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I confirm that I understand my coursework needs to be submitted online via Google Classroom under the relevant module page before the deadline in order for my assignment to be accepted and marked. I am fully aware that late submissions will be treated as non-submission and a marks of zero will be awarded.

ACKNOWLEDGEMENT

I have taken efforts in this project. However, it would be selfish and unethical of me to accredit all the accomplishment to myself. Although it was an individual project, several external volunteers gave me an enthusiastic co-operative hand in the completion of this project.

I would like to express my gratitude to Mr. Pratik Karki, for giving me a valuable guidance, constant supervision as well as for providing all the necessary information regarding the project and for their support in the completion of this project.

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I would also like to thank my parents and friends for their kind co-operation and encouragement which helped me finalize this project within the limited time given to us.

ABSTRACT

One of the modules that we, the Computing students’ study in Year 2 is “Networks and Operating Systems”. The coursework was assigned to us on the 4th week which carries 30% of the overall module grade. It is an individual coursework and covers network simulation models / simulation and research. The assignment is divided into two parts i.e., Task A and Task B.

The Task A contains a scenario in which a multinational bank named ABC Bank is willing to set up two ATM transaction networks in Nepal. A network simulation model is created for the company, and reports are obtained from running the simulation.

In case of Task B, we are required to write a technical report on the Internet. This task requires thorough research on every subject under the internet. The entire task covers the history, architecture, commercial expansion, advantages and disadvantages and privacy on internet.

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1. TASK A

1.1. INTRODUCTION

A network (also referred to as a data network) is a collection of interconnected nodes which is can send, receive, and exchange data, voice, and video traffic. It has a variety of uses which includes file sharing, communication, e-commerce and many more. Because of the network's critical nature, it's usually impossible or impractical to shut it down in order to test, analyse, or upgrade. Network simulation can be a valuable tool in this case as it provides a manner of modelling a network in order to determine its performance features, it provides a means of testing proposed changes placing them into effect. (CACI, 1996)

The first task (Task A) is to create a network description specified by ABC Bank. It created graphically using a window interface COMNET III. The application was created primarily to model both Wide Area Networks and Local Area Networks which is required for the scenario.

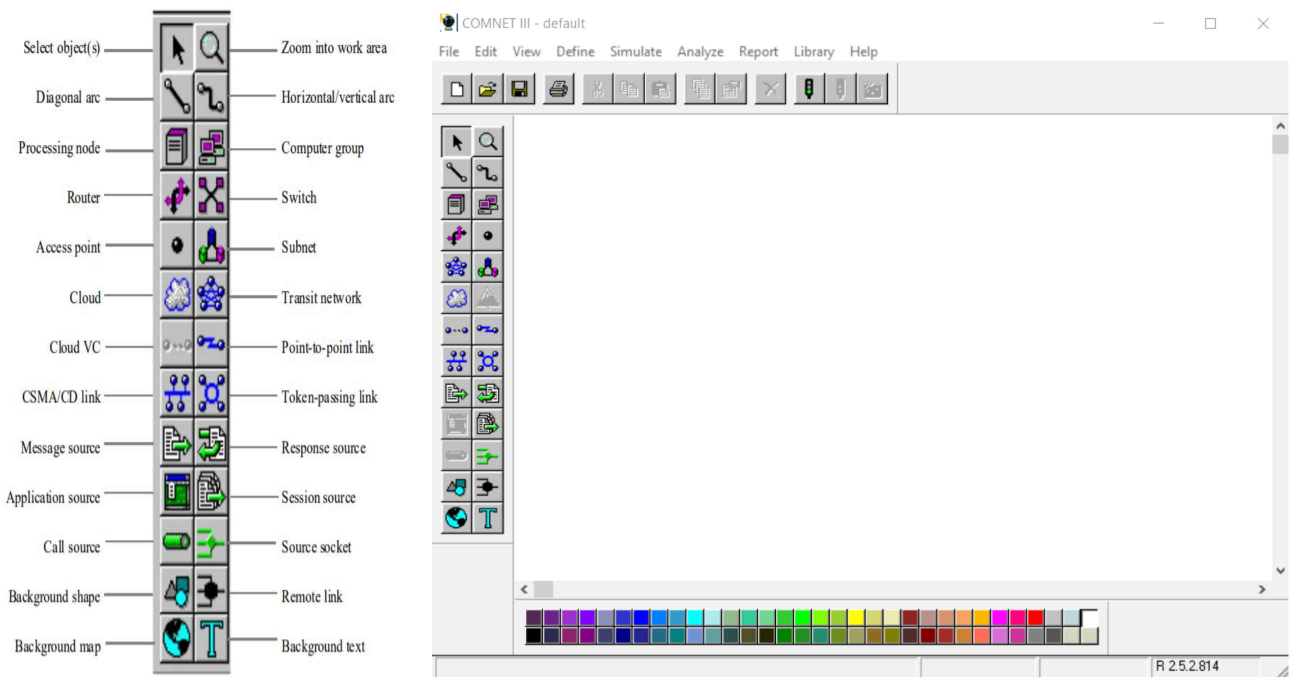


Figure 1: COMNET III. (CACI, 1996)

1.2. WAN MODEL

WAN which is also known as Wide-Area Network is a data communications network that manages beyond the geographic horizon of a LAN (Local-Area Network). It allows the transmission of data beyond a geographical distance. (Vachon & Graziani, 2008) LANs may be able to provide speed and efficiency in transmitting the data however, it is only possible in a relatively small area, growth outside of that certain zone would not be possible. As organizations grow and become international, WANs allow people in the regional or branch offices communicate and share resources with the central site. (Computing Technology Industry Association, 2021)

Here, a multinational company named ABC Bank having their headquarter in Manchester, is willing to set up two Automatic Teller Machines (ATM) transaction in Nepal. The two-location chosen by them are Kathmandu and Pokhara. Each network in Nepal consists of an ATM transaction node along with a teller, the two network depend upon the Manchester LAN as it contains an ATM processing server. Each LANs is connected to the frame relay WAN Cloud through access point.

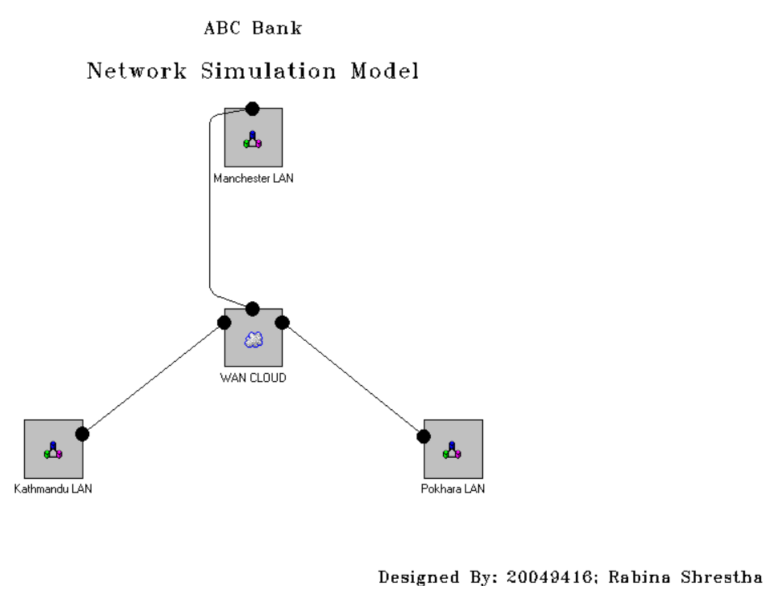


Figure 2: WAN Model.

