Reconciliation of formulas for maxBurst in 802.1Qav

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IEEE 802.1 AVB TG
2008.11.11

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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 \(\text{maxBurst}_X\)

- 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, \ldots, 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, \ldots, 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 $\text{maxBurst}_X$ 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\textsubscript{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 \( \text{maxBurst}_X \) as \( \text{highCredit}_X \) minus \( \text{loCredit}_X \), 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 \( \text{highCredit}_X \) multiplied by \( R_0 \) because higher priority classes are transmitting during this time.

- \( \text{loCredit}_X \) is given by \( -M_X \).

- But this is not correct; \( \text{loCredit}_X \) is actually obtained by computing the time to transmit \( M_X \) and then multiplying by \( \text{sendSlope}_X = -W_x \); the result is
  \[
  \text{loCredit}_X = -\frac{M_X W_x}{R_0}
  \]

- \( \text{hiCredit}_X \) is given by the amount of credit that can be accumulated in time \( \text{qDelay}_X \), which is \( \text{qDelay}_X \) multiplied by the idle slope \( R_X \); the result is
  \[
  \text{hiCredit}_X = \frac{M_0 + \sum_{k < X} M_k}{W_{<X}} R_X
  \]
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

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

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

\[ = \frac{\left( M_0 + \sum_{k<X} M_k \right) R_0}{W_X} + M_X \]
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.
maxBurst for only final class X burst

Based on reference 3, but with corrections

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

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

\[
= \left( M_0 + \sum_{k<X} M_k \right) \frac{R_0}{W_X} + M_X - \left( M_0 + \sum_{k<X} M_k \right)
\]
maxBurst based on busy period for classes A through X

Based on reference 2, but with corrections

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


3. P802.1Qav D3.0.