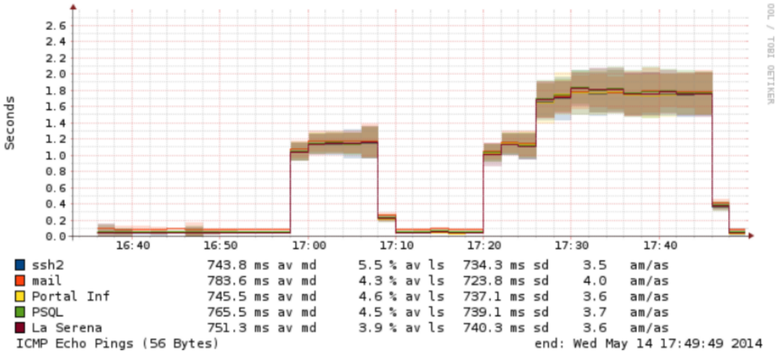


Figure : Good performance Network

Smokeping



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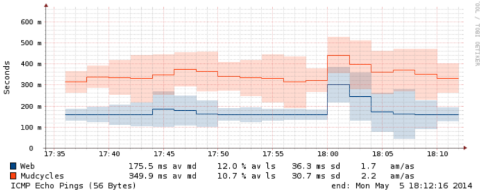

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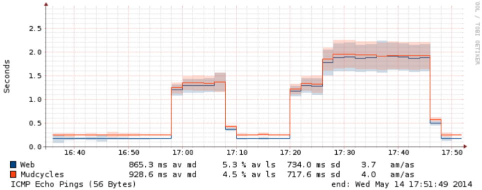


(b) Bad performance network

Figure : Ping test to International servers

Smokeping

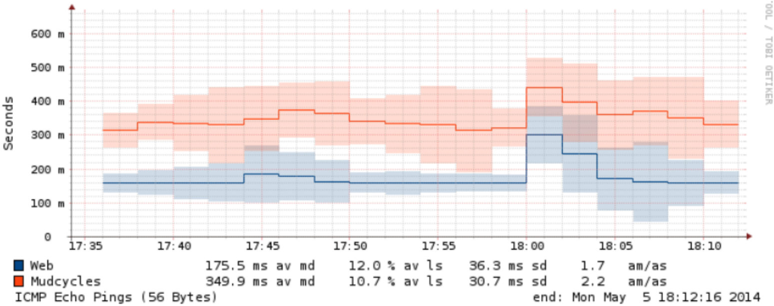
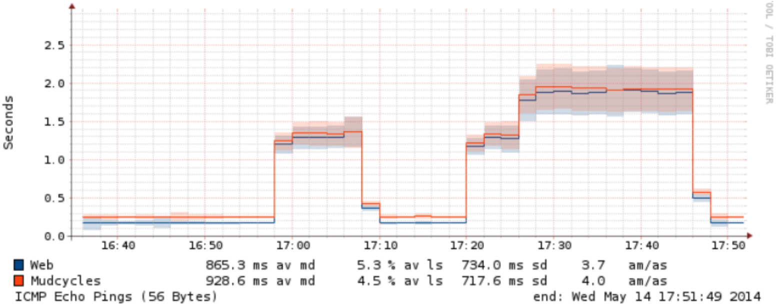


Figure : Good performance network

Smokeping



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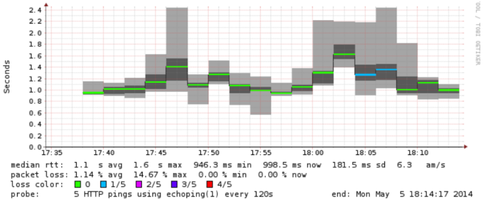

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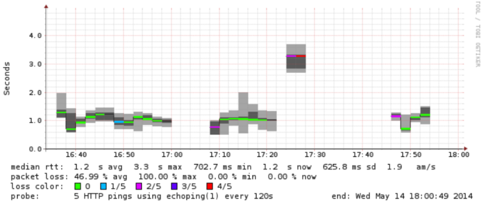

(b) Bad performance network

Figure : Web requests to National servers

Smokeping

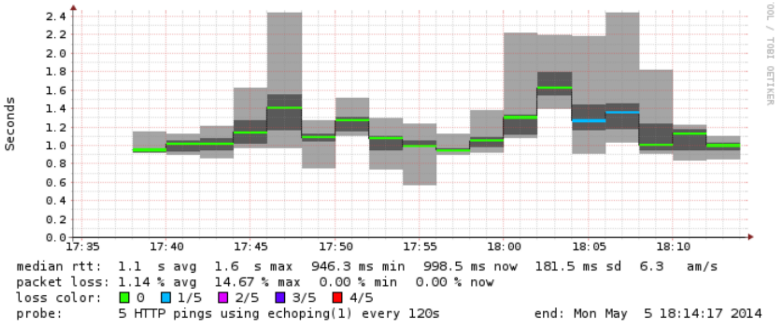

Figure : Good performance network

Smokeping

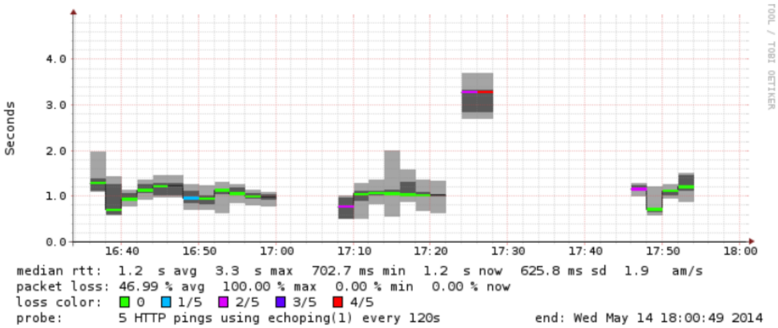

Figure : Bad performance network

Results Overall

- The range for latency in a problematic network can be from 250ms to about 2 seconds.
- Lost related to problematic network can be over 70% with 3 seconds to load and can reach to fully lost of communication.

Conclusions [1/5]

1. *A low latency network is wanted in order to exchange messages between a server and a client.*

Conclusions [2/5]

2. *Having 12 times the latency when the network overload is not normal and as mentioned by Jim Gettys several times, the culprit is Bufferbloat.*

Conclusions [3/5]

3. *Thanks to the various tests it was possible to demonstrate the presence and feel the effects of Bufferbloat in some networks.*

Conclusions [4/5]

4. *With the advance in communications (evolution of real-time or on-demand apps.), the effects of phenomenons like Bufferbloat are more easily to feel and detect.*

Conclusions [5/5]

5. *The larger the buffer size, the longer it takes for a packet to go through it, not adding any value in the packet transfer and only adding additional latency.*

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To keep in mind

- Low Bandwidth $\rightarrow$ Bufferbloat?
- Low Latency or High Bandwidth?
- Why 12 times Lacenty??!!!!
- Benefits of bigger Buffers

Questions & Comments


THANKS
FOR
LISTENING