A WAN model is created (Figure 1) with the information given in order to analyse the corresponding result. Although a network simulator might not be perfect, it is close enough to give researches a meaningful understanding of the network under analysis, and how each change will influence its operation. (Pan, 2008)

1.2.1. MANCHESTER LAN

The headquarter of the of ABC Bank is located in Manchester. The LAN is set up with an ATM processing server and is connected to a frame relay cloud using a router and access point. This server processes all the ATM requests and responds back with a message. A random list with respective destinations is also generated for the destination list of message response.

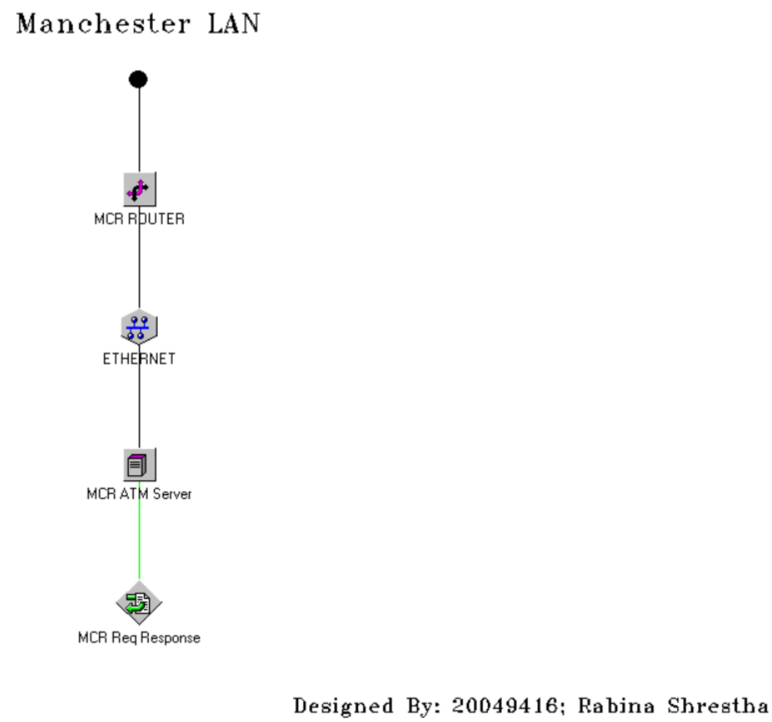
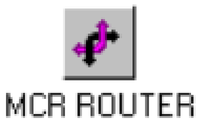


Figure 3: Manchester LAN.

The Manchester LAN consists of the following components:

Router:



Network Device; MCR Router is a hardware device designed to acquire, analyse and locomote incoming packets from one to another network. (Computer Hope, 2019)

- Network Device Parameters:

Name:	**MCR ROUTER**
Node Type	
Type:	Network Device
Parameters:	Cisco 7000/7010 sp

Table 1: Manchester Router Parameters.

Every LAN i.e., Kathmandu LAN, Manchester LAN, and Pokhara LAN is linked to a frame relay cloud through a Cisco 7000/7010sp router. It is connected to the access point and ethernet of the Manchester LAN.

- Parameters:

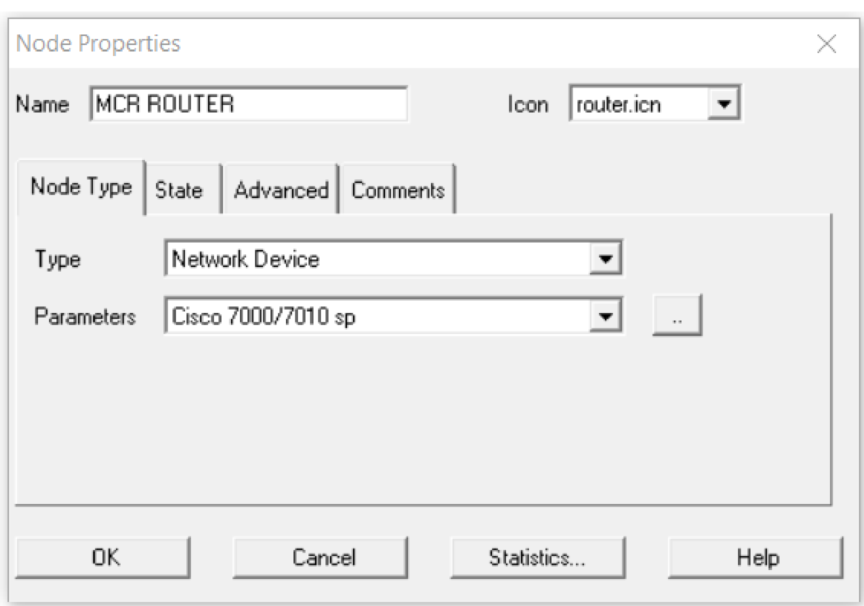
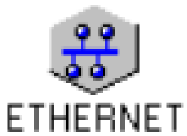


Figure 4: Manchester Router Node Type.

Ethernet:



CSMA/CD Link; Ethernet which is also known as Carrier Sense Multiple Access / Collision Detection, is a fast and reliable network solution widely used as LAN protocol. (Computer Hope, 2020)

➢ CSMA/CD Link Parameters:

Name:	**ETHERNET**
Link Type	
Type:	CSMA/CD
Parameters:	802.3 CSMA/CD 10BASET

Table 2: Manchester Ethernet Parameters.

Manchester LAN is modelled based on the IEEE 802.3 CSMA/CD which is suitable for a wide range of ethernet based protocols. The 10BASET represents the wiring standard for an ethernet that transmits data at 10 megabits per second bandwidth using unshielded twisted pair cabling. (The Linux Information Project, 2005) It is connected to the router and Manchester ATM server.

➢ Parameters:

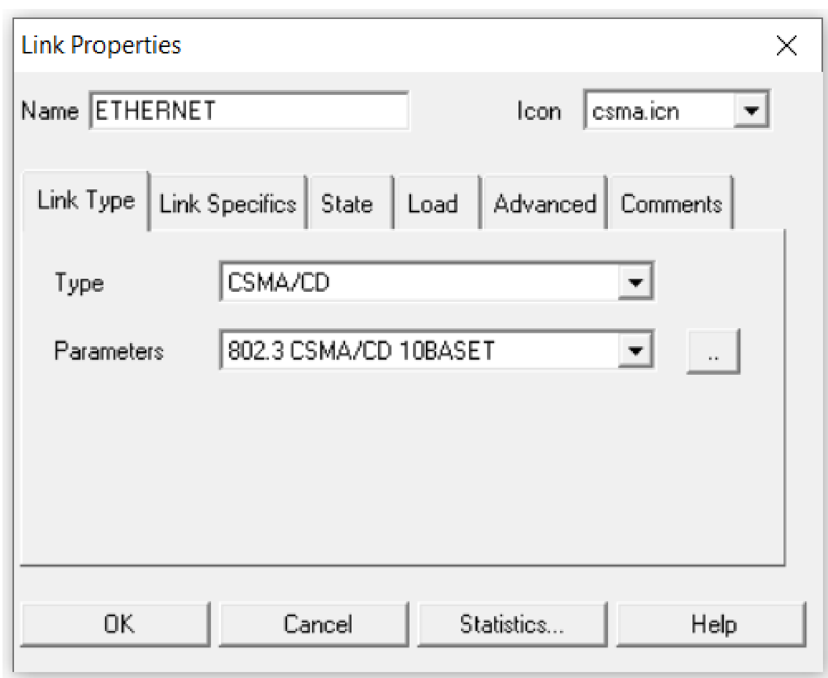


Figure 5: Manchester Ethernet Link Type.

