                   Terminology for ATM ABR Benchmarking

Status of this Memo

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Abstract

   This memo discusses and defines terms associated with performance
   benchmarking tests and the results of these tests in the context of
   Asynchronous Transfer Mode (ATM) based switching devices supporting
   ABR (Available Bit Rate). The terms defined in this memo will be
   used in addition to terms defined in RFCs 1242, 2285, and 2544 and
   2761. This memo is a product of the Benchmarking Methodology Working
   Group (BMWG) of the Internet Engineering Task Force (IETF).

1. Introduction

   This document provides terminology for benchmarking ATM based
   switching devices supporting ABR. It extends terminology already
   defined for benchmarking network interconnect devices in RFC's 1242,
   2285, and 2544 and 2761. Although some of the definitions in this
   memo may be applicable to a broader group of network interconnect
   devices, the primary focus of the terminology in this memo is on ATM
   ABR.

   This memo contains two major sections: Background and Definitions.
   The background section provides the reader with an overview of the
   technology and IETF formalisms. The definitions section is split
   into two sub-sections. The formal definitions sub-section is
   provided as a courtesy to the reader. The measurement definitions
   sub-section contains performance metrics with inherent units.

   This document assumes that necessary services are available and
   active. For example, IP connectivity requires SSCOP connectivity
   between signaling entities. Further, it is assumed that the SUT has

the ability to configure ATM addresses (via hard coded addresses,
ILMI or PNNI neighbor discovery), has the ability to run SSCOP, and
has the ability to perform signaled call setups (via UNI or PNNI
signaling). Finally, this document presents only the terminology
associated with benchmarking IP performance over ATM; therefore, it
does not represent a total compilation of ATM test terminology.

The BMWG produces two major classes of documents: Benchmarking
Terminology documents and Benchmarking Methodology documents. The
Terminology documents present the benchmarks and other related terms.
The Methodology documents define the procedures required to collect
the benchmarks cited in the corresponding Terminology documents.

2. Existing Definitions.

RFC 1242, "Benchmarking Terminology for Network Interconnect
Devices", should be consulted before attempting to make use of this
document. RFC 2544, "Benchmarking Methodology for Network
Interconnect Devices", contains discussions of a number of terms
relevant to the benchmarking of switching devices and should be
consulted. RFC 2285, "Benchmarking Terminology for LAN Switching
Devices", contains a number of terms pertaining to traffic
distributions and datagram interarrival. RFC 2761, "Terminology for
ATM Benchmarking", contains a number terms pertaining to traffic
management [TM4.0, TM4.1]. Many of the metrics defined in RFC 2761
(e.g., CDV, CER, CLR, CMR, and CTD) also apply to ABR performance
benchmarking. These metrics will not be redefined in this document.
For the sake of clarity and continuity, this RFC adopts the template
for definitions set out in Section 2 of RFC 1242.

II. Definitions

The definitions presented in this section have been divided into two
groups. The first group is formal definitions, which are required in
the definitions of the performance metrics but are not themselves
strictly metrics. These definitions are subsumed from other work
done in other working groups both inside and outside the IETF. They
are provided as a courtesy to the reader.

1. Formal Definitions

1.1. Definition Format (from RFC 1242)

Term to be defined.

Definition: The specific definition for the term.

   Discussion: A brief discussion of the term, its application and any
   restrictions on measurement procedures.

   Specification: The working group and document in which the terms are
   specified and are listed in the references section.

1.2. Related Definitions.

1.2.1. Allowed Cell Rate (ACR)

   Definition: An ABR service parameter, ACR is the current rate
   (cells/second) at which a source is allowed to send.

   Discussion: For ABR traffic, ACR constitutes the actual data
   throughput for a particular VC. The time change of this value
   effects TCP round trip time calculations, which in turn effects TCP
   throughput.

   Specification: AF-TM4.0

1.2.2. ACR Decrease Time Factor (ADTF)

   Definition: This is the time permitted between sending RM-cells
   before the rate is decreased to ICR (Initial Cell Rate). The time
   units are .01 to 10.23 seconds with a granularity of 10 ms.

   Discussion: For ABR traffic, ADTF constitutes the time rate of the
   ACR. This value effects TCP round trip time calculations, which in
   turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.3. Additive Increase Rate (AIR)

   Definition: An ABR service parameter, AIR controls the rate at which
   the cell transmission rate increases. It is signaled as AIRF, where

       $AIRF = AIR*Nrm/PCR.$

   Discussion: For ABR traffic, AIR effects the time rate of change of
   the ACR. This value effects TCP round trip time calculations, which
   in turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.4. Additive Increase Rate Factor (AIRF)

   Definition: Refer to AIR.

