****
ATM Forum Document Number: ATM Forum/97-0613
****

Title: Modifications to section 3.3 and 3.4 of ATM Forum Performance Testing Specification - Baseline Text
****

Abstract: Improved text for throughput fairness and frame loss ratio measurement for throughput section of the baseline text is presented.
****

Source:
Gojko Babic, Arjan Durresi, Raj Jain, Justin Dolske.
The Ohio State University

Raj Jain is now at Washington University in Saint Louis, jain@cse.wustl.edu http://www.cse.wustl.edu/~jain/

The presentation of this contribution at the ATM Forum is sponsored by NASA.
****

Date: July 1997
****

Distribution: ATM Forum Technical Working Group Members (AF-TEST, AF-TM)
****

****

This contribution is a resubmission of a part of our contribution 97-0426 submitted in April. In this, we explain the proposed changes to the section 3.3 (throughput fairness) and 3.4 (frame loss ratio) of the baseline text. As instructed in the last meeting, this contribution has three parts. In the first part, we describe the changes. The second part contains the proposed text and the third part shows the changes from current baseline.

A1. Explanations of the changes in the section "3.3. Throughput Fairness".

a. Old 3.3.1. is split into new 3.3.1. and 3.3.2. in order to reach a clearer explanation–
b. 3.3.1. – Peak-throughput fairness and full-load throughput fairness introduced as necessary in describing the throughput fairness of the switch plus some editorial changes of parts from old 3.3.1.
c. 3.3.2. – New paragraph which includes parts of old 3.3.1. plus editorial changes
d. Old 3.3.2. removed as unnecessary because load level and traffic pattern issues are discussed in the throughput measurement section 3.1.4.
e. 3.3.3 –Description of measurement procedures as necessary for the measurement process (new);
f. 3.3.4. – Minor changes from old 3.3.3
g. Old 3.3.4 removed because the background traffic is for further study.
h. 3.3.5. – Minor appropriate changes made. Part of it is covered now by Section 3.3.1
i. Old 3.3.6. removed as not needed.

A2. Explanations of the changes in the section "3.4. Frame Loss Ratio".

j. 3.4.1. – Minor editorial changes
k. 3.4.2. – Unchanged
l. Old 3.4.3 removed because the traffic pattern issue is the same as in throughput measurements.
m. New 3.4.3 describes the measurement procedure
n. 3.4.4. Removed mean and /or standard deviation since there is only one sample of the three frame-level throughput metrics.
o. 3.4.5. – Minor appropriate changes made
p. Old 3.4.6. removed as not needed.

B1. Revised text.

3.3. THROUGHPUT FAIRNESS

3.3.1. Definition

There are two throughput fairness metrics that are of interest to users:

- *Peak-throughput fairness*: this is the fairness at a frame load for the peak throughput.
- *Full-load throughput fairness*: This is the fairness at a frame load for the full-load throughput.

Given n virtual circuits sharing a system (a single switch or a network of switches) and contending for the resources, throughput fairness indicates how far the actual individual allocations are from the ideal allocations. In the simplest case for a total throughput T, the ideal allocation should be T/n. We consider that in the most general case, the ideal allocation is defined by max-min allocation and that allocation is to be used.[1]

If the actual measured throughputs of n virtual circuits are found to be $\{T_1, T_2, ..., T_n\}$, where the ideal throughputs should be $\{\hat{T}_1, \hat{T}_2, ..., \hat{T}_n\}$, then the throughput fairness of the system under test is quantified by the "fairness index" computed as follows:

$$\text{Fairness index} = (\sum x_i)^2 / (n \times \sum x_i^2)$$

where:

- $x_i = T_i/\hat{T}_i$ is the relative allocation to ith VC.

Note that fairness index is not limited to throughput. It can be applied to other metrics, such as latency. However, extreme unfairness in latency is expected show up as unfairness in throughput and vice versa. Therefore, it is not required to quantify fairness of latency.

3.3.2. Units

This fairness index is dimension-less. The units used to measure the throughput (bits/sec, cells/sec, or frames/sec) do not affect its value. In addition, the fairness index has the following desirable properties:

- It is a normalized measure that ranges between zero and one. The maximum fairness is 100% and the minimum 0%. This makes it intuitive to interpret and present.
- If all x_i's are equal, the allocation is fair and the fairness index is one.

---

[1] Other policies could be used but must be specified.

- If n-k of n x_i's are zero, while the remaining k x_i's are equal and non-zero, the fairness index is k/n. Thus, a system which allocates all its capacity to 80% of VCs has a fairness index of 0.8 and so on.

3.3.3. Measurement procedures

To measure a peak throughput fairness, the peak throughput for the given SUT has to be first obtained as described in 3.1.4. An experiment for peak throughput fairness is performed by generating the input load corresponding to the peak throughput and recording throughput for each foreground virtual circuit. The experiment is repeated p times. Here p is a parameter and its default value is 30.

To measure a full throughput fairness, the full-load throughput for the given SUT has to be first obtained as described in 3.1.4. Then experiments for full-load throughput fairness are performed similarly to peak throughput fairness experiments.

