Assignment 3 - CSC 467

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1 Network wide Max - Min Allocation

1.1 No network wide allocation

$S_1, ..., S_{16}$ will each recieve $\frac{1}{16}$th of a unit of bandwidth through $Link_1$ originating from $SwitchingElement_1$.

$S_{17}, ..., S_{19} + Link_1$ will each recieve $\frac{1}{4}$th of a unit of bandwith through $Link_1$ originating from $SwitchingElement_2$, resulting in S_{15}, S_{16} recieving $\frac{1}{8}$th of a unit of bandwith.

$S_{20}, S_{26} + Link_2$ will each recieve $\frac{1}{7}$th of a unit of bandwidth through $Link_3$ originating from $SwitchingElement_3$, resulting in S_{19} recieving $\frac{1}{7}$th a unit of bandwidth.

1.2 Network wide allocation

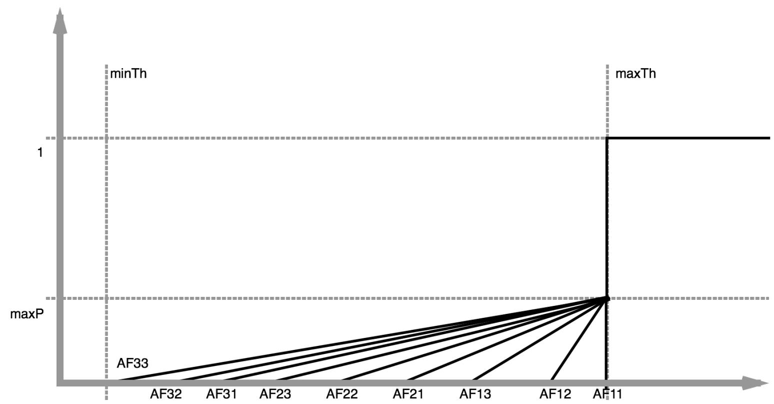
$S_1, ..., S_{16}$ will each recieve $\frac{1}{16}$th a unit of bandwidth through Link 1 originating from Switching Element 1.

$S_1, ..., S_{14}$ terminate in Switching Element 2. $\{S_{15}, S_{16}\}$ join $S_{17}, ..., S_{19}$ incident on Link 2. $\{S_{15}, S_{16}\}$ will recieve at most $\frac{1}{16}$th of a unit of bandwidth each, leaving $\frac{1}{8} = \frac{3}{24}$th a unit left for the other links. $S_{17}, ..., S_{19}$ recieve $\frac{1}{4} + \frac{1}{24}$th a unit of bandwidth each in Link 2.

$S_{15}, ..., S_{18}$ terminate in Switching Element 3. S_{19} joins $S_{20}, ..., S_{26}$ incident on Link 3. S_{19} requests $\frac{3}{24}$th of a unit of bandwidth, but $min(\frac{3}{24}, \frac{1}{8}) = \frac{1}{8}$. Because of this $S_{19}, ..., S_{26}$ all recieve $\frac{1}{8}$th of a unit of bandwith at Link 3.

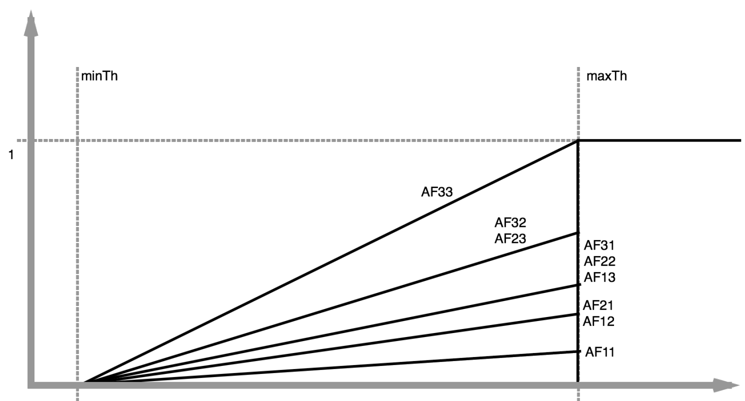
2 RED

2.1 Colours maintained when dropping



2.2 Colours on same curve

In this scenario, we'll maintain the same $minTh$ and $maxTh$, but modify $maxP$ accordingly.



3 Traffic Marking

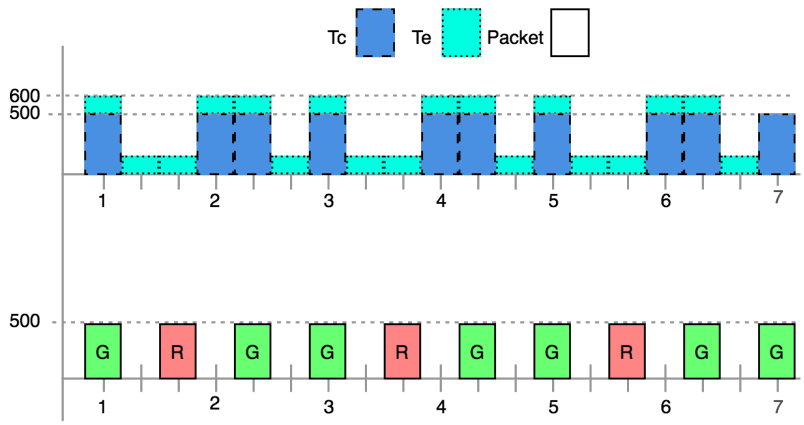
Setting the overall rate of the connection to 500 bytes/sec, and line rate as 2000 bytes/sec, as instructed during class.