MCR ATM Server:

Processing Node; MCR ATM Server is used to exhibit the end systems, packet switches, pads, and general network components. It creates all types of traffic, route both data, circuit-switched calls and executes application. (CACI, 1996)

- Processing Node Parameters:

Name:	**MCR ATM Server**
Node Type	
Type:	Processing Node
Parameters:	DEFAULT

Table 3: Manchester ATM Server Parameters.

A Manchester ATM Server is set up. The parameters of this server remain the same. It is connected to the ethernet and Manchester's request response source.

- Parameters:

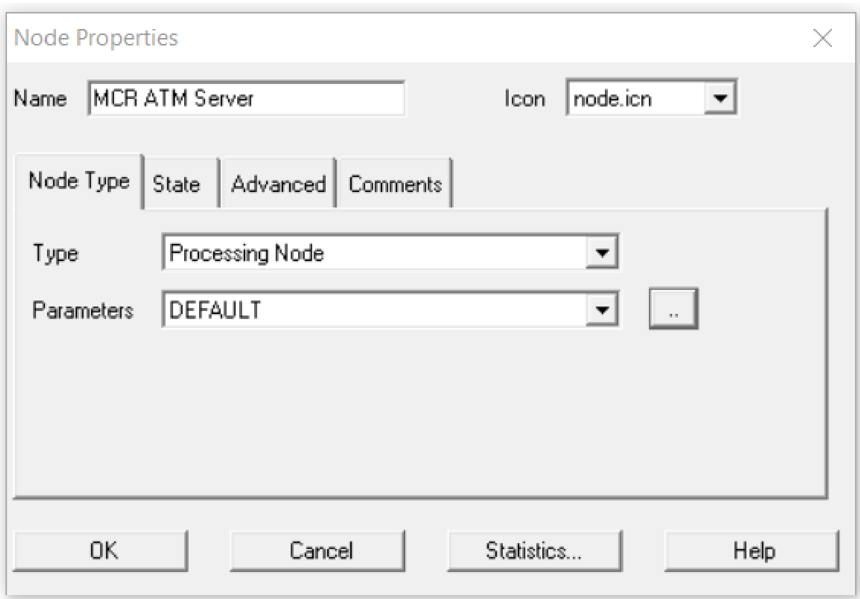


Figure 6: Manchester ATM Server Node Type.

MCR Req Response:

MCR Req Response

Response Source; MCR Req Response is a message generator used to send messages in reply to the received messages. Packet routing for this is based upon the routing protocol for triggering messages. (CACI, 1996)

➢ Response Source Parameters:

Name:	**MCR Req Response**
Scheduling	
Edit Received Messages:	1 Ktm Authorization 1 Ktm Teller Req 1 Pkr Authorization 1 Pkr Teller Req
Messages	
Msg size calc:	Probability distribution
Prob distrib:	Uni (40.0,80.0,2)
Packets	
Protocol:	TCP/IP - Microsoft V1.0
Packetize (ms):	10.0
Routing class:	IGRP Hop Limit: 65535 K1 = 1.0

Table 4: Manchester Request Response Parameters.

A random list is created with respective destinations for the destination list of message source and response. All ATM requests from Kathmandu LAN and Pokhara LAN are processed in the Manchester LAN. The MCR Req Response responds back with a message that can be explained with uniform probability distribution. The size is evenly dispersed over the range of minimum 40 to maximum 80 bytes with stream 2. TCP/IP – Microsoft V1.0 is used for the packets routing protocol with 10 ms as the packetize time. Routing class defined with a hop count of 65535 along with the IGRP metric weight (k1) as 1 is used for all systems.

➢ Parameters:

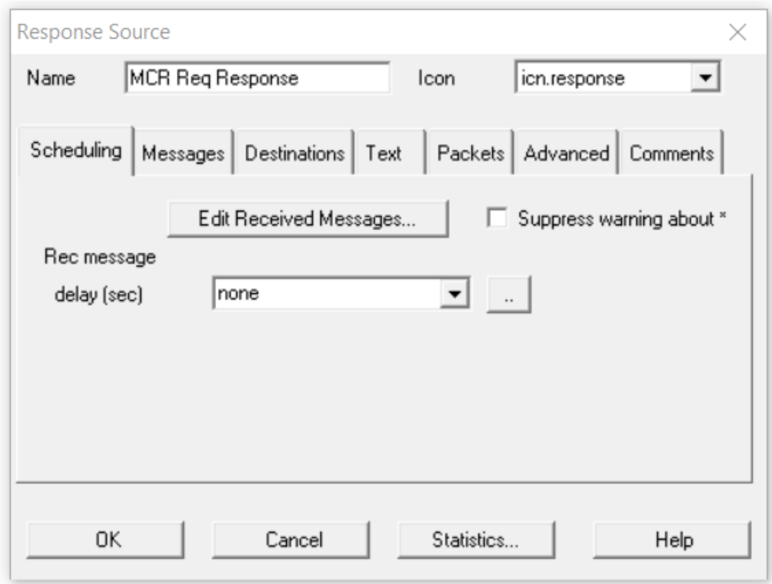


Figure 7: Manchester Request Response Scheduling.

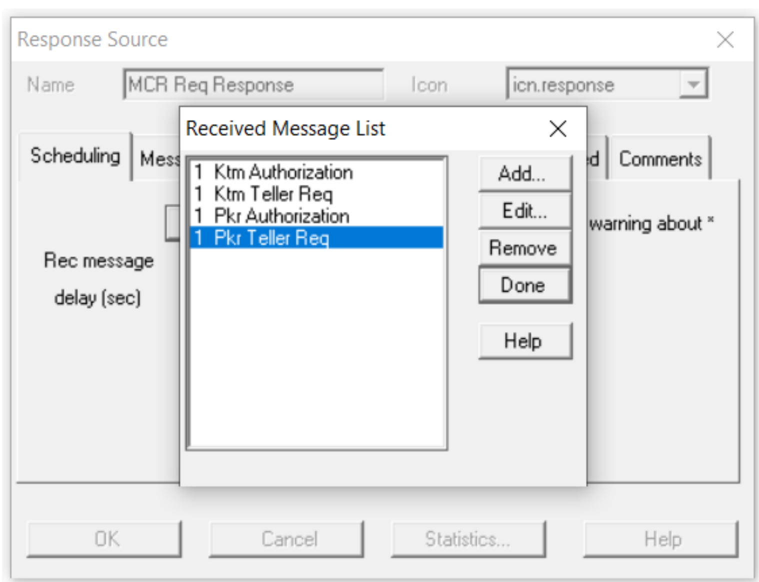


Figure 8: Manchester Request Response Scheduling: Received Message List.

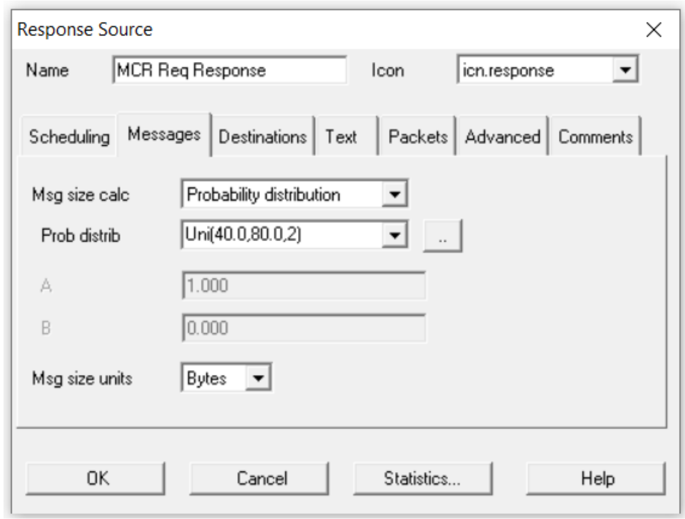


Figure 9: Manchester Request Response Messages.

