The University of Kansas
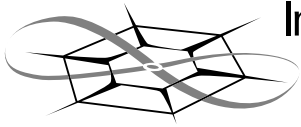
Information and Telecommunication Technology Center

Technical Report

Development of Simulation Models for AAL1 and AAL5

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Contents

Abstract

As a part of previous work at ITTC, simulation models for AAL2 Transmitter for homogeneous traffic sources have been developed based on the current specifications developed by the ATM Forum and the ITU-T. It is instructive to compare its performance to that of AAL1 and AAL5 based transmitters. Specifically, one would like to determine the maximum number of users which can be supported on a given link given a maximum tolerable delay for the transmitter. This document describes the development of the simulation models for these transmitters and results of simulations conducted to validate the design.

1 Overview

The objective was to develop simulation models for AAL1 and AAL5 transmitters along the lines similar to that of the AAL2 Transmitter [1] using BONeS. The AAL2 Transmitter puts onto a VCC combined traffic from various sources after processing it. Along similar lines the developed simulations put the combined traffic from various sources onto a single VP or link.

The key modules involved in the developed simulation models are:

- A combined traffic source to emulate the combination of the voice packets generated by each of the individual sources (users). The simulations were developed for homogeneous traffic sources. This combined traffic source is an improved version of the one described in [1].

- A set of modules to implement the AAL1 or AAL5 processing of the combined traffic.

- A module for generation of cells and clocking them on to the link.

- A module for measuring the delays involved.

The key parameters associated with the simulation are AAL1/5 Assembly size, Number Of Users, Voice Bit Rate(kbps), Mean off time(secs), Mean on-time(secs), Max packets to simulate, Start Data Collection(time), Silence detection enabled/disabled, Wireless/Trunking, Link rate of VP(kbps).

The primary characteristic measured is the total delay involved, starting from assembling of the voice packet to clocking the packet onto the VP. This measurement is determined for different parameter combinations.

The data flows involved in AAL1 and AAL5 models are shown in Figure 1.

What follows is a detailed description of the AAL1 and AAL5 models and the simulation strategies.

2 The AAL1 Model

2.1 The Model

The simulation model was developed using BONeS. The block diagram of the model is shown in Figure 2.

A single traffic source

AAL5

A single traffic source

AAL1

Talk Spurt Generator

Talk spurt generator

Combination of traffic sources

Combination of traffic sources

In Assembler

Assembles Samples of Specified size

Assembler

FIFO

Delay

Assembler

Assembles Samples of Specified size

SSCS SDU

$$\text{Delay} = \frac{\text{Size of samples collected}}{\text{Voice coding rate}}$$

SSCS SDU

Null

SSCS

SSCS

Add Pad
Add 1 Byte header

SSCS PDU

SSCS PDU

Add Trailer
(8 bytes)