3.3.4. Statistical Variations

Let F_i be the fairness for the ith throughput experiment, then the mean fairness is computed as follows:

$$\text{Mean Fairness} = (\Sigma F_i) / p$$

3.3.5. Reporting Results

Values of the mean fairness for peak and lossless throughput (with indication of a number of experiments) are reported along with a detailed description of the SUT, foreground traffic characteristics, and background traffic characteristics (if any), as defined in 3.1.8.

B2. Revised text.

3.4 Frame loss ratio

3.4.1 Definition

Frame loss ratio is defined as the fraction of frames that are not forwarded by a system under test (SUT) due to lack of resources. Partially delivered frames are considered lost.

Frame loss ratio = (Input frame count - output frame count)/(input frame count)

There are two frame loss ratio metrics that are of interest to a user:

- *Peak-throughput frame loss ratio*:- This is the frame loss ratio at a frame load for the peak throughput.
- *Full-load frame loss ratio*:- This is the frame loss ratio at a frame load for the full-load throughput.

3.4.2. Units

The frame loss ration is expressed as a fraction of input frames.

3.4.3. Measurement Procedures

The frame loss ratio metric is related to the throughput:

Frame Loss Ratio = (Input Rate - Throughput)/Input Rate

Thus, no additional experiments are required for frame loss ratios. These can be derived from tests performed for throughput measurements.

3.4.4. Statistical Variations

Since there is only one sample for any of the three frame-level throughput metrics, there is no need for calculation of the means and/or standard deviations of frame loss ratio.

3.4.5. Reporting Results

Values of the frame loss ratios for peak and lossless are reported along with a detailed description of the SUT, foreground traffic characteristics, and background traffic characteristics (if any), as defined in 3.1.8.

C1. Differences between the Revised and Old Text.

3.3. THROUGHPUT FAIRNESS

3.3.1. Definition

There are two throughput fairness metrics that are of interest to users:

- *Peak-throughput fairness*: this is the fairness at a frame load for the peak throughput.
- *Full-load throughput fairness*: This is the fairness at a frame load for the full-load throughput.

Given *n* virtual circuits sharing a system (a single switch or a network of switches) ~~Given *n* contenders~~and contending for the resources, throughput fairness indicates how far the actual individual allocations are from the ideal allocations. In the simplest case for a total throughput T, the ideal allocation should be T/n. We consider that in the most general ~~case of a network,~~case, the ideal allocation is defined by max-min allocation ~~to various contending virtual circuits. For the simplest case of *n* VCs sharing a link with a total throughput *T*, the throughput of each VC should be *T/n*.~~and that allocation is to be used.[2]

If the actual measured throughputs of *n* ~~VCssharing a system (a single switch or a network of switches)~~ virtual circuits are found to be $\{T_1, T_2, ..., T_n\}$, where the ~~optimal max-min throughputs~~[3]ideal throughputs should be $\{\hat{T}_1, \hat{T}_2, ..., \hat{T}_n\}$, then the throughput fairness of the system under test is quantified by the "fairness index" computed as follows:

$$\cancel{\text{Fairness Index} = \frac{\left(\Sigma x_i\right)^2}{n\Sigma x_i^2}}$$

$$\text{Fairness index} = (\sum x_i)^2 / (n \times \sum x_i^2)$$

where:

- ~~Where, $x_i = T_i/$~~$x_i = T_i / \hat{T}_i$ is the relative allocation to *i*th VC.

~~This Fairness Index has the following desirable properties:~~

Note that fairness index is not limited to throughput. It can be applied to other metrics, such as latency. However, extreme unfairness in latency is expected show up as unfairness in throughput and vice versa. Therefore, it is not required to quantify fairness of latency.

3.3.2. Units

---

[2] Other policies could be used but must be specified.

~~[3] Other policies could be used but must be specified.~~

~~1. It is dimensionless.~~This fairness index is dimension-less. The units used to measure the throughput (bits/sec, cells/sec, or frames/sec) do not affect its ~~value.~~
value. In addition, the fairness index has the following desirable properties:

- ~~2.~~ It is a normalized measure that ranges between zero and one. The maximum fairness is 100% and the minimum 0%. This makes it intuitive to interpret and present.
- ~~3.~~ If all x_i's are equal, the allocation is fair and the fairness index is one.
- ~~4.~~ If n-k of n x_i's are zero, while the remaining k x_i's are equal and non-zero, the fairness index is k/n. Thus, a system which allocates all its capacity to 80% of VCs has a fairness index of 0.8 and so on.

