Chapter 5

Discussions and Conclusions

Chapter 5: Discussions and Conclusions

This chapter discusses ATM network simulations that have been performed and assumptions made. Advantages and limitations of using Simulink in ATM modeling and simulation is explained. Areas of enhancements and overall conclusion for the project are given.

5.1 Examples of ATM Simulation and Discussions

5.1.1 Single Hop Topology

- Port 1 to Port 1, Port 2 to Port 2 (Figure A.1)
  - Two pairs of source and destination with two traffic types: CBR and ABR.
  - The link capacity is 414 cells persecond, which is [(155 Mbps x 1024 bits) / (48 bytes x 8 bits)]. All the link capacities are the same throughout the discussions.
  - The link utilization for **link1** is 30 cells (Mbps for source) out of 414 cells at that particular time because the cells have not completed its transmission.
  - The link utilization for **link2** is 0 because all cells are transmitted at that particular time since fewer cells need to be transmitted.
  - No cells are dropped at BTEs and switches since the buffers are big enough to queue up all the incoming cells.
  - Cells received at **bte501**, **switch800p2**, **bte2** and **destination2** that show the same value indicate that all cells sent by **abrsource1** have been successfully received by **destination2** as intended.
  - Cells received at **bte504**, **switch800p1**, **bte1** and **destination1** that show the different value indicate that cells sent by **cbrsource1** have been successfully received by **destination1** and there are still cells being generated and in transmission.

- Port 1 to Port 2, Port 2 to Port 1 (Figure A.2)
  - Two pairs of source and destination with two traffic types: CBR and ABR.
  - The link utilization for both **link1** and **link2** is 0 because no cells are transmitted at that particular time.
  - No cells are dropped at BTEs and switches since the buffers are big enough to queue up all the incoming cells.
  - Cells received at **bte501**, **switch800p2**, **bte1** and **destination1** that show the same value indicate that all cells sent by **abrsource1** have been successfully received by **destination1** as intended.
  - Cells received at **bte504**, **switch800p1**, **bte2** and **destination2** that show the same value indicate that all cells sent by **cbrsource1** have been successfully received by **destination2** as intended.

5.1.2 Multi Hop Topology

- 2 switches with one connection (Figure A.3)
  - Two pairs of source and destination with two traffic types: CBR and ABR.
  - One connection from first switch to second switch, in port 2 and out port 1 of second switch is not connected to any components.
  - The link utilization for **link1**, **link2**, **link3**, **link4** and **link6** is 0 because no cells are transmitted at that particular time.
  - No cells are dropped at BTEs and switches since the buffers are big enough to queue up all the incoming cells.
  - Cells received at **bte504**, **switch800p1**, **switch801p1**, **bte1** and **destination1** that show the same value indicate that all cells sent by **cbrsource1** have been successfully received by **destination1** as intended.
  - Cells received at **bte501**, **switch800p2**, **bte2** and **destination2** that show the different value indicate that cells sent by **abrsource1** have been successfully received by **destination2** and there still cells being generated and in transmission.

- 2 switches with connection to each other (Figure A.4)
  - Two pairs of source and destination with two traffic types: CBR and ABR.
  - One connection from first switch to second switch, another connection from second switch to first switch.
  - The link utilization for **link1**, **link2**, **link3**, **link4**, **link5** and **link6** is 0 because no cells are transmitted at that particular time.
  - No cells are dropped at BTEs and switches since the buffers are big enough to queue up all the incoming cells.
  - Cells received at **bte504**, **switch800p1**, **switch801p1**, **bte1** and **destination1** that show the same value indicate that all cells sent by **cbrsource1** have been successfully received by **destination1** as intended.
  - Cells received at **bte501**, **switch801p2**, **switch800p2**, **bte2** and **destination2** that show the different value indicate that cells sent by **abrsource1** have been successfully received by **destination2** and there are still cells being generated and in transmission.

5.1.3 Ring Topology

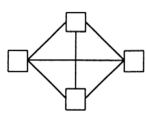
- 3 switches with large buffer (no cells are dropped) (Figure A.5)
  - Three pairs of source and destination with two traffic types: CBR and ABR.
  - One connection from first switch to second switch, one connection from second switch to third switch, and another connection from third switch to first switch.
  - The link utilization for **link1 to link9** is 0 because no cells are transmitted at that particular time.
  - No cells are dropped at BTEs and switches since the buffers are big enough for queueing up all the incoming cells.
  - Cells have successfully reached their respective destination from the source since the pair of source-destination BTEs that shows the same value of cell received.