CPCS SDU

CPCS SDU

Pad to multiple Of 48 bytes

CPCS

CPCS

Add 1byte header

CPCS PDU

Segent into 48 byte chunks

SAR SDU

SAR

CPCS PDU

SAR PDU

ATM SDU

ATM SDU

Add 5 Byte Header

ATM

ATM

Add 5 byte header

ATM Cell

ATM Cell

FIFO

FIFO

$$\text{Abs Delay} = \frac{\text{Size of ATM cell}}{\text{Peak Link Rate}}$$
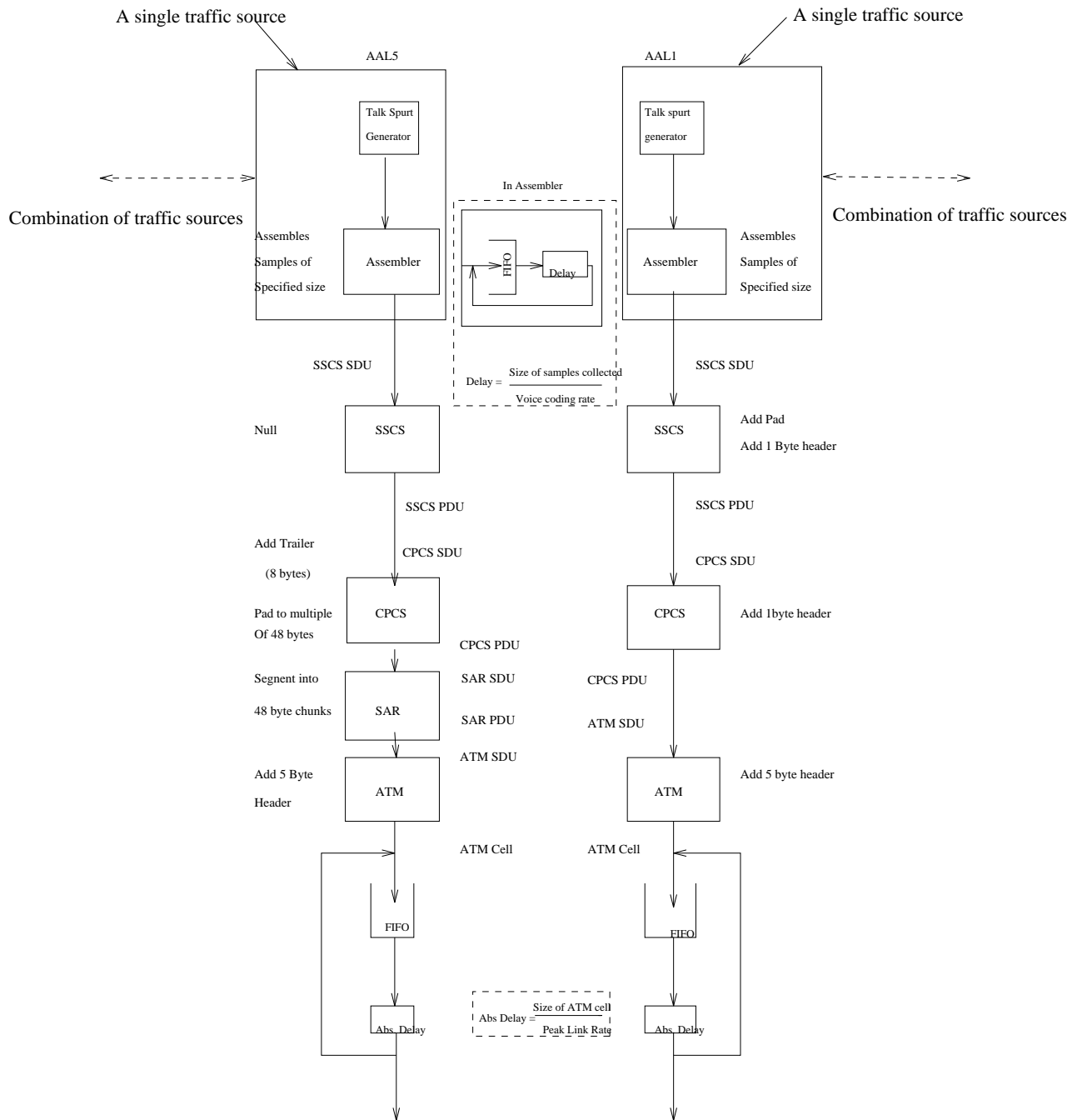
Abs Delay

Abs Delay
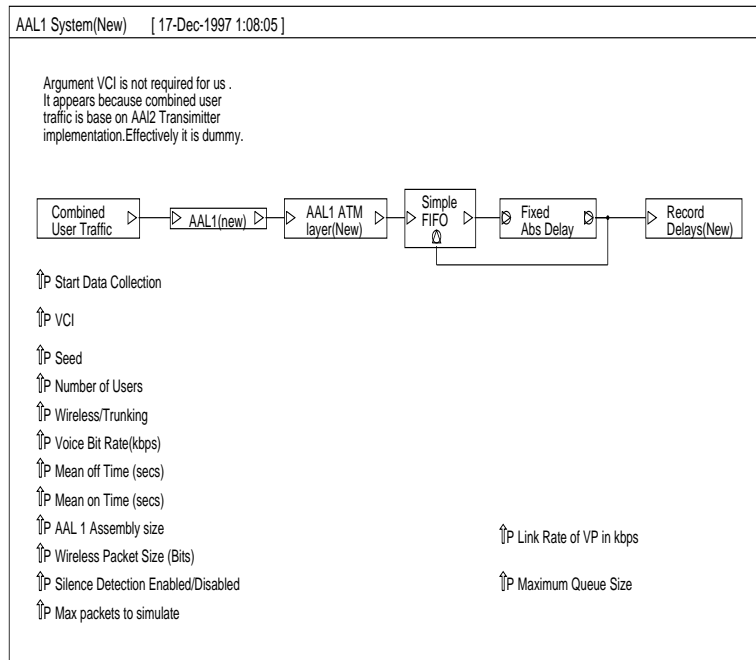
Figure 1: Data flows for AAL1 and AAL5

