Specification of Measurement Metrics for the AAI Network

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The measurements of the AAI network performance and traffic will be conducted in various layers of the network. Currently, measurements at Application , TCP, AAL 5, and ATM layers are planned. This note sumarizes the planned metrics and measurement approaches.

1 Application Layer Measurement

Measeurement at the application layer will focus on the nature of requests for network service and the times for those requests to be satified. We have instrumented two application, the Over-the-Shoulder (OTS) remote screen viewing application developed by KU for the MAGIC project, and ttcp has been modified to collect traffic information. For the OTS application frame delay, frame size, and frame interarrival times have been measured in the Application layer. The techniques used to modify the OTS and ttcp applications can be implemented in selected applications running on the AAI network.

- Interarrival Time: Time between read/write to the network
- Frame Size: Size of frame in bytes
- Frame Delay: The delay of application layer between two measurement points (MP)

2 TCP Layer Measurement

2.1 Packet Error Measurements

- Errored Packet Ratio: Errored packets are packets with one or more bit errors received by the receiver. Errored packets are counted by running the test host-to-host, and looking for checksum errors in the receiving host

2.2 Latency Measurements

- Service Latency: Service latency should be measured router to router. Ping will be one used to determine the one way latency by dividing the loopback latency by 2.

2.3 Traffic Statistics

Traffic Statistics include packet interarrival time and the size of packets. Measurements can be taken at both the transmitter side and the receiver side. The measurements can be done using the KU/DEC ATMTIMES program.

- Packet Interarrival Time: TCP packet interarrival time
- Packet Size: Size of TCP packets in bytes

3 AAL5 Layer

3.1 AAL5 Traffic Statistics

AAL5 traffic statistics include PDU counts per time unit and PDU size. Both can be measured using KU/DEC ATMSTAT program.

- PDU Interarrival Time: AAL5 PDU interarrival time
- PDU size: The size of PDU in bytes

3.2 AAL5 PDU Error Rate

- AAL5 PDU Error Rate: AAL5 PDU error rate is defined as

$$\frac{AAL5\ PDU\ received\ in\ error}{Total\ number\ of\ PDU\ received} \tag{1}$$

  This can be measured by checking the AAL5 CRC, verification results are within the ATM device driver.

3.3 AAL5 Bit Error Ratio

- Bit Error Ratio: Bit Error Ratio is computed by running the test host-host and examining bits in error that have made it to the host. The checksum should be disabled in order to examine potentially flawed packets.

4 ATM Layer Measurements

The ATM cell level measurements techniques have not been implemented yet. To obtain ATM cell level measurements requires specialized hardware. There are plans to use both the KU developed OC-12c SONET/ATM gateway and the HP 75000 network analyzer to collect the following ATM layer information.

4.1 Cell Delay Measurements

In order to perform the Cell Delay Measurements, the equipment generating the test traffic and the equipment analyzing the received test traffic must have a synchronized time reference in the order of microseconds, or a suitable loopback mechanism has to be used. OAM cells with time stamps are monitored for testing.

- Mean Cell Transfer Delay: Arithmetic average of a specified number of cell transfer delays for one or more connections.
- 1-Point Cell Delay Variation (CDV): For cell k, the 1-Point CDV y_k is defined as the difference between the cell's reference arrival time c_k and actual arrival time a_k. The reference arrival time c_k is defined as follows: $c_0 = a_0 = 0$ and

$$c_{k+1} = \begin{cases} c_k + T & \text{if } c_k \geq a_k \\ a_k + T & \text{otherwise} \end{cases} \tag{2}$$

  where T is defined such that $1/T$ is the negotiated peak rate.
- 2-Point CDV: For cell k, 2-Point CDV v_k between two measurement points (MP) is the difference between the absolute cell transfer delay x_k between the two MP's and a defined reference cell transfer delay $d_{1,2}$ between the two MP's: $v_k = x_k - d_{1,2}$. $d_{1,2}$ is the absolute cell transfer delay experienced by a reference cell between the two measurement points.

4.2 Cell Loss Measurements

- Cell Loss Ratio (CLR): The CLR is defined for an ATM connection as:

$$\frac{Lost\ Cells}{Total\ Transmitted\ Cells} \tag{3}$$

Lost and transmitted cells counted in severely errored cell blocks should be excluded from the cell population in computing cell loss ratio. OAM cells can be used for In-Service measurement. The transmitter inserts OAM cells into a transmitted user information cell stream at suitable intervals. Each OAM cell contains a count of the number of user information cells transmitted since the last OAM cell. The receiver keeps a running count of the number of user information cells transmitted N_t and received N_r. Cell loss ratio can then be calculated as $(N_t - N_r)/N_t$, if $N_t - N_r$ is positive. This method undercounts CLR if misinsertion occurs during the measurement period.

4.3 Cell Misinsertion Rate

- Cell misinsertion rate (CMR): The Cell Misinsertion Rate for an ATM connection is defined as,

$$\frac{Misinserted\ Cells}{Time\ Interval} \tag{4}$$

Severely errored cell blocks should be excluded from the population when calculating the cell misinsertion rate. Cell misinsertion is most often caused by an undetected error in the header of a cell being transmitted on a different connection. In-service measurements can be performed using the similar procedure as for the CLR measurements. Over the measurement period T_m, if $N_r - N_t$ is positive,then the cell misinsertion rate is estimated as $(N_r - N_t)/T_m$. Cell misinsertion event will be under counted if cell loss events occur.

Out-Of-Service measurement method has also been developed. Basically a VP or VC is maintained for a known period of time. However, no cells are transmitted on it. Any cells received on the VP or VC are misinserted cells.

4.4 Cell Error Measurements

- Cell Error Ratio (CER): CER is defined as follows for an ATM connection:

$$\frac{Errored\ Cells}{Successfully\ Transfered\ Cells + Errored\ Cells} \tag{5}$$

  Cell Error events can be counted using out-of-service measurement. It basically involves transferring a known data stream into the network at the transmitter and comparing the received data stream with the known data stream at the destination measurement point.

- Severely-Errored Cell Block Ratio: The severely errored cell block ratio for an ATM connection is defined as:

$$\frac{Severely\ Errored\ Cell\ Blocks}{Total\ Transmitted\ Cell\ Blocks} \tag{6}$$

  A cell block is a sequence of N cells transmitted consequtively on a given connection. A severely errored cell block outcome occurs when more than M errored cell, lost cell,or misinserted cell outcomes are observed in a received cell block. For practical measurement purposes, a cell block will normally correspond to the number of user information cells transmitted between successive OAM cells. The value M is to be specified.

  Severely errored cell block ratio can be estimated in service for a set of consecutive or non consecutive cell blocks by computing the number of lost cell or mis-inserted cell outcomes in each cell block, identifying cell blocks with more than M lost cell or mis-inserted cell outcomes as severely errored cell blocks. This In-Service measurement method will undercount severely errored cell blocks to some degree, since it does not include delivered errored cells in the estimation of M. A more accurate estimate of severely errored cell block ratio can be obtained by comparing transmitted and received data in an out-of-service measurement.

4.5 Cell Interarrival Time Measurements

- Cell Interarrival Time: Interarrival time of cells that contain valid payload. Empty cells inserted for cell rate decoupling are not counted.