~~3.3.2 Load Level and Traffic Pattern~~

~~Throughput fairness is quantified via the fairness index for each of the throughput experiments in which there are either multiple VCs or multiple input or output ports. Thus, it applies to all three throughput measures (lossless, peak, and full-load) and all four traffic patterns (n-to-n straight, n-to-n cross, n-to-1, and 1-to-n) described in Section 3.1.4.~~
~~Note that in the case of n-to-n cross, there are~~ $\cancel{n^2}$ ~~VCs and, therefore,~~ $\cancel{n^2}$ ~~should be substituted in place of n in the fairness index.~~
~~In the case of a 1-to-n pattern, there is only one VC and all input is expected to be multicast to n output ports. The fairness will measure the equality of throughput to the output ports.~~
~~No additional experiments are required for throughput fairness. The detailed results obtained for the throughput tests are analyzed to compute the fairness.~~

~~3.3.3 Statistical Variation~~**3.3.3. Measurement procedures**

To measure a peak throughput fairness, the peak throughput for the given SUT has to be first obtained as described in 3.1.4. An experiment for peak throughput fairness is performed by generating the input load corresponding to the peak throughput and recording throughput for each foreground virtual circuit. The experiment is repeated *p* times. Here p is a parameter and its default value is 30.

To measure a full throughput fairness, the full-load throughput for the given SUT has to be first obtained as described in 3.1.4. Then experiments for full-load throughput fairness are performed similarly to peak throughput fairness experiments.

3.3.4. Statistical Variations

~~The throughput tests are run NRT times for TRT seconds each. Recall that NRT and TRT are parameters. The fairness is computed for each individual run.~~ Let F_i be the fairness for the ith ~~run,~~throughput experiment, then the mean fairness is computed as follows:

$$\cancel{\text{Mean Fairness} = \text{sum}(F_i)/\text{NRT}}$$

~~3.3.4 Background Traffic~~

~~The throughput tests are conducted with and without background traffic. Higher priority VBR traffic can act as background traffic. Further details for measurements with background traffic (multiple service~~

~~classes simultaneously) are for further study. Until then all performance testing will be done without any background traffic.~~

~~3.3.5 Reporting Results~~

~~The fairness index values are reported for each of the throughput experiments in the tabular format specified in Table 3.1.~~

~~Note that fairness index is not limited to throughput. It can be applied to other metrics, such as latency. However, extreme unfairness in latency is expected show up as unfairness in throughput and vice versa. Therefore, it is not required to quantify fairness of latency.~~

~~3.3.6 Guidelines For Using This Metric~~

~~To be specified.~~

$$\text{Mean Fairness} = (\Sigma F_i) / p$$

3.3.5. Reporting Results

Values of the mean fairness for peak and lossless throughput (with indication of a number of experiments) are reported along with a detailed description of the SUT, foreground traffic characteristics, and background traffic characteristics (if any), as defined in 3.1.8.

C2. Differences between the Revised and Old Text.

~~3.4. FRAME LOSS RATIO~~*3.4 Frame loss ratio*

3.4.1 Definition

Frame loss ratio is defined as the fraction of frames that are not forwarded by a system under test (SUT) due to lack of resources. Partially delivered frames are considered lost.

Frame loss ratio = (Input frame count - output frame count)/(input frame count)

There are two frame loss ratio metrics that are of interest to a ~~user.~~user:

- ~~i.~~ *Peak-throughput frame loss* ~~**ratio** - It~~*ratio*:- This is the frame loss ratio at a frame load for the peak throughput.
- ~~ii.~~ *Full-load frame loss* ~~**ratio** - It~~*ratio*:- This is the frame loss ratio at a frame load for the full-load throughput.

3.4.2. Units

The frame loss ration is expressed as a fraction of input frames.

3.4.3. Measurement Procedures

~~These metrics are~~The frame loss ratio metric is related to the throughput:

Frame Loss Ratio = (Input Rate - Throughput)/Input Rate

Thus, no additional experiments are required for frame loss ratios. These can be derived from tests performed for throughput ~~measurements provided the input rates are recorded.~~measurements.

~~3.4.2 Unit~~

~~The frame loss ratio is expressed as a fraction of input frames.~~

~~3.4.3 Traffic Patterns~~

~~FLRs are measured for each of the four traffic patterns (n-to-n straight, n-to-n cross, n-to-1, and 1-to-n) specified for throughput measurements in Section 3.1.4. All frames are of the same size.~~

~~3.4.4 Statistical Variation~~

~~The throughput experiments are repeated NRT times for TRT seconds each. Here, NRT and TRT are parameters. If FLR_i is the frame loss ratio for the *i*th run:~~

~~Frame Loss Ratio FLR_i = (Input $Rate_i$ - $Throughput_i$)/Input $Rate_i$~~

~~Since frame loss ratio is a "ratio," its average cannot be computed via straight summation. The average frame loss ratio for NRT runs is computed as follows:~~

~~Average Frame Loss Ratio FLR = [Σ Input $Rate_i$ - Σ $Throughput_i$]/ Σ Input $Rate_i$~~

~~The average is reported as the FLR for the experiment.~~

~~3.4.5 Reporting Results~~

~~FLR values are reported for peak throughput and full-load throughput experiments in the tabular format specified in Table 3.1.~~

~~3.4.6 Guidelines For Using This Metric~~

~~To be specified.~~

3.4.4. Statistical Variations

Since there is only one sample for any of the three frame-level throughput metrics, there is no need for calculation of the means and/or standard deviations of frame loss ratio.

3.4.5. Reporting Results

Values of the frame loss ratios for peak and lossless are reported along with a detailed description of the SUT, foreground traffic characteristics, and background traffic characteristics (if any), as defined in 3.1.8.