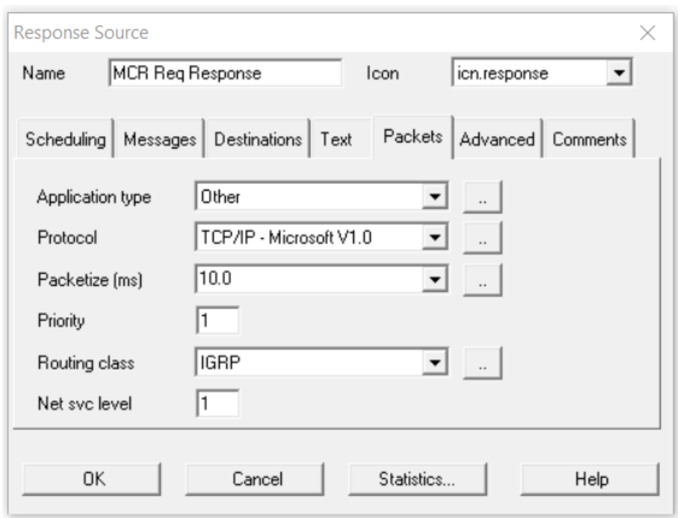


Figure 10: Manchester Request Response Packets.

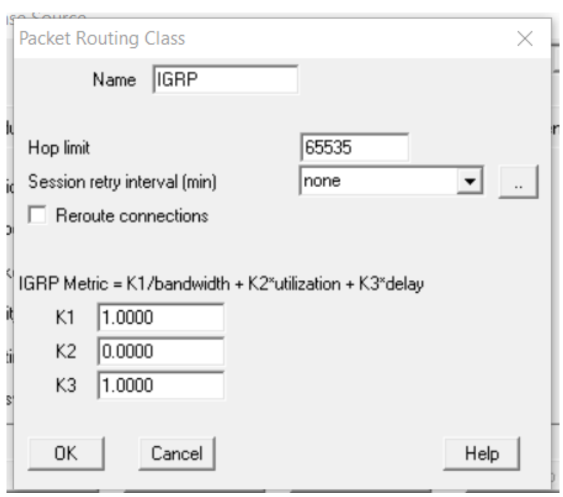


Figure 11: Manchester Request Response Packet: Routing Class

1.2.2. WAN CLOUD

A WAN Cloud is used for modelling wide-area network services conceptually, in terms of Access Links. WAN Clouds' internal topology includes the two which is the Access Link and Virtual Circuit. Outside of this, the node and the WAN Cloud is connected through the Access Point which represents the Access Link inside the topology. (CACI, 1996)

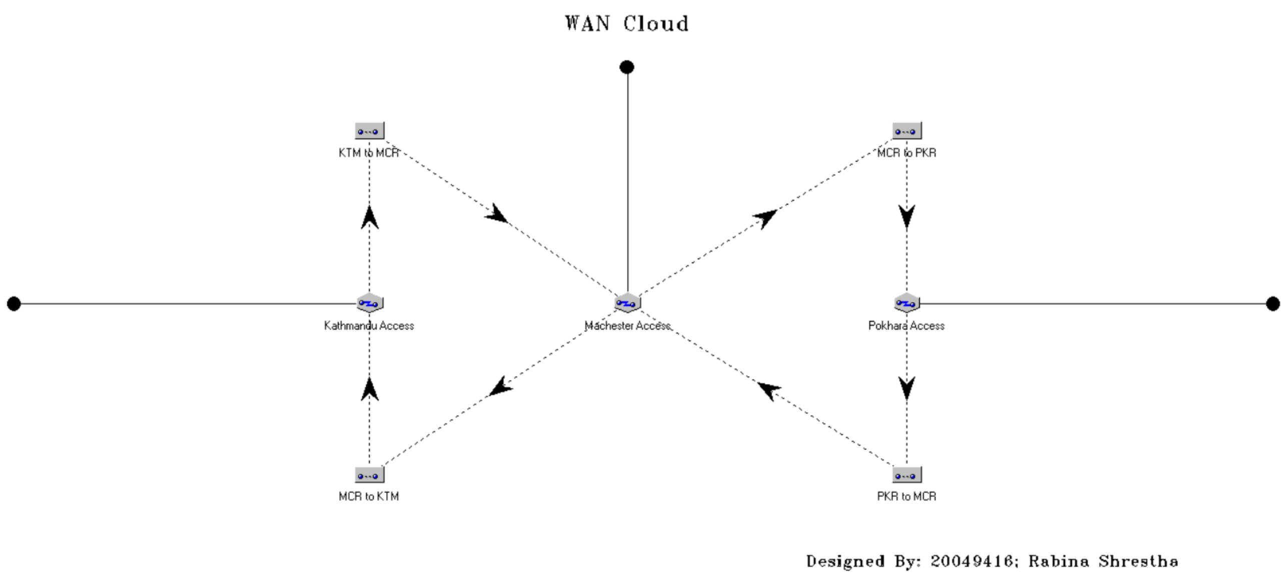


Figure 12: WAN Cloud.

The internal structure of WAN cloud includes three point-to-point links i.e., Kathmandu Access, Manchester Access, and Pokhara Access. Several virtual circuits are also used inside the cloud topology as shown in Figure 12. The tunnel from the LAN to WAN has a transmission rate of 56 kilobits per second committed information rate which is the same for the links in the WAN, whereas the tunnel from the WAN to LAN has a transmission rate of 9.6 kbps.

1.2.2.1. ACCESS LINK

Point-to-point; Access link is a unique case of a point-to-point link that works with the WAN Cloud. The interconnection between the WAN Cloud and a node beyond the boundaries of the cloud topology is connected through the access point which is represented by the Access Link inside the topology of the cloud. It provides the point of existence to the WAN Cloud. (Kurose & Ross, 2013)

Kathmandu Access, Manchester Access, and Pokhara Access are the three-access link present in the cloud topology. The parameters of each access link match one another. So, taking Manchester Access link as an example the following table shows the access link detail of each link present in the WAN Cloud topology.

Name:	**Manchester Access**
Cloud Access Link Parameters	
Name:	9.6 kbps
Number of circuits:	1
Entry (Ingress) BW/circuit (kbps):	9.600
Exit (Egress) BW/circuit (kbps):	9.600
Propagation (ms)	0.000

Table 5: Access Link Parameters.

The entry and exit bandwidth/circuit (kbps) of the access link is 9.6. It specifies that the transmission rate from the WAN to the LAN is 9.6 kbps.

Parameters:

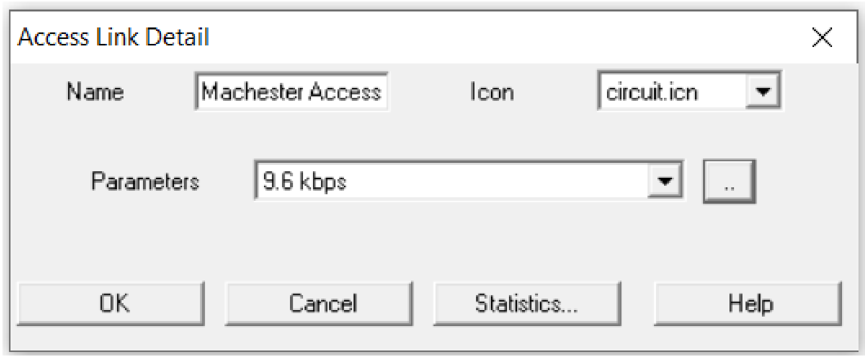


Figure 13: Access Link Detail.