3.1 Connection sends traffic at exactly the peak rate

Since this is a well behaved flow all packets are marked green. This is because $CBS = PIR = 500$ bytes.

3.2 Connection sends traffic at 1.5 times the peak rate (contract violation)

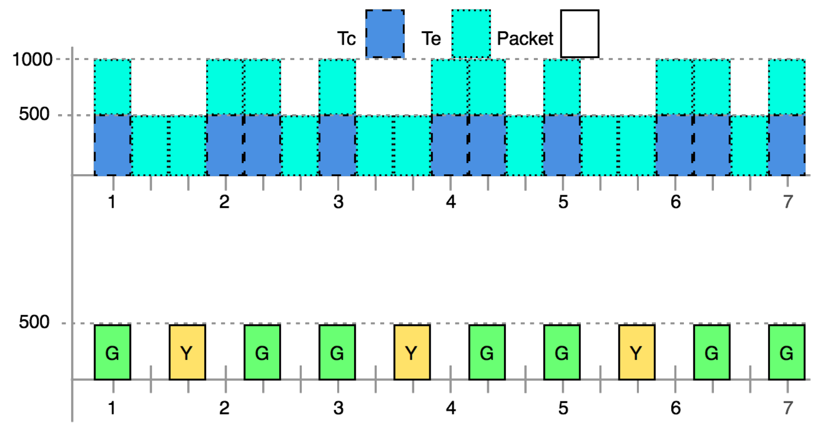
In this case, the source sends 500 byte packets at 1.5 times it's peak rate, so every 0.66 seconds instead of every 1 second.



Approximately $\frac{1}{3}$rd of the packets are marked Red. There are no packets marked Yellow as the EBS, and as such T_e, is 100 bytes, not enough for a whole packet.

3.3 How will your answer for part (3.2) change if EBS=500 bytes?

In this case the packets that would have been marked Red are marked Yellow because the EBS is big enough.



3.4 If CBS set to 250 and EBS=100, what will be the outcome for part (3.1)?

If the CBS is set to 250, and the EBS is set to 100, then no packets will ever be eligible to be either Green or Yellow since $T_c + T_e < Packet$. Thus all packets will be marked as red.

3.5 What is your inference about the bucket settings on marking?

$CBS + EBS$ should always be greater than the average packet size. In order to have Yellow packets, $(CBS \mod packet_{size}) + EBS$ should be at least the average packet size (that is, 750 CBS, 250 EBS in the above would work, so sould 500 CBS and 500 EBS). In order to have Green packets, CBS should be at least the size of the average packet size.

4 EBW

Since we know that the proportions of CLR and Buffer are the same for both queues, their zeta values are the same.

$$\frac{\log(CLR_1)}{B_1} = \frac{\log(CLR_2)}{B_2} = \zeta$$

Because of this, and the fact that both queues have the save parameters PCR, SCR, ABS, means the formula can be solved with $\mu_i = \frac{PCR}{ABS}$, $\lambda_i = \frac{\mu_i * SCR_i}{(PCR - SCR)}$, $\gamma_i = PCR$.

$$c_i = \frac{(\zeta\gamma_i + \mu_i + \lambda_i) - \sqrt{(\zeta\gamma_i + \mu_i - \lambda_i)^2 + 4\lambda_i\mu_i}}{2\zeta}$$

This means that both queues will calculate the same EBW value for their services. Since the number of connections admitted is based on $\sum EBW$ this means it shall be the same for both.

Setting $PCR = 1.0$, $SCR = 0.3$, $ABS = 10$. $\mu_i = \frac{PCR}{ABS} = \frac{1.0}{0.3} = \frac{10}{3}$, $\lambda_i = \frac{\mu_i * SCR_i}{(PCR - SCR)} = \frac{\frac{1.0}{0.3} * 0.3}{(1.0 - 0.3)} = \frac{1.0}{0.7}$, $\gamma_i = PCR = 1.0$. Recall that ζ was not provided. The resulting Effective Bandwidth Calculations will result in the same values, meaning the number of connections admitted will be the same.

$$\frac{(\zeta\gamma_1 + \mu_1 + \lambda_1) - \sqrt{(\zeta\gamma_1 + \mu_1 - \lambda_1)^2 + 4\lambda_1\mu_1}}{2\zeta} = \frac{(\zeta\gamma_2 + \mu_2 + \lambda_2) - \sqrt{(\zeta\gamma_2 + \mu_2 - \lambda_2)^2 + 4\lambda_2\mu_2}}{2\zeta}$$

$$c_1 = c_2 = \frac{(\zeta + 4.7619) + \sqrt{(\zeta + 1.90476)^2 + 19.0476}}{2\zeta}$$

Since the only remaining variable is ζ these two queues will admit an identical number of connections, since their EBW calculations will be the same.