- 3 switches with small buffer (some cells are dropped) (Figure A.6)

  - Three pairs of source and destination with two traffic types: CBR and ABR.
  - One connection from first switch to second switch, one connection from second switch to third switch, and another connection from third switch to first switch.
  - The link utilization for **link1 to link9** is 0 because no cells are transmitted at that particular time.
  - Cells are dropped at **bte504**, **switch800p2** and **switch801p2** since the buffers are not big enough for queueing up of all the incoming cells.
  - The pair of source-destination BTEs that shows the different value of cell received because some of cells have been dropped at either BTEs or switches during transmission.

5.1.4 Mesh Topology

- Figure A.7
  - Two pairs of source and destination with two traffic types: CBR and VBR.
  - The switch connection is as shown below:



  - All the link utilization is 0 except for **link7** because there are 30 cells in transmission.
  - No cells are dropped at BTEs and switches since the buffers are big enough for queueing up all the incoming cells.
  - Pairs of source-destination BTEs that shows the same value of cell received indicate that all the cells are received successfully.
  - Pairs of source-destination BTEs that show the different value of cell received indicate that some of the cells are still in transmission.

5.1.5 Star Topology

Star topology cannot be implemented since the switch is of 2x2 dimension as shown in Figure A.8. All in ports and out ports of switches will be used to connect to other switch in order to form a star topology. Since the switch is 2x2, no ports are available for source and destination.

5.1.6 Assumptions

A number of assumptions have been made for the above ATM models:

1. All the traffic sources generate cells at the same time that is when the simulation begins.
   In this assumption, all the sources are synchronized for the cells to be generated. In reality, this might not be the case and cells can be generated randomly by the source. Cells can be generated intermittently (bursty) or can be stopped completely.

2. Cells will be dropped when buffer is full but will not damage.
   This is an important assumption where cells are dropped only due to the overflow of the buffer. Other factors that may cause cell damages are ignored. The idea is to keep the model simple.

3. All cells will have equal priority.
   This again may not be true in an actual situation. For CBR traffic, the QoS is guaranteed and the cells are given priority but in this model CBR, VBR ABR cells are given equal priority.

4. There will be no congestion during cell transmission.
   The input buffer or output buffer can be full and this will cause congestion during cell transmission. Various approaches such as credit-based, rate-based (section 2.7.4) are available for congestion control. A major assumption of the model is that the flow of cells is smooth.

5. No traffic management is needed.
   The simulator does not incorporate any of the traffic management function as described in section 2.7.3 based on the assumption that no traffic management is needed.

6. All the physical links are unidirectional.
   A computer (end system) can be a source or sink and the links are bi-directional. In the model adopted in this project, traffic flow is unidirectional.

7. FIFO methods are applied for buffering/queueing at BTEs and switches.
   This method of buffering is reasonably fair but does not take into consideration QoS for CBR traffic. Although the simulation considers the three types of traffic CBR, VBR, ABR at the source, the QoS in terms of bandwidth allocation (contract) is not fully complied with.

8. No delay will occur in the BTEs and switches.
   Hardware components have inherent delays and a more realistic model will have to consider this limitations.

9. Request calls for establishing and releasing connection are not required.
   Connection admission control is the first defense in protecting from excessive load. When a user requests a new VCC, the user must specify the service required in both directions for that connection. This model adopted does not consider any connection control.

10. The network resources are always available.
    Network resources are adaptable and realistic model will have to consider not only resource variation but also rapid depletion of critical resource requirements.

5.2 Advantages of Using Simulink

- User friendly modeling and simulation environment

  Simulink provides a user-friendly modeling environment through the graphical user interface (GUI) for building models as block diagram. By using click-and-drag mouse operation, models can be drawn and refined efficiently. Blocks in a model can be colored based on their functionality to differentiate from others to increase the readability of complex models. Subsystem blocks can be created to group low-level models together to reduce the complexity of a model.

  Simulation sample time and necessary parameters can be set and changed through the dialog boxes provided. For example, the parameters for Random Number block include mean and variance of the numbers, the initial seed and sample time of the block.

- Interactive simulation environment

  Simulink is a powerful tool for simulating dynamic system. The simulation environment is interactive in a sense that the parameters can be changed "on the fly". The effect of parameter changes can be captured immediately even during the execution time of the simulation. In an ATM network, many parameters influence the performance of the network such as the buffer size and traffic condition. With this feature of Simulink, ATM network can be simulated in a more effective way.