Figure 2: Block Diagram Of The AAL1 Model

- The Combined User Traffic has been borrowed from the AAL2 simulation model. Based on the Number Of Users parameter, it simulates combined traffic of users (one on each VCC) put onto a single VP as AAL1 SSCS Service Data Units(SDUs). For each user the traffic is generated by assembling the voice packets generated by an on-off source into AAL1 SDUs of length specified by the the AAL1 Assembly size parameter. In case of Wireless mode of voice traffic the voice packets are first segmented into Wireless Packets based on the Wireless Packet size and then assembled to form the AAL1 SDUs. The parameters Mean off Time, Mean on Time, Silence detection Enabled/Disabled are associated with the on-off source.

- The AAL1(new) block performs functions associated with AAL1 layer as shown in Figure 1.

- The AAL1 ATM layer(New) block generates the ATM cell.

- The Simple FIFO and Fixed Abs Delay blocks perform the function of clocking out the ATM cells onto the VP at a rate determined by the Link Rate of VP parameter.

- The Record Delays(New) module is used to measure the total delay involved for each voice packet after it is clocked out onto the VP. This includes the delay involved in assembling the AAL1 SDU and the queueing delay while transmitting the ATM cell.

2.2 The Simulation Strategy

Our goal is to determine the maximum number of users which can be supported on a given link for a given maximum tolerable total delay in the transmitter. The Record Delays block measures the total delay for the voice packet. Now, the total delay is the sum of queuing delay and the AAL1 SDU assembly delay. The former is dependent on the VP link rate, voice coding rate, number of users, and mean on and off times of the on-off source. The latter is dependent on the AAL1 Assembly size and the voice coding rate. Thus, one might want to vary the above mentioned parameters for different values of the Number of Users parameter and for each combination, simulate a fixed number of packets to determine the maximum total delay incurred amongst all the generated packets and compare it with the tolerable delay value.

However, the maximum total delay being just a single value, will not by itself, truly reflect the range of large delays that the voice packet can experience. Therefore one would want to look at the cumulative distribution of the total delay values and determine the total delay value which corresponds to 95 % of all the delay values being less than it (95 percentile delay) .

Thus, the record delays block is configured to capture the cumulative distributions of the measured total delay values.

Comments on parameters :AAL1 Assembly sizes and Number of Users

- *Range of AAL1 Assembly sizes*:
  Our aim in using various AAL1 assembly sizes for voice packets is to reduce the waiting time to assemble voice packets into AAL1 SDUs of larger size. The AAL1 layer effectively adds a 1 byte CPCS header plus an optional 1 byte header when padding for AAL1 SDUs less than 47 bytes in size,to the incoming AAL1 SDU to form a 48 byte payload of the ATM cell. Given the above, if we increase the AAL1 assembly size beyond 47 bytes :

  - The assembly delay will increase and may not be acceptable for voice traffic.
  - More importantly, we would be forced to break up the AAL1 SDU to form segments of smaller size. This would mean further overhead because of a new cell being generated.

  Therefore it does not make sense to go for AAL1 Assembly sizes greater than 47 bytes.

- *The Number of Users* parameter should be set to a value such that the average load on the system does not exceed 100 %. This can be determined using the following formula for calculation of average load:

$$ave\_load = \frac{BNS}{L}\frac{53}{A}$$

where,

- B=Bit Rate of each voice source in kbps
- N=number Of Users
- S=Speech Activity Factor= $\frac{Mean\ On\ Time}{Mean\ On\ Time + Mean\ Off\ Time}$
- A=AAL1 Assembly Size (< 47 bytes)
- L=Link rate of the VP in kbps

In order to test the design of the simulation model following are the *key* parameter values used in the simulations:

- Start Data Collection : Mean on time + Mean Off Time . This indicates the time to start collection of data.The time is chosen such that by that time the transients in the on-off voice sources involved would have died down. It is from this point of time that the number of packets generated is counted.

- AAL1 Assembly Size: Two ranges were used:

    - 5 to 40 in steps of 5
    - 41 to 47 in steps of 1

- Number Of Users : Two ranges were used corresponding to the ranges defined for the assembly size.