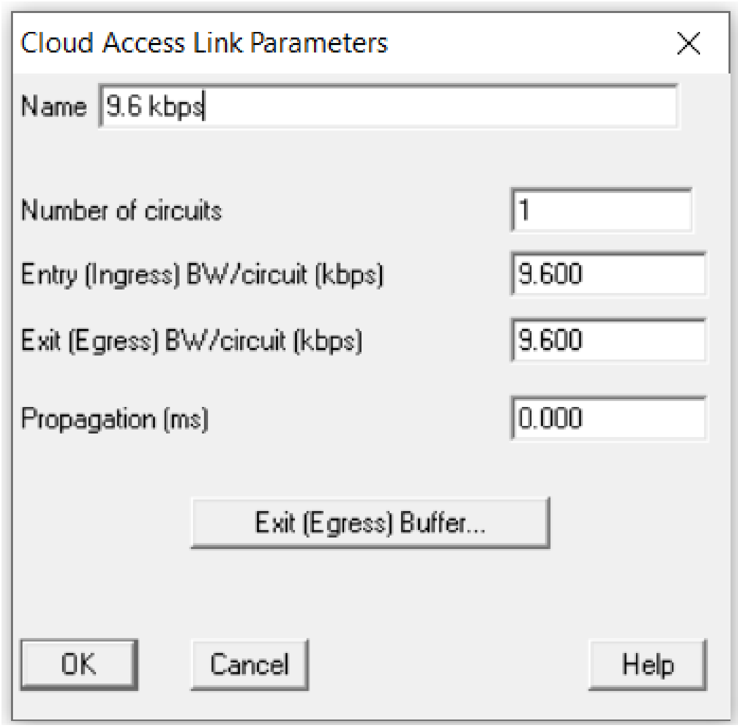


Figure 14: Cloud Access Link Parameters.

1.2.2.2. VIRTUAL CIRCUIT

WAN Link or VC; Virtual Circuit is the network-layer connections used in network architectures like an ATM. It consists of a path i.e., a series of routers and links between the source and destination hosts, provides one number for each link and also includes entries in the forwarding table in each router along the path. A packet will carry the virtual circuit's number in its header if it belongs to a virtual circuit. The new VC number is obtained by forwarding table; each intervening router replaces the VC number of each traversing packet with a new VC number as a virtual circuit may have a different VC number on each link. (Kurose & Ross, 2013)

There are four virtual circuits i.e., Kathmandu to Manchester, Manchester to Kathmandu, Pokhara to Manchester, and Manchester to Pokhara inside the WAN Cloud topology. The virtual circuits; KTM to MCR and MCR to KTM is connected to the access link of Kathmandu and Manchester whereas the virtual circuit; Pokhara to Manchester and Manchester to Pokhara is connected to the access link of Pokhara and Manchester. As all the virtual circuit's parameters match one another, the following table will give us the details of each virtual circuit.

Name:	**KTM to MCR**
Type:	Frame Relay VC
Cloud VC Policing Algorithm	
Committed Info. Rate (kbps):	56
Committed burst size, Bc (kb):	56
Excess burst size, Be (kb)	56

Table 6: Virtual Circuit Parameters.

All virtual circuit parameters i.e., Committed Info. Rate (kbps), Committed burst size, Bc (kb), and Excess burst size, Be (kb) are set to 56. The links in the WAN and the tunnel from the LAN to WAN has the transmission rate of 56kbps CIR.

Parameters:

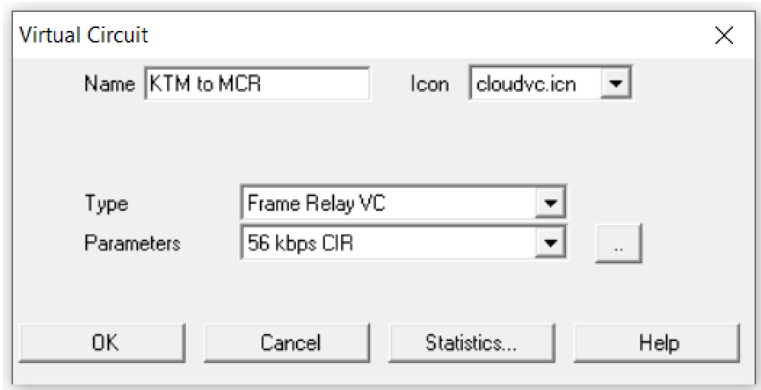


Figure 15: Virtual Circuit.

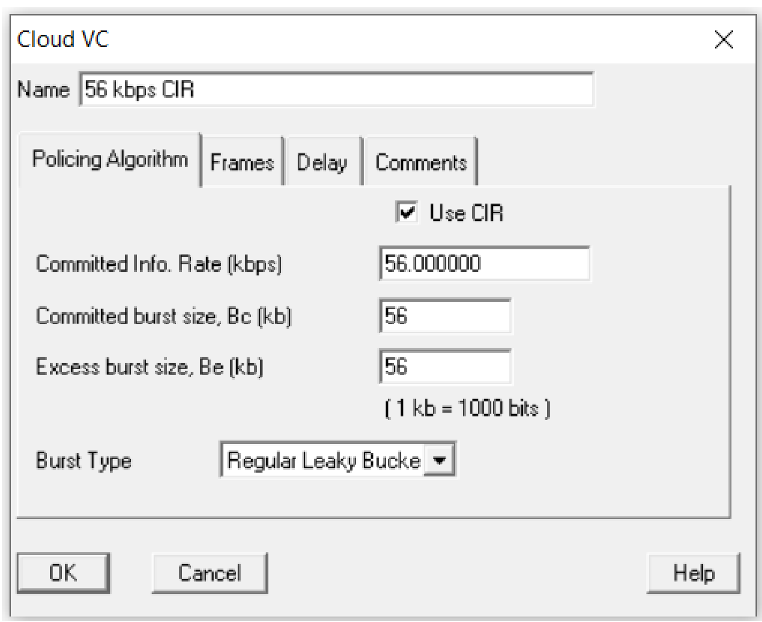


Figure 16: Cloud VC Policing Algorithm.

1.2.3. KATHMANDU AND POKHARA LAN

ABC Bank is planning to set up two ATM transaction network in Nepal. The two chosen locations are Kathmandu and Pokhara. A LAN also known as local area network is set up in the two locations. Each network in Nepal has 40 ATM transaction nodes plus one single teller. So, in total 41 ATMs are present in each LAN which is connected to the frame relay cloud through a router. All ATM requests are to be processed in the Manchester server. The single teller machines in both LANs are generated at an interarrival time. A random list with respective destinations is also generated for the destination list of message response.