- Flexibility

  Besides the existing block libraries, Simulink enables user to customize and create their own block. Masking facility enables user to customize the dialog box and icon for a subsystem. Through creating S-function, user can incorporate their existing C code into Simulink block. This flexibility has made ATM network modeling and simulation possible using Simulink. Besides taking advantages of Simulink as a powerful simulation tool, ATM network behavior can be also reflected through user-defined S-function block.

5.3 Limitations of Using Simulink

- Inability to recognize non-numeric signal

  All the Simulink signal must be in numeric form such as integer or real. This has caused some inconveniences for ATM network simulation. Due to the variety of ATM signal form, for example, the ATM cell traffic type: CBR, ABR is in character form. In order to send the cell traffic type signal, they have to be represented by numeric signal and matched to their respective traffic type before sending and after receiving

- Inability to send grouped data using one signal

  One signal can only send one data in Simulink. For an ATM cell, at least three data are to be sent in one signal – source, traffic type and destination. However, this problem can be resolved by multiplexing the signals before sending and demultiplex after receiving by using Simulink provided MUX and DEMUX block.

- Memory allocation

  While creating Simulink S-function, memory allocation is a very important issue to be taken into considerations. Memory allocation problems can easily occur during program running time such as *illegal access to memory* and *tried free previous freed memory*. This is not actually limitation of Simulink. It is mentioned here because it can cause many program errors.

- Inflexibility of S-function format

  To write an S-function, there is certain format to follow and modules calling are in fix sequence. This somehow limits the flexibility of implementing the user's own algorithms using S-function. For example, ATM routing table is found difficult to be incorporated in S-function defined ATM switch.

5.4 Areas of Enhancements

- Virtual Connection

  The virtual connection simulated is Permanent Virtual Connections that are actually not common for current ATM network development. It is chosen because the process of establishing and releasing the virtual connection required for Switched Virtual Connection can be surpassed to simplify the modeling. For future work, Switched Virtual Connection can be simulated to reflect the current ATM network development more accurately. Connection establishment and release strategies, routing algorithms of connection calls, or Connection Admission Control (CAC) techniques are some of the specific areas.

- Switch architecture

  The switch simulated does not follow any existing switch architecture. It is just a simple switch algorithm and many switch functions are not taken into consideration. For example, buffer management and queueing methods are not considered. ATM switch architecture such as Banyan, Knockout and Tandem Banyan can be implemented to make ATM modeling more comprehensive, as a switch plays an important role in ATM network performance. Traffic management and congestion control can be incorporated in a switch.

- BTE

  For the time being, one BTE can just connect to one application that is not true for the current situation. BTEs should be able to cater for multiple application, which are dynamically set by the users.

- Traffic

  The source traffic can be modeled using some traffic modeling methods such as Poisson and self-similar. Traffic characteristics such as burstiness nature and arrival pattern can be into consideration. By taking traffic characteristics into account, the simulated results will be more realistic.

5.5 Overall Conclusions

This work is an initial attempt to model ATM network using Simulink tools. ATM network, simulation concepts, and Simulink tools have been studied as thoroughly as possible so as to implement dynamic modeling of cell flow for an ATM network in a most effective way. As a result, Simulink is found to be a good simulation tool for dynamic systems. Somehow, the existing Simulink block libraries are inadequate for ATM network simulation. Fortunately, Simulink do provide users with the facility to add their own algorithms using S-function. All the ATM network component blocks are created using S-functions. These components are reusable and could be used to built more complex network.

This research will enable researchers to study and evaluate ATM network performance. By simulation, network planners can design the network infrastructure with different configuration and perform analysis and measurement of the traffic load. With the information obtained, optimal performance can be expected.

Although, fairly simple topology was simulated, the components developed and experience gained will enable more compiex network to be modeled. This will enable a designer to study issues in traffic management, congestion control and routing.

The models explored are based on various assumptions listed in section 5.1.6. The model adapted is idealistic and does not represent very closely to the real network environment. It is important to note assumption 4 and 8. In an-actual network environment, congestion will be present during cell transmission and any realistic simulation should take this factor into consideration. Delays in BTEs and switches are characteristics features of the hardware used in ATM networking.

Future enhancement of the simulation design using Simulink will attempt to relax some of the assumptions made and will attempt to create a more realistic model of an ATM network. An attempt will also be made to take into considerations the enhancement as listed in section 5.4 to reflect ATM network and its component behavior more accurately.