    - 4 to 94 in steps of 10
    - 4 to 114 in steps of 10

- Max Packets to simulate : 30000

- Voice Bit Rate(kbps) : 32

- Mean On Time(secs) : 0.42

- Mean Off Time(secs): 0.58
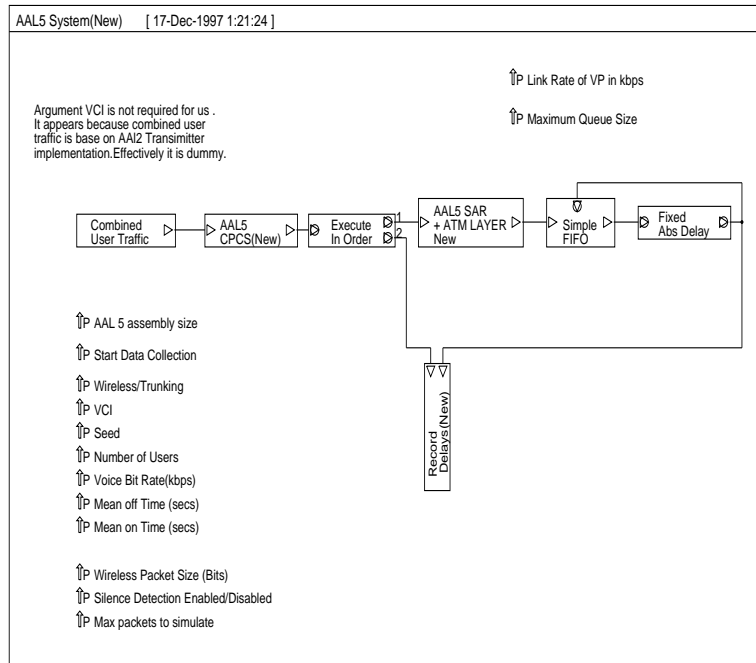
- Link Rate of VP (kbps) : 1536

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Figure 3: Block Diagram Of The AAL5 Model

3 The AAL5 Model

3.1 The Model

The simulation model was developed using BONeS. The block diagram of the model is shown in Figure 3.

- The Combined User Traffic is similar to that of AAL1 model excepting that the AAL5 Assembly size parameter is used as against AAL1 assembly size parameter for the generation of AAL5 SSCS SDUs as against AAL1 SSCS SDUs.

- It has been assumed that the AAL5 SSCS is null and therefore no implementation is provided for it.

- The AAL5 CPCS(New) block performs the functions as indicated in Figure 1.

- For implementation convenience the functions of AAL5 SAR layer have been implemented in the AAL5SAR +ATMLAYER New block. Here, the Payload Type Indicator field of the ATM cell header is assigned binary 1 for the last segment of the SAR layer and binary 0 for other segments.

- The Simple FIFO and Fixed Abs Delay blocks perform the function of clocking out the ATM cells onto the VP at a rate determined by the Link Rate of VP parameter.

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The Record Delays(New) module is used to measure the total delay involved for each voice packet before it is clocked out onto the VP. This includes the delay involved in assembling the AAL5 SDU and the queueing delay while transmitting the ATM cell.

3.2 The Simulation Strategy

As was the case for AAL1, the record delays block is configured to capture the cumulative distribution of the total delay values. The 95 percentile delay is chosen for comparison with the maximum tolerable delay.

Comments on parameters :AAL Assembly sizes and Number of Users

- *Range of AAL5 Assembly sizes*:

  As was the case with AAL1, when using AAL5 for voice packets we would want to minimize the overhead involved. It can be observed that for all assembly sizes less than 40 bytes, exactly one ATM cell will be produced for each AAL5 SDU. The same is the case for AAL1 with assembly sizes less than 40 bytes because the SSCS pads up the SDUs to 47 bytes and then the CPCS adds a 1 byte header. Therefore the performance of AAL1 and AAL5 should be identical for assembly sizes up to 40 bytes.

  When we start increasing the AAL5 assembly size from 40 to 47 bytes, two cells would be generated for each AAL5 SDU as compared to one for AAL1. This would mean:

  - More assembly delay which may not be tolerable for voice traffic.
  - More importantly, we have a huge overhead for two cells being generated which is double that of AAL1 and therefore the performance in terms of total delay experienced will degrade.

  Therefore we would want to see the degradation of AAL5's performance with respect to AAL1 in the simulation results .

Keeping the above things in mind, following are the *key* parameter values used for the simulations performed to test the design of the simulation model:

- Start Data Collection : Mean on time + Mean Off Time .This indicates the time to start collection of data.The time is chosen such that by that time the transients in the on-off voice sources involved would have died down. It is from this point of time that the number of packets generated is counted.