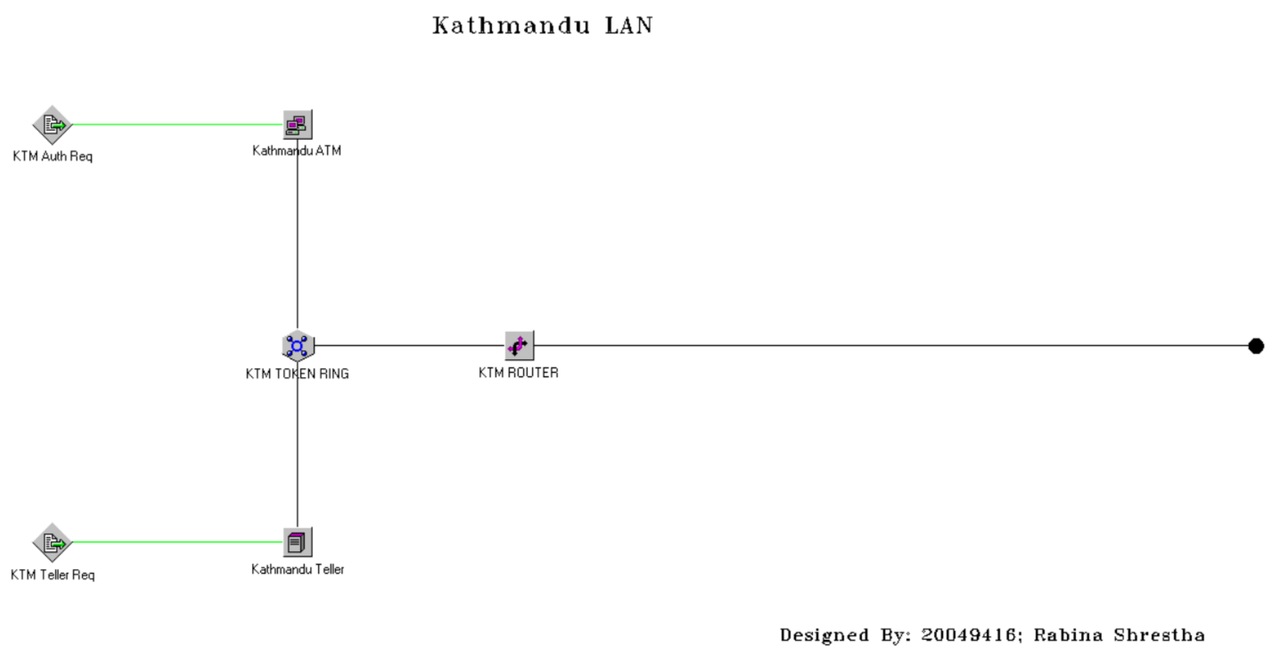


Figure 17: Kathmandu LAN.

Kathmandu LAN consists of a network device, a token passing link, a processing node, a computer group, and two message sources.

1.2.3.1. NETWORK DEVICE: ROUTER

Network Device; KTM Router is a hardware device that collects, analyses, and moves incoming packets from one network to another. (Computer Hope, 2019)

➢ Network Device Parameters:

Name:	**KTM ROUTER**
Node Type	
Type:	Network Device
Parameters:	Cisco 7000/7010 sp

Table 7: Kathmandu Router Parameters.

A Cisco 7000/7010sp router connects Kathmandu LAN, Manchester LAN, and Pokhara LAN to the frame relay cloud. It is interconnected to the Kathmandu LAN's access point and token ring.

➢ Parameters:

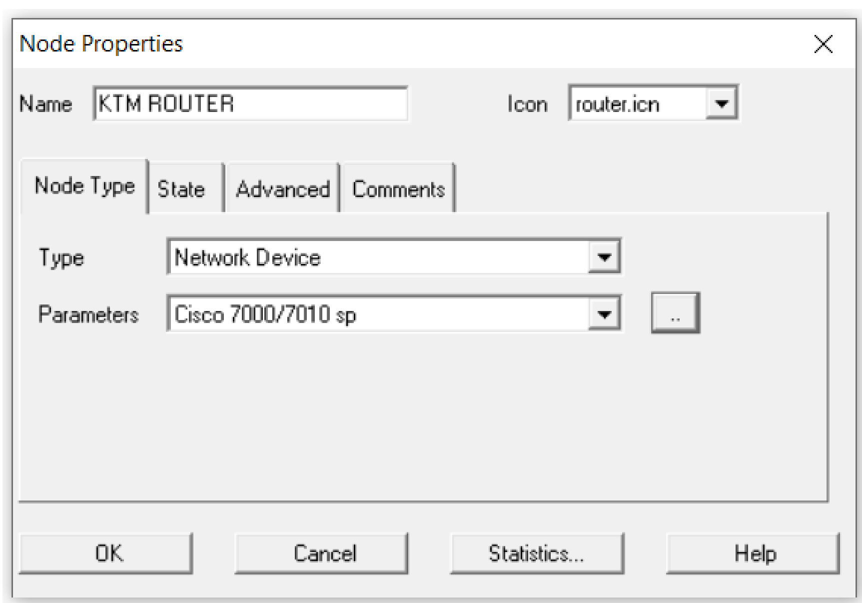


Figure 18: Kathmandu Router Node Type.

1.2.3.2. TOKEN PASSING LINK

Token Passing Link; KTM Token Ring is local area network's data link where all devices are linked together in a ring or star like topology to pass one or more tokens from one host to another. It presents data packets from colliding. (Zola, et al., 2021)

- Token Passing Link Parameters:

Name:	**KTM TOKEN RING**
Link Type	
Type:	Token Passing
Parameters:	802.5 16 Mbps

Table 8: Kathmandu Token Ring Parameters.

The token ring model used in the Kathmandu network is the IEEE 802.5 with a bandwidth of 16 mbps. It is interconnected to the Kathmandu LAN's router, computer group; Kathmandu ATM, and the processing node named Kathmandu Teller.

- Parameters:

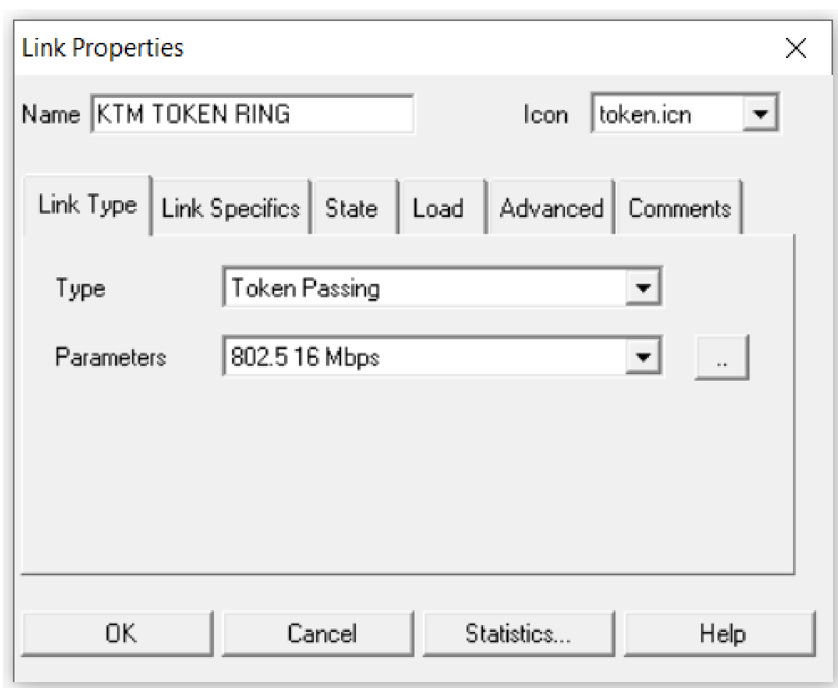


Figure 19: Kathmandu Token Ring Link Type.

1.2.3.3. PROCESSING NODE

Processing Node; Kathmandu Teller presents all the end systems, packet switches, pads, and general network. It generates a wide range of traffic, routes data and circuit-switched communications, and runs applications. (CACI, 1996)

➢ Processing Node Parameters:

Name:	**Kathmandu Teller**
Node Type	
Type:	Processing Node
Parameters:	DEFAULT

Table 9: Kathmandu Teller's Parameters.

Kathmandu Teller has been set up and the parameters remain untouched. It is connected to the Kathmandu's token ring and KTM teller req which is the message source.