   Discussion: Refer to AIR.

   Specification: AF-TM4.0

1.2.5. Available Bit Rate (ABR)

   Definition: ABR is an ATM layer service category for which the
   limiting ATM layer transfer characteristics provided by the network
   may change subsequent to connection establishment. A flow control
   mechanism is specified which supports several types of feedback to
   control the source rate in response to changing ATM layer transfer
   characteristics.

   Discussion: It is expected that an end-system that adapts its traffic
   in accordance with the feedback will experience a low cell loss ratio
   and obtain a fair share of the available bandwidth according to a
   network specific allocation policy. Cell delay variation is not
   controlled in this service, although admitted cells are not delayed
   unnecessarily.

   Specification: AF-TM4.1

1.2.6. Available Bit Rate (ABR) Compliance (Conformance)

   Definition: ABR connection conformance refers to the behavior
   specified for ABR destination and switches, but allows for delays
   between the source and the UNI [UNI3.1, UNI4.0], which may perturb
   the traffic flow.

   Discussion: The cells on an ABR connection applies to CLP=0 cells,
   which are tested upon arrival. At the arrival point, each cell is
   identified as conforming or non-conforming. The minimal conformance
   definition for ABR is GCRA((1/PCR),t1), where PCR is defined for
   CLP=0 flow.

   Specification: AF-TM4.1

1.2.7. BN

   Definition: The BN bit in the RM-cell indicated whether the RM-cell
   is a BECN cell or not.

   Discussion: If BN=0, the RM cells were generated by the source. If
   BN=1, the RM cells were generated by the destination or a switch.

   Specification: AF-TM4.1

1.2.8. CCR

   Definition: The CCR field in the RM-cell is set by the source to its
   current ACR. CCR is formatted as a rate.

   Discussion: For BECN cells, CCR=0.

   Specification: AF-TM4.1

1.2.9. Cell Blocks (CB)

   Definition: Cell blocks are a sequence of N cells transmitted
   consecutively on a given connection.

   Discussion: A cell block will normally correspond to the number of
   information cells transmitted between successive OAM cells.

   Specification: AF-TM4.1

1.2.10. Congestion Indication (CI)

   Definition: The CI bit in the RM-cell allows a network element to
   indicate that there is congestion in the network.

   Discussion: When the source receives a backward RM-cell with CI=1,
   ACR is decreased. When the destination turns around a forward RM-
   cell, the CI is set to 1 to indicate that the previously received
   data cell had the EFCI state set.

   Specification: AF-TM4.1

1.2.11. Cutoff Decrease Factor (CDF)

   Definition: CDF controls the decrease in ACR (Allowed Cell Rate)
   associated with CRM (missing RM cell count).

   Discussion: For ABR traffic, CDF effects the time rate of change of
   the ACR. This value effects TCP round trip time calculations, which
   in turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.12. DIR

   Definition: The DIR bit in the RM-cell indicates which direction of
   data flow is associated with the RM-cell. DIR is changed from 0 to 1
   when an RM-cell is turned around at the destination.

   Discussion: A forward RM-cell is indicated by DIR=0 and is associated
   with data cells flowing in the same direction. A backward RM-cell is
   indicated by DIR=1 and is associated with data cells flowing in the
   opposite direction.

   Specification: AF-TM4.1

1.2.13. Explicit Rate (ER)

   Definition: The ER field in the RM-cell is used to limit the source
   ACR to a specific value. For each RM-cell, ER is set by the source
   to a requested rate (e.g., PCR). It may be reduced by any network
   element in the path to a value that the element can sustain. ER is
   formatted as a rate.

   Discussion: None.

   Specification: AF-TM4.1

1.2.14. Feedback

   Definition: Information carried in the backward RM-cells provided by
   the network elements and/or the destination back to the source.

   Discussion: Feedback may include information in the ER field, or the
   CI or NI bits of each backward RM-cell.

   Specification: AF-TM4.1

1.2.15. Ideal Transmission Time (ITT)

   Definition: The transmission time for ABR CLP=0 cells, if the
   difference between itself and the transmission time for the previous
   CLP=0 cell on the connection is greater than or equal to the minimum:
   a) the inverse of the ACR in effect immediately after the
   transmission time of the first of the two cells b) the inverse of the
   ACR in effect immediately before the transmission time of the second
   of the two cells.