- AAL5 Assembly Size: Two ranges were used:

  - 5 to 40 in steps of 5

10

- 41 to 47 in steps of 1 and 50,55,60,65

- Number Of Users : Two ranges were used corresponding to the ranges defined for the assembly size.

  - 4 to 94 in steps of 10
  - 4 to 74 in steps of 10

- Max Packets to simulate : 30000

- Voice Bit Rate(kbps) : 32

- Mean On Time(secs) : 0.42

- Mean Off Time(secs): 0.58

- Link Rate of VP (kbps) : 1536

4   Results and Observations

Simulations were run to verify the validity of the model developed.The plots of 95th percentile delay values vs. Number of users for AAL1 is shown in Figure 4 and for AAL5 is shown in Figure 5. The curves reach a plateau of 15 msec since the gathering of associated cumulative distribution was limited to a maximum delay of 15 msec . It is observed that:

- For a given assembly size as the number of users increases, the 95th percentile delay value increases. This is because as the number of users increase, the associated queueing delay will be larger.

- For a given number of users, as the assembly size increases the 95th percentile delay value increases. This is also expected because as the assembly size increases the assembly delay increases.

- For smaller assembly sizes the assembly delay is small but the overhead is large and hence the queueing delay plays a dominant role leading to steeper slopes as shown in the figure. For larger assembly sizes, however, the assembly delay is large and plays a dominant role leading to slopes that are not that steep.

- If one were given the maximum tolerable total delay, the determination of maximum number of users supported can be accomplished by drawing a horizontal line parallel to the Number Of Users axis and observing the number of users corresponding to the point where it intersects the last(right most) curve. For exammple, if the maximum tolerable delay was 10 msec, the maximum number of users for AAL1(Figure 4) or AAL5(Figure 5) would be approximately 55, using an assembly size of 35 bytes. Note that the assembly delay in this case is $\frac{(35)(8)}{32 kbps} = 8.75\,msec$
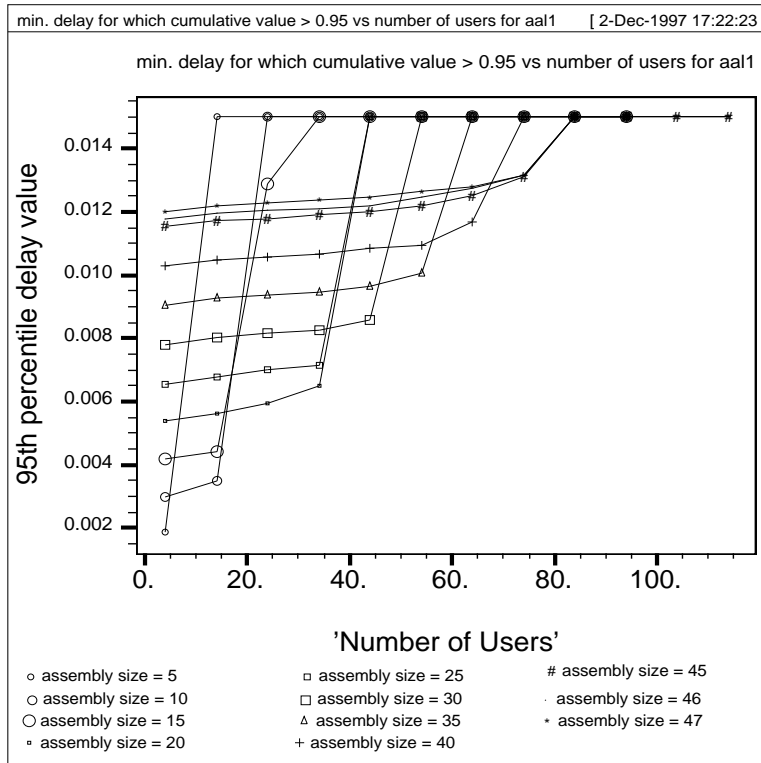
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Figure 4: Simulation Results for The AAL1 Model

- The plots for AAL1 and AAL5 match for assembly sizes less than 40. But, as seen in a comparative plot for AAL1 and AAL5 in Figure 6, it can be observed that the performance of AAL5 degrades as compared to AAL1 as assembly size is increased beyond 40 bytes.