➢ Parameters:

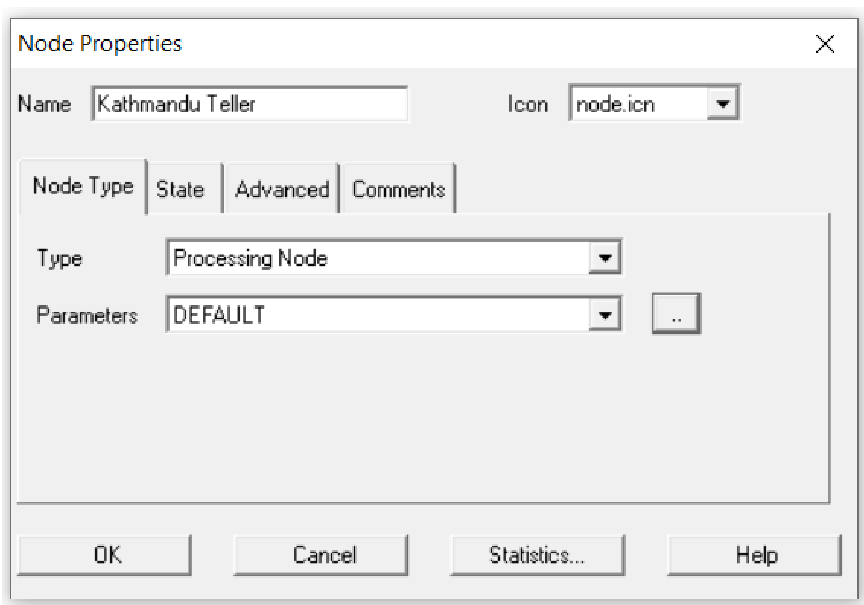


Figure 20: Kathmandu Teller Node Type.

1.2.3.4. COMPUTER GROUP

Computer Group; Kathmandu ATM is used to represent a number of end systems rather than making and editing details of a node to represent each of them. (CACI, 1996)

- Processing Node Parameters:

Name:	**Kathmandu ATM**
Node Type	
Type:	Computer group
Parameters:	ATM Transaction Nodes
Computer Group Parameters	
Parameter set name	ATM Transaction Nodes
Number in group	40

Table 10: Kathmandu ATM's Parameters.

In Nepal, each LAN consists of 40 ATM transaction nodes and one single teller, making a total of 41 ATMs. The number in group is set as 40 in order to fulfil the requirements of ABC Bank. It is connected to the Kathmandu's token ring and KTM auth req which is the message source.

- Parameters:

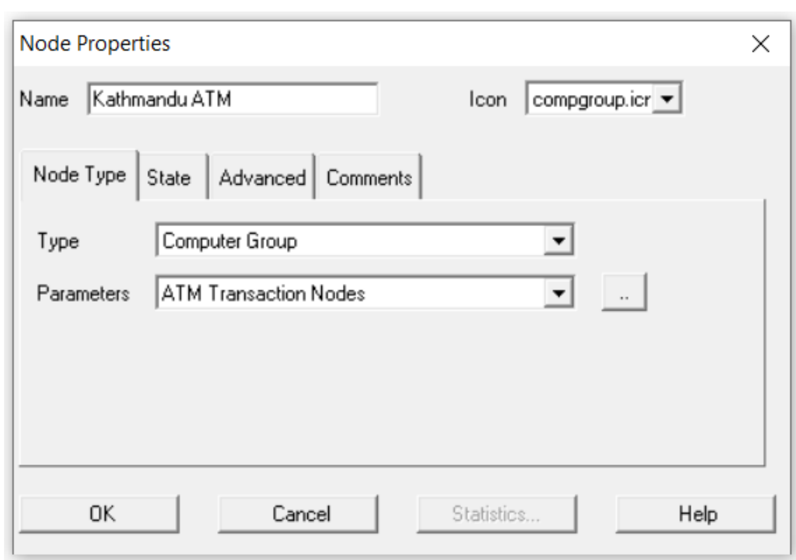


Figure 21: Kathmandu ATM Node Type.

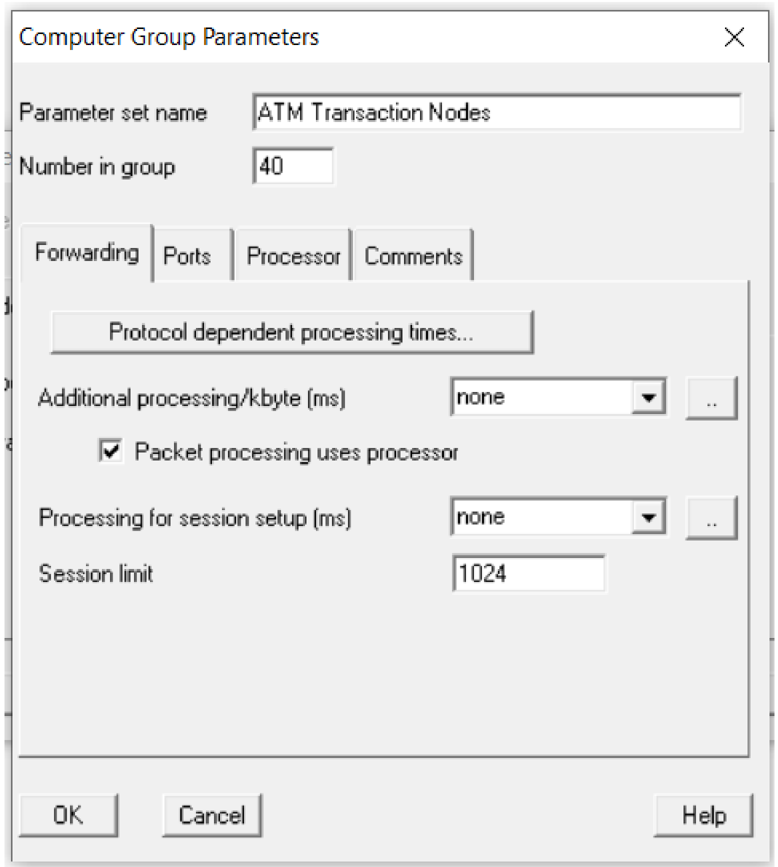


Figure 22: Kathmandu ATM Computer Group Parameters.

1.2.3.5. MESSAGE SOURCE

Message Source: It is a message generator that can send messages to one or more destination. Many types of data transit, such as file transfers and e-mail, can be modelled in a message source. (CACI, 1996)

Two message sources have been used in the Kathmandu LAN. They are:

1. KTM Teller Req

The single teller machine in Kathmandu LAN; the KTM Teller Req is generated at an interarrival time which can be described from the following table.

Name:	**KTM Teller Req**
Scheduling	
Schedule by	Iteration time
Arrival times(seconds)	
Interarrival	Exp (15,0)
Messages	
Msg size calc	Probability distribution
Prob distrib	Uni (50.0,100.0)
Msg size units	Bytes
Destinations	
Destination type	Random list
Destination list	Manchester LAN.MCR ATM Server
Packets	
Protocol:	TCP/IP - Microsoft V1.0
Packetize (ms):	10.0
Routing class:	IGRP Hop Limit: 65535 K1 = 1.0

Table 11: Kathmandu Teller Request Parameters.

The single teller machines in each LANS (Kathmandu and Pokhara) are generated at an interarrival time through the exponential probably distribution with mean 15. The size of can be defined by a uniform distribution, with the size evenly dispersed over the range of 50 and 100 bytes. As all ATM requests will be handled by the Manchester server, a random list is created with respective destination (which stands for Manchester LAN.MCR ATM Server in this case) for the destination list of message source and response. TCP-IP Microsoft V1.0 has been used as the routing protocol with 10 ms as its packetized time. The system uses routing class defined with hop limit of 65535 with IGRP metric weight k1 = 1.