   Discussion: The transmission time for the first cell on the
   connection is automatically an ITT.

   Specification: AF-TM4.1

1.2.16. Initial Cell Rate (ICR)

   Definition: An ABR service parameter, in cells/sec, that is the rate
   at which a source should send initially and after an idle period.

   Discussion: none.

   Specification: AF-TM4.0

1.2.17. In-Rate Cells

   Definition: In-Rate ABR cells are sent with CLP=0.

   Discussion: ABR RM-cells shall be sent with CLP=0 except in certain
   circumstances, See Out-of-Rate Cells. All other ABR cells shall be
   sent with CLP=0.

   Specification: AF-TM4.1

1.2.18. Minimum Cell Rate (MCR)

   Definition: An ABR service traffic descriptor, in cells/sec, that is
   the rate at which the source is always allowed to send.

   Discussion: MCR may be set to zero. The bandwidth available from the
   network may vary, but shall not become less than MCR.

   Specification: AF-TM4.1

1.2.19. Mrm

   Definition: An ABR service parameter that controls allocation of
   bandwidth between forward W-cells, backward RM-cells, and data cells.

   Discussion: none.

   Specification: AF-TM4.0

1.2.20. No Increase (NI)

   Definition: The NI bit in the RM-cell is used to prevent a source
   from increasing its ACR. NI does not require any decrease in value.

   Discussion: None.

   Specification: AF-TM4.0

1.2.21. Nrm

   Definition: An ABR service parameter, Nrm is the maximum number of
   cells a source may send for each forward RM-cell.

   Discussion: none.

   Specification: AF-TM4.0

1.2.22. Out-of-Rate Cells

   Definition: Out-of-Rate ABR cells are sent with CLP=1.

   Discussion: This may be used to enable a rate increase for a
   connection that has an ACR=0. The source would generate out-of-rate
   cells to probe the network to learn when it may increase its rate.

   Specification: AF-TM4.1

1.2.23. Rate Decrease Factor (RDF)

   Definition: An ABR service parameter, RDF controls the decrease in
   the cell transmission rate. RDF is a power of 2 from 1/32,768 to 1.

   Discussion: For ABR traffic, RDF effects the time rate of change of
   the ACR. This value effects TCP round trip time calculations, which
   in turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.24. Rate Increase Factor (RIF)

   Definition: This controls the amount by which the cell transmission
   rate may increase upon receipt of a RM-cell. The additive increase
   rate AIR=PCR*RIF. RIF is a power of 2, ranging from 1/32,768 to 1.

   Discussion: For ABR traffic, RIF effects the time rate of change of
   the ACR. This value effects TCP round trip time calculations, which
   in turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.25. Resource Management (RM) Cells

   Definition: RM cells are used to convey network status (available
   bandwidth, congestion levels) and request peak cell rates for ATM
   blocks. The RM cell has the following format:

Header: 5 bytes, same as the ATM cell header Protocol ID: 3 bytes,
protocol ID value is 1 for ABR service Function specific field: 45
bytes, data required for the specific protocol (See DIR, BN, CI, NI,
ER, CCR, and MCR for field information.) Rsvd: 6 bytes, reserved for
future specification EDC: 10 bytes, CRC-10 error detection code
computed over the cell payload .ti6 (except the CRC-10 field) and
used to check for data corruption

Discussion: RM information can exist at the VP and/or VC level. VP
level cells are identified with a VCI value of 6. VC level cells are
identified with a PT of 6. See DIR, BN, CI, NI, ER, CCR, and MCR for
additional protocol field information.

Specification: AF-TM4.0

1.2.26. Severely Errored Cell Block (SECB)

Definition: A severely cell block outcome occurs when more than M
errored cells, lost cells, or misinserted cell outcomes are observed
in a received cell block.

Discussion: none.

Specification: AF-TM4.1

1.2.27. Tagged Cell Rate (TCR)

Definition: An ABR service parameter, TCR limits the rate at which a
source may send out-of-rate forward RM-cells. TCR is a constant
fixed at 10 cells/second.

Discussion: none.

Specification: AF-TM4.0

1.2.28. TDF

Definition: An ABR service parameter, TDF controls the decrease in
ACR associated with TOF. TDF is signaled as TDFF, where TDF=TDFF/RDF
times the smallest power of 2 greater or equal to PCR. TDF is in
units of 1/seconds.