Using Roberts Approach, $EBW = 1.2m + \frac{60m(P-m)}{C}$, where the peak rate $P = PCR = 1.0$, the mean $m = SCR = 0.3$, and the link capacity C (not provided).

$$EBW = 1.2(0.3) + \frac{60(0.3)((1.0) - (0.3))}{C} = 0.36 + \frac{12.6}{C}$$

5 Multi - class EBW in a single queue

5.1 What's the remaining (available) bandwidth on the link?

For the 20 AF services, we need to calculate Effective Bandwidth, where:

$$\mu_i = \frac{PCR}{ABS} = \frac{0.01}{10} = 0.001$$
$$\lambda_i = \mu_i \frac{SCR_i}{(PCR - SCR)} = 0.001 \frac{0.001}{(0.01 - 0.001)} = 0.0001$$
$$\gamma = PCR = 0.01$$

$$\zeta = \frac{\log CLR}{B} = \frac{\log(10^{-7})}{1000} = -0.01612$$

$$c_i = \frac{(\zeta\gamma_i + \mu_i + \lambda_i) - \sqrt{(\zeta\gamma_i + \mu_i - \lambda_i)^2 + 4\lambda_i\mu_i}}{2\zeta}$$

$\frac{(-0.01612(0.01)+0.001+0.0001)-\sqrt{(-0.01612(0.01)+0.001-0.0001)^2+4(0.0001)(0.001)}}{2(-0.01612)}$

Which results in 0.001147 as the EBW for the 20 AF Services.

Then use that to determine the remaining portion of bandwidth:

$$Link - (\sum BW(EF) + \sum EBW(AF) + \sum BW(BE))$$

$$1.0 - (10(0.01) + 20(0.001147) + 100(0.001)) = 0.77706$$

5.2 What's the Statistical gain achieved for VBR services?

For the variable bit rate, the statistical gain is $\frac{PCR}{EBW} = \frac{0.01}{0.001147} = 8.715808$.

5.3 What is the load (utilization) on the switch?

Since the link has 77.7% of it's bandwidth available, it's utilization is 100% − 77.7% = 22.3%.

$$\rho = \frac{(10(0.01) + 20(0.001147) + 100(0.001))}{1.0} = .223$$

5.4 What will the delay experienced by these packets when traversing through the switch?

$$E(T) = \frac{1}{\mu(1-\rho)} = \frac{1}{1.0(1-.223)} = 1.287$$

6 Multi - class EBW

6.1 What is the load on EF queue?

With an outgoing link capacity of 1.0, and a queue weight of 20 (out of a total of 100), the EF queue recieves up to $\frac{1}{5}$th the possible bandwidth, 0.20.

However the services will only utilize (10(0.01) = 0.1 worth of bandwidth. Thus the load is

$$\frac{0.1}{0.20} = 0.5$$

As such it is 50% loaded.

6.2 What is the load on AF queue?

With an outgoing link capacity of 1.0, and a queue weight of 40 (out of a total of 80), the AF queue recieves up to $\frac{2}{5}$th the possible bandwidth, 0.40.

The services will utilize $20(0.001147) = 0.02294$ worth of bandwidth. Thus the load is

$$\frac{0.02294}{0.40} = 0.05735$$

As such it is 5.7% loaded.

6.3 What is the load on BE queue?

With an outgoing link capacity of 1.0, and a queue weight of 40 (out of a total of 80), the BE queue recieves up to $\frac{2}{5}$th the possible bandwidth, 0.40.

The services will utilize $100(0.001) = 0.1$ worth of bandwidth. Thus the load is

$$\frac{0.1}{0.40} = 0.25$$

As such it is 25% loaded.

6.4 Assuming that the unallocated bandwidth for EF and AF is given to BE queue by the WFQ, what will be the bandwidth achieved by the BE queue?

The bandwidth achieved by the BE queue will be the Total Bandwidth minus the allocated bandwidth of the EF and AF queues.

$$1.0 - 0.1 - 0.02294 = 0.877$$

6.5 As each queue can get its dedicated bandwidth, for now model each queue independently with that allocated bandwidth as an M/M/1 queue . With this assumption what would be the delay experienced by packets when traversing these queues? How does it compare with Question 5?

$$E(T) = \frac{1}{\mu(1-\rho)}$$

$$E(EF) = \frac{1}{0.2(1-.5)} = 10$$

$$E(AF) = \frac{1}{(0.02294)(1 - 0.05735)} = 46$$

$$E(BE) = \frac{1}{(0.877)(1 - \frac{0.1}{0.877})} = 1.2870$$

The queues are longer in this model than Question 5.