Reconciliation of formulas for maxBurst in 802.1Qav

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Introduction

- References 1 and 2 (these are 2 revisions of the same document), and 3 use different modeling assumptions in deriving maximum burst size for a traffic class X ($maxBurst_X$)
- In addition to the modeling assumptions being different, the results are different
- The purpose of this presentation is to reconcile the 2 approaches and derive a consistent result

Reference 2 methodology and result – 1

- Reference 2 uses the following model (see reference 2 for the notation definition)
  - Total time to transmit all the queued class A through X traffic, worst case, is given by (see slide 41 of 1

$$T_{\alpha\delta} = \frac{M_0 + \sum_{k=A}^{X} M_k}{W_X}$$

  - This result apparently comes from the result for the queueing delay for class X on slide 34 of reference 2, but applying this result to class X+1

$$T_{\alpha\delta} = \frac{M_0 + \sum_{k=A}^{X} M_k}{W_{<(X+1)}}$$

  - In using the result, the approximation has been used that $W_{<(X+1)} \approx W_X$; this is a good approximation when class X gets most of the bandwidth
    - The validity of this is shown on the next slide

Reference 2 methodology and result - 2

- From slide 25 of reference 2

$$W_{<X} = -sendSlope_{<X} = R_0 - \sum_{k<X} R_k$$

- For the case where classes 1, 2, …, X-1 all get negligible bandwidth compared to class X and the line rate, $R_k \approx 0$ for all k
  - Then

$$W_{<X} = R_0$$

- For classes 1, 2, …, X, an analogous result can be derived

$$W_{<(X+1)} = -sendSlope_{<(X+1)} = R_0 - \sum_{k<(X+1)} R_k \approx R_0 - R_X$$

- But we also know that the send slope for class X is given by

$$sendSlope_X = -W_X = R_X - R_0$$

- Then, when classes 1 through X-1 get negligible bandwidth

$$W_{<(X+1)} \approx W_X$$

Reference 2 methodology and result – 3

- Reference 2 goes on (slide 41) to subtract the time to transmit the final class X frame, of size M_X; the resulting time after this subtraction is multiplied by the average rate of transmission of class X data, under the assumption that class X has been transmitting for the entire time, since it has been allocated almost all the bandwidth
  - This average rate is given as

$$\sum_{k<(X+1)} R_k = R_0 - W_X$$

- However, this is not correct
  - The above is the sum of the idle slopes of classes 1 through X, and not the average rate of transmission of class X data
  - Since data is being transmitted all this time, the correct rate is the line rate R_0
- Making this correction, the result for maxBurst_X on slide 42 of reference 2 becomes

Reference 2 methodology and result - 4

$$\text{maxBurst}_X = \left[\frac{M_0 + \sum_{k=A}^{X} M_k}{W_X} - \frac{M_X}{R_0} \right] R_0 + M_X = \left(M_0 + \sum_{k=A}^{X} M_k \right) \frac{R_0}{W_X}$$

- This can be rewritten (to facilitate reconciliation with the result in reference 3

$$\text{maxBurst}_X = \left(M_0 + \sum_{k=A}^{X-1} M_k \right) \frac{R_0}{W_X} + \frac{M_X R_0}{W_X}$$

- Note that reference 2 considers maxBurst_X to be the maximum burst due to all the class A through X traffic during the busy period for these classes
  - This includes both class A through X-1 traffic, plus earlier class X traffic that is separated from the final contiguous class X frames by class A through X-1 traffic

Reference 3 Methodology and result - 1

- Reference 3 computes maxBurst$_X$ as highCredit$_X$ minus loCredit$_X$, divided by W_X to get the time to use up these credits, and multiplied by R_0 to get the burst size
- But this is not complete; we must add the time to build up highCredit$_X$ multiplied by R_0 because higher priority classes are transmitting during this time
- loCredit$_X$ is given by -M_X
- But this is not correct; loCredit$_X$ is actually obtained by computing the time to transmit M_X and then multiplying by sendSlope$_X$ = -W_x; the result is

$$loCredit_X = -\frac{M_X W_X}{R_0}$$

- hiCredit$_X$ is given by the amount of credit that can be accumulated in time qDelay$_X$, which is qDelay$_X$ multiplied by the idle slope R_X; the result is

$$hiCredit_X = \frac{M_0 + \sum_{k<X} M_k}{W_{<X}} R_X$$

Reference 3 Methodology and result - 2

- Then

$$\text{maxBurst}_X = \frac{\left(M_0 + \sum_{k<X} M_k\right) R_0 R_X}{W_{<X} W_X} + M_X + \frac{\left(M_0 + \sum_{k<X} M_k\right) R_0}{W_{<X}}$$

- From slide 4, $W_{<X} \approx R_0$. Then

$$\text{maxBurst}_X = \frac{\left(M_0 + \sum_{k<X} M_k\right) R_X}{W_X} + M_X + \left(M_0 + \sum_{k<X} M_k\right)$$

$$= \frac{\left(M_0 + \sum_{k<X} M_k\right)\left(R_0 - W_X\right)}{W_X} + M_X + \left(M_0 + \sum_{k<X} M_k\right)$$

$$= \frac{\left(M_0 + \sum_{k<X} M_k\right) R_0}{W_X} + M_X$$

Reconciliation - 1

- The result from Reference 2 (bottom of slide 6) and Reference 3 (bottom of slide 8) are almost the same. They differ in the last terms; the former is $M_X R_0/W_X$, while the latter is M_X
- The difference seems to be due to the fact that Reference 2 assumes that many frames of Class X are transmitted during the entire interval; the final frames are Class X, but there are earlier ones interspersed with the higher-priority class frames
  - Reference 3 assumes that only higher-priority class frames are transmitted before the class X frames
  - In reference 2, the class X frames queue during periods when classes A through X-1 are being transmitted.

Reconciliation - 2

- maxBurst for only final class X burst
  - Based on reference 3, but with corrections

$$\mathrm{maxBurst}_X = \frac{\left(M_0 + \sum_{k<X} M_k\right) R_X}{W_X} + M_X$$

$$= \frac{\left(M_0 + \sum_{k<X} M_k\right)\left(R_0 - W_X\right)}{W_X} + M_X$$

$$= \frac{\left(M_0 + \sum_{k<X} M_k\right) R_0}{W_X} + M_X - \left(M_0 + \sum_{k<X} M_k\right)$$

Reconciliation - 3

- maxBurst based on busy period for classes A through X
  - Based on reference 2, but with corrections

$$\mathrm{maxBurst}_X = \left(M_0 + \sum_{k=A}^{X-1} M_k \right) \frac{R_0}{W_X} + \frac{M_X R_0}{W_X}$$

References

1. Norman Finn, *P802.1Qat Delay and Bandwidth Parameterization, Parameters for delay and bandwidth capacity calculations for IEEE P802.1Qat SRP*, Version 4 (at-nfinn-delay-bw-parameters-0508-v4), July, 2008.
2. Norman Finn, *P802.1Qat Delay and Bandwidth Parameterization, Parameters for delay and bandwidth capacity calculations for IEEE P802.1Qat SRP*,, Version 6 (at-nfinn-delay-bw-parameters-0508-v6), July, 2008.
3. P802.1Qav D3.0.