Discussion: For ABR traffic, TDF effects the time rate of change of
the ACR. This value effects TCP round trip time calculations, which
in turn effects TCP throughput.

Specification: AF-TM4.0

1.2.29. TDFF

   Definition: Refer to TDF. TDFF is either zero or a power of two in
   the range 1/64 to 1 in units of 1 /cells.

   Discussion: Refer to TDF.

   Specification: AF-TM4.0

   1.2.30. Time Out Factor (TOF)

   Definition: An ABR service parameter, TOF controls the maximum time
   permitted between sending forward RM-cells before a rate decrease is
   required. It is signaled as TOFF where TOF=TOFF+1. TOFF is a power
   of 2 in the range: 1/8 to 4,096.

   Discussion: For ABR traffic, TOF effects the time rate of change of
   the ACR. This value effects TCP round trip time calculations, which
   in turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.31. Time Out Factor (TOFF)

   Definition: Refer to TOF.

   Discussion: none.

   Specification: AF-TM4.0

1.2.32. Trm

   Definition: An ABR service parameter that provides an upper bound on
   the time between forward RM-cells for an active source. It is 100
   times a power of two with a range of 100*2-7 to 100*20

   Discussion: For ABR traffic, Trm effects the time rate of change of
   the ACR. This value effects TCP round trip time calculations, which
   in turn effects TCP throughput.

   Specification: AF-TM4.0

1.2.33. Virtual Source/Virtual Destination (VSND)

   Definition: An ABR connection may be divided into two or more
   separately controlled ABR segments. Each ABR control segment, except
   the first, is sourced by a virtual source. A virtual source
   implements the behavior of an ABR source endpoint. Backward RM-cells

received by a virtual source are removed from the connection. Each
ABR control segment, except the last, is terminated by a virtual
destination. A virtual destination assumes the behavior of an ABR
destination endpoint. Forward RM-cells received by a virtual
destination are turned around and not forwarded to the next segment
of the connection.

Discussion: none.

Specification: AF-TM4.0

1.2.34. Xrm Decrease Factor (XDM)

Definition: An ABR service parameter, XDF controls the decrease in
ACR associated with Xrm. It is a power of two in range: [0, 1].

Discussion: For ABR traffic, XDM effects the time rate of change of
the ACR. This value effects TCP round trip time calculations, which
in turn effects TCP throughput.

Specification: AF-TM4.0

1.2.35. Xrm

Definition: An ABR service parameter, Xrm limits the number of
forward RM-cells which may be sent in the absence of received
backward PM-cells. The range is 0-255.

Discussion: For ABR traffic, Xrm effects the time rate of change of
the ACR. This value effects TCP round trip time calculations, which
in turn effects TCP throughput.

Specification: AF-TM4.0

2. Performance Metrics

2.1. Definition Format (from RFC 1242)

Metric to be defined.

Definition: The specific definition for the metric.

Discussion: A brief discussion of the metric, its application and any
restrictions on measurement procedures.

Measurement units: Intrinsic units used to quantify this metric.
This includes subsidiary units; e.g., microseconds are acceptable if
the intrinsic unit is seconds.

2.2. Definitions

2.2.1. ABR Rate Decrease Response Time (ARDRT)

   Definition: The amount of time required by the SUT to adjust its
   transmission rate based on an ABR rate decrease request.

   Discussion: During the ARDRT, cells transmitted by the SUT may be
   dropped by the network due to traffic policing. These dropped cells
   may contain a portion of an IP datagram. This may cause IP and TCP
   packet loss.

   Measurement Units: seconds

2.2.2. ABR Rate Increase Response Time (ARIRT)

   Definition: The amount of time required by the SUT to adjust its
   transmission rate based on an ABR rate increase request.

   Discussion: During the ARIRT, the SUT will not fully utilize the
   available bandwidth. This will negatively impact IP and TCP
   throughput.

   Measurement Units: seconds

2.2.3. RM-Cell Delay Variation (RM-CDV)

   Definition: The variation in RM-cell transfer delay (RM-CTD) of RM-
   cells associated with a given traffic load, orientation and
   distribution, as well as an integration period. RM-CDV = max (RM-
   CTD) - min (RM-CTD) where max and min indicate the maximum and
   minimum over the integration period, respectively.

   Discussion: RM-CDV is a component of RM-cell transfer delay, induced
   by buffering and RM-cell scheduling.

