T3. Performance and Reliability Analysis of Communication Networks

# Submit to srp@es.aau.dk with subject [NetPerf24][T3][Emil L. H Jens-Ulrik L-M]

## Task 1. What is congestion? Discuss ways to control congestion.

## “Too many sources sending too much data too fast for network to handle” [Kurose, Ross] (from slides)”

Congestion in networks happens when too much data is being sent through the network for the network to handle. This manifests itself as queues in the network where packets are being held up, resulting in long delays. Common scenarios where congestion occurs is when resources are shared by many users, e.g. many PC’s using the same router. The problem then becomes how to control the traffic of the users in such a way that the packets still arrive at their destinations without overflowing the buffers and getting dropped or lost.

Problems with congestion only worsen with safety mechanisms such as retransmissions and redundant information from protocols as these features will inhibit actual goodput from being sent. However, they are needed since if congestion happens the information should still arrive eventually, which can only be guaranteed by having the safety mechanisms.

Congestion can thus be tackled in many ways, however in general to approaches exist End-End congestion and Network-Assisted. In the end-end approach the state of congestion is inferred from measures such as loss, delay, RTT and so on to help protocols such as TCP to manage the congestion. In the network-assisted approach the routers provide feedback which more advanced and modern takes on protocols such as TCP-ECN or ATM can use to control the congestion.

Common for most congestion algorithms is the goal of achieving shared and controlled resource management such that the users in the network do not experience lack of service.

## Task 2. What is the bandwidth-delay product? Explain its relation with congestion.

BDP is the maximum amount of data that can be in action without creating a queue

If Capacity increases [C] gets bigger, then it means that the time to deliver [s] in has shrunk, Thus the number of bits in a second has increased. And if RTT increases then we have more seconds thus more bits.

For Congestion this means that if we reduce the individual queues the amount bits exciting the router in a second rises, thus a greater (C).

If we enhance the network size say with more routers, in other words adding a larger [s] (RTT) then more routers can carry more information, elevating the maximum amount of data in action (BDP)

## Task 3. Explain the AIMD approach of TCP. Discuss Slow Start, Congestion Avoidance, and Fast Recovery phases.

The concept of Additive Increase Multiplicative Decrease (AIMD) is to be more optimistic about the network than resetting the Congestion Window (CWND) size to 1 every time a loss happens. The algorithm constantly increases the CWND size additively when there is no congestion to increase the transmission rate. When congestion happens, the window is reduced multiplicatively, typically halved, to lower the transmission rate to avoid congestion. This process results in saw tooth patterns in the CWND size as TCP constantly tries to achieve maximum transmission rate. If multiple users exhibit the same behavior simultaneously the rate will converge to a fair rate shared between the users.

Slow start is a measure taken to softly ease into transmitting. The CWND is only increased by the next power of 2 when an ACK is received, thus the CWND will follow (1, 2, 4, 8, 16, 32…). When congestion is detected, the algorithms note the CWND size and halves it, thus algorithm has also explored the performance of the network. From this point on normal performance can begin such as AIMD, only when timeouts occur does the CWND reset to 1 and slow start starts once again.

Congestion avoidance (CA) is seen during the AI phase of the TCP transmission. Here the protocol carefully increases the rate to avoid causing congestion. When in the CA phase we look for congestion and when it happens due to the AI we retransmit and reduce the window. Congestion can be detected by either timeout or receiving three ACKs.

Fast recovery (FR) is implemented in the Reno variant among other variants of TCP. This measure does not fully reset when congestion is detected (3 DUPACK’s) but starts again from CWND/2+3. This is an optimistic approach with the assumption that whatever caused the congestion is most likely gone again. Thus, this measures gambles on the state of the network to decrease the time spent in a low transmission state.

## Task 4. Discuss TCP Reno and TC Tahoe.

|  |  |
| --- | --- |
| Figure 1 TCP Tahoe (1988)  [we have taken the image Form the Slides] | Figure 2 TCP Reno (1990) [we have taken the image Form the Slides] |

**TCP Tahoe (1988) was the first version made of CC (Congestion Control).**

When one of the two happens:

3 DUPACKs (3 packet request send back)

RTO (**Retransmission Time-Out**.)

1 The system CWND (**Congestion Window)** goes back to 1MSS (Maximum Segment Size) and begin SS (Slow start) .

When it hit form last run the SSTHRESH (slow start threshold), it begins with a liner assent.

**TCP Reno (1990)**

In case RTO reno behaves like Tahoe

When 3 DUPACKs received reno goes into fast recovery mode setting CWND increases with every DUPACK to make up for potential lost data. When an ACK is received and then work linear for her on.

This is with the goal of creating a better throughput

**TCP New Reno (1998)**

SSTHRESH is not reset immediately but we wait until the largest SN (**Sequence Number**.) is ACK then entering fast recovery mode. This ensures better performance in the case of multiple loas where the old would reduce CWND by a factor of 2L(Length) every time.

## Task 5. What are the signals to indicate congestion?

There are many measures for the congestion of a network. Traditionally the measures have been timeout and a 3 DUPACK message. However, in the newer protocol’s measures such as bandwidth product or RTT or delay or maybe even an congestion flag in the packets is also used to indicate that congestion is present in the network.

## Task 6. What is the fairness problem in TCP congestion control?

The fairness problem in TCP congestions control consists of achieving equal rates for all users on the network. Let’s say one user doesn’t follow AIMD while the others do. If this user is greedier than the other users, it can ensure a higher rate than the remaining users, since their AIMD will adapt to the greedy user. In this case the congestion control might be stable and converge to a solution but not a fair one. Thus, a problem arises since fairness should not be used in communication between the users, it should naturally arise from the congestion control exerted by each user individually. In the case of AIMD every user will try to increase their rate but feel the consequences of all the users. This results in the overall rate converging to a fair solution where all users have the same rate.

## Task 7. Provide an overview of BBR, AQM, and ECN options.

**BBR**

Optimum point of operation

If the speed of packets is faster than capacity, RTT will increase due to the queue growing

If the speed of packets is slower than capacity, RTT will shrink to the queue is empty

**Active Queue Management (AQM)**

AQM can control buffers in switches enabling it to, drop packets among different flows if it knows this will help the queue not to over fill. Control delays if a queue is causing consistent delays, it can drop packets

**The ECN option**

In 2001 a feature was added to the IP header ECN (Explicit Congestion Notification). AQM enabled routers could set a flag so TCP end points could learn from the congestion event this can avoiding retransmissions it can also reduce delay significantly for shorter-lived TCP flows.