5   Conclusion

As seen in the previous section all the observations are as expected. In particular the comparative performance of AAL1 vs AAL5 is what we had hoped to see when designing the simulation strategy. Hence the simulation models developed have been verified.
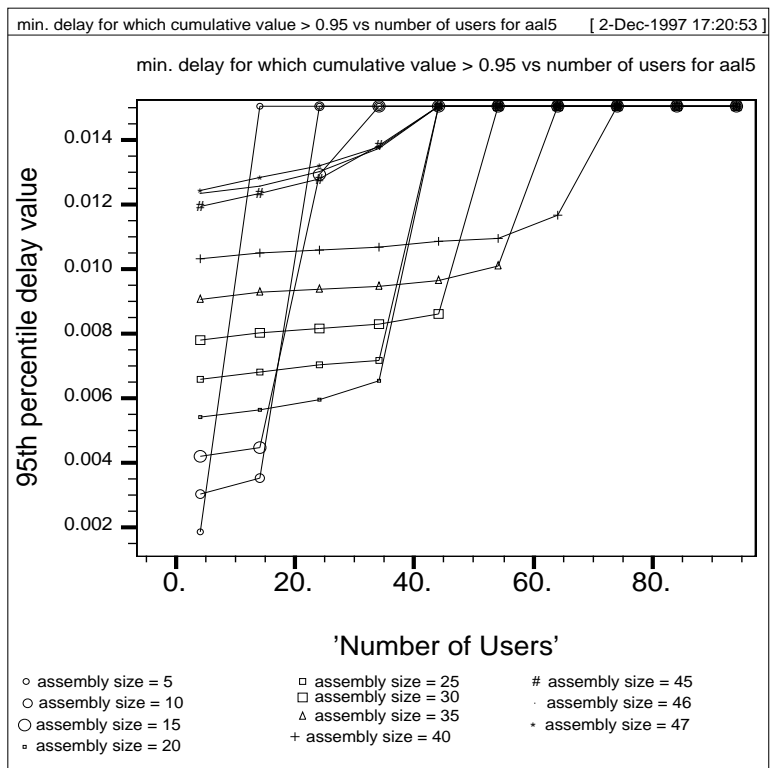
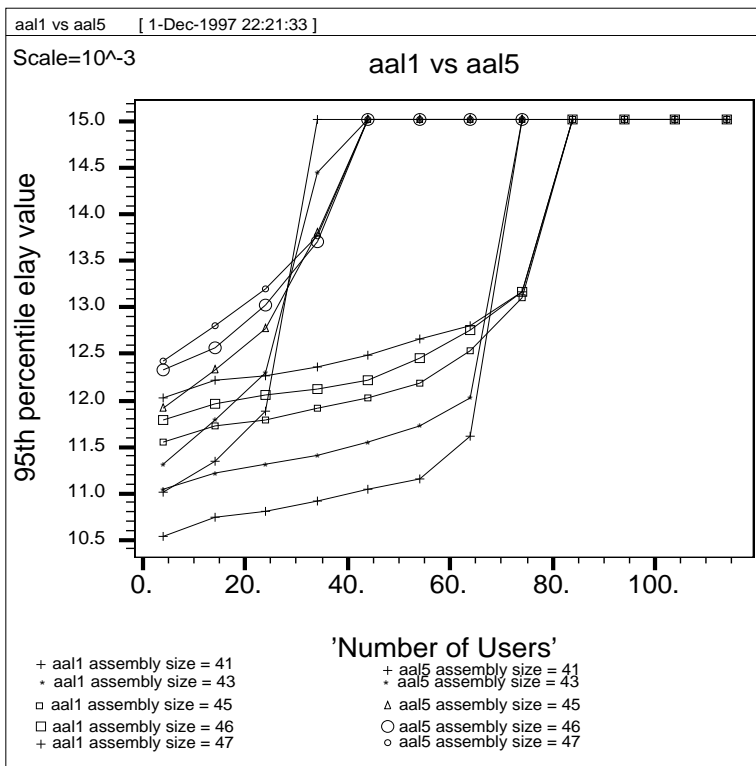Figure 5: Simulation Results for The AAL5 Model

Figure 6: Comparison of AAL1 and AAL5 Models

References

[1] P.Sampath, D.W.Petr, " *AAL2 Transmitter Simulation Study*", Technical Report ITTC, University of Kansas, July 97

[2] " *BONeS Designer: Core Library Reference*"

[3] " *BONeS Designer: User Guides*"