   RM-CDV effects the time required to notify the source of a change in
   the condition of the network. This in turn effects TCP round trip
   time calculations. Large values of RM-CDV will adversely effect TCP
   throughput and cause SAR timeout.

   Measurement Units: seconds

2.2.4. RM-Cell Error Ratio (RM-CER)

   Definition: The ratio of RM-cells with payload errors in a
   transmission in relation to the total number of RM-cells sent in a
   transmission associated with a given traffic load, orientation and

distribution, as well as an integration period. Note that errors occurring in the RM-cell header will cause RM-cell loss at the ATM layer. Note further that multiple errors in a payload will only be counted as one cell payload error.

   RM-CER = RM-Cells with payload errors / Total RM-Cells Transmitted.

Discussion: The measurement is taken over a time interval and is desirable to be measured on an in-service circuit. RM-CER effects the time required to notify the source of a change in the condition of the network. This in turn effects TCP round trip time calculations. Large values of RM-CER will adversely effect TCP throughput and cause SAR timeout.

Measurement Units: dimensionless.

2.2.5. RM-Cell Loss Ratio (RM-CLR)

Definition: The ratio of lost RM-cells in a transmission in relation to the total RM-cells sent in a transmission associated with a given traffic load, orientation and distribution, as well as an integration period.

    RM-CLR = Lost RM-Cells / Total RM-Cells Transmitted.

Discussion: The objective is to minimize RM-CLR. It is expressed as an order of magnitude, having a range of 10^{-1} to 10^{-15} and unspecified.

RM-CLR effects the time required to notify the source of a change in the condition of the network. This in turn effects TCP round trip time calculations. Large values of RM-CLR will adversely effect TCP throughput and cause SAR timeout.

Measurement Units: dimensionless.

2.2.6. RM-Cell Misinsertion Ratio (RM-CMR)

Definition: The ratio of RM-cells received at an endpoint that were not originally transmitted by the source end in relation to the total number of RM-cells properly transmitted associated with a given traffic load, orientation and distribution, as well as an integration period.

    RM-CMR = Misinserted RM-Cells / Total RM-Cells Transmitted.

Discussion: The measurement is taken over a time interval and is
desirable to be measured on an in-service circuit.

RM-CMR effects the time required to notify the source of a change in
the condition of the network. This in turn effects TCP round trip
time calculations. Large values of RM-CMR will adversely effect TCP
throughput and cause SAR timeout.

Measurement Units: dimensionless.

2.2.7. RM-CRC Error Ratio

Definition: The ratio of RM-cells received at an endpoint which
contain an invalid CRC in relation to the total number of RM-cells
properly transmitted associated with a given traffic load,
orientation and distribution, as well as an integration period.

Discussion: RM-CRC errors cause ATM RM-cells to be lost.

RM-CRC effects the time required to notify the source of a change in
the condition of the network. This in turn effects TCP round trip
time calculations. Large values of RM-CRC will adversely effect TCP
throughput and cause SAR timeout.

Measurement Units: dimensionless

2.2.8. RM-Cell Transfer Delay (RM-CTD)

Definition: The elapsed time between a RM-cell exit event at the
measurement point 1 (e.g., at the source UNI) and the corresponding
RM-cell entry event at a measurement point 2 (e.g., the destination
UNI) for a particular connection.

Discussion: The RM-cell transfer delay between two measurement points
is the sum of the total inter-ATM node transmission delay and the
total ATM node processing delay. This number is a constant and
should not adversely effect performance.

Measurement units: seconds

2.2.9. Severely Errored Cell Block Ratio (SECBR)

Definition: The ratio of severely errored cell blocks in a
transmission in relation to the total cell blocks sent in a
transmission associated with a given traffic load, orientation and
distribution, as well as an integration period.

    SECBR = Severely Errored Cell Blocks/Total Transmitted Cell Blocks

   Discussion: SECBR may cause the SUT to drop cells that may contain a
   portion of an IP datagram. This may cause IP and TCP packet loss.

   Measurement Units: dimensionless.

3. Security Considerations

   As this document is solely for providing terminology and describes
   neither a protocol nor an implementation, there are no security
   considerations associated with this document.

4. References

   [AF-TM4.0] ATM Forum, Traffic Management Specification Version 4.0,
               af-tm-0056.00, April 1996.

   [AF-TM4.1] ATM Forum, Traffic Management Specification Version 4.1,
               af-tm-0121.000, March 1999.

   [AF-UNI3.1] ATM Forum, User Network Interface Specification Version
               3.1, September 1994.

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               4.0, July 1996.

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