- Parameters:

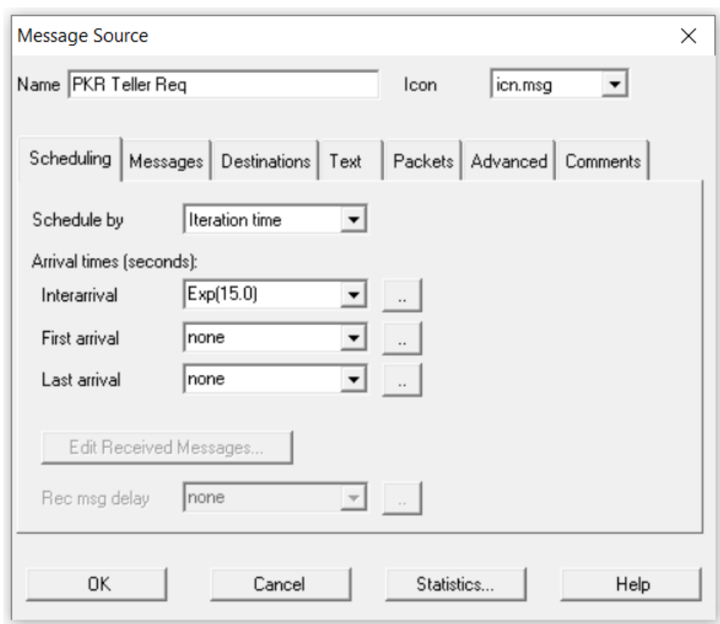


Figure 23: Kathmandu Teller Request Scheduling.

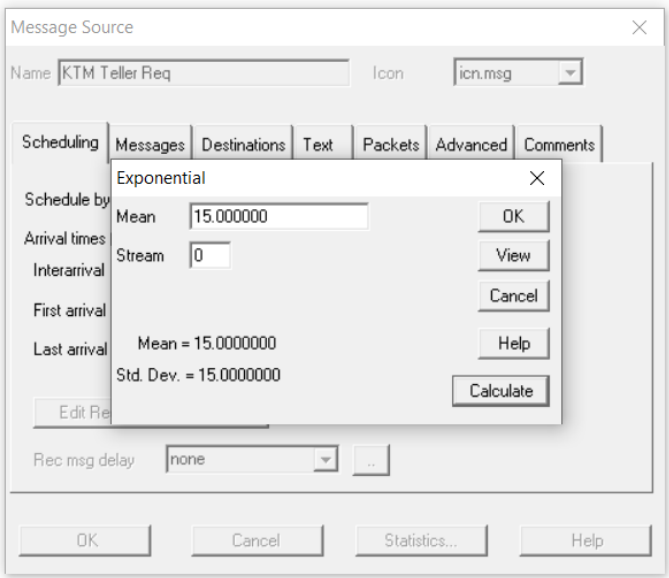


Figure 24: Kathmandu Teller Request Scheduling: Exponential.

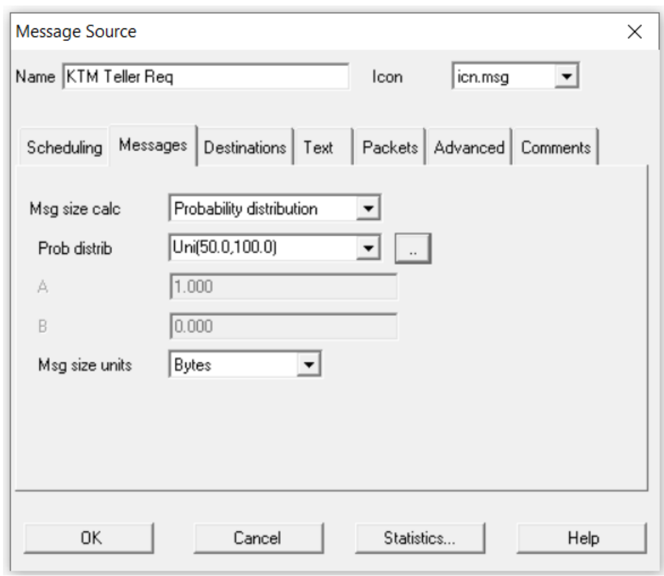


Figure 25: Kathmandu Teller Request Messages.

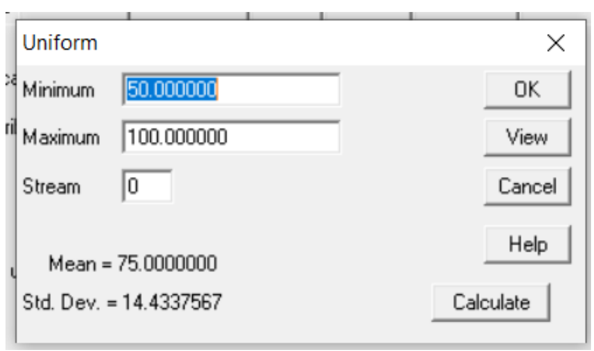


Figure 26: Kathmandu Teller Request Packets.

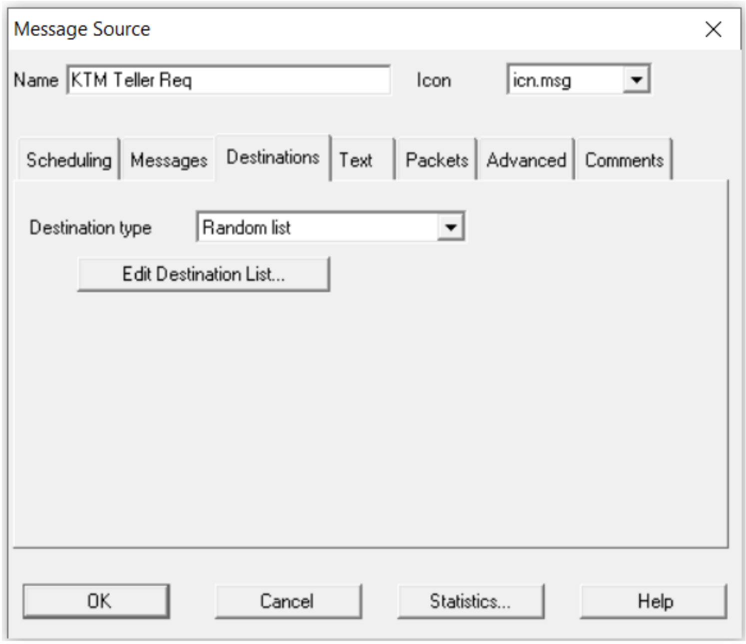


Figure 27: Kathmandu Teller Request Destinations

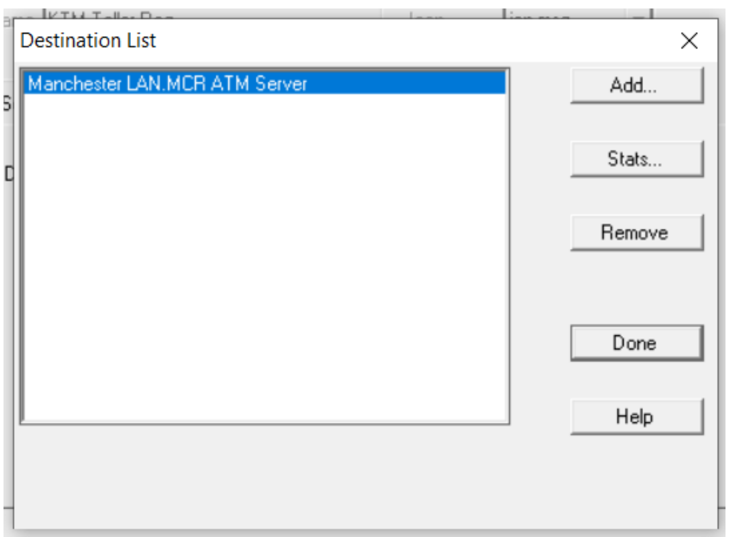


Figure 28: Kathmandu Teller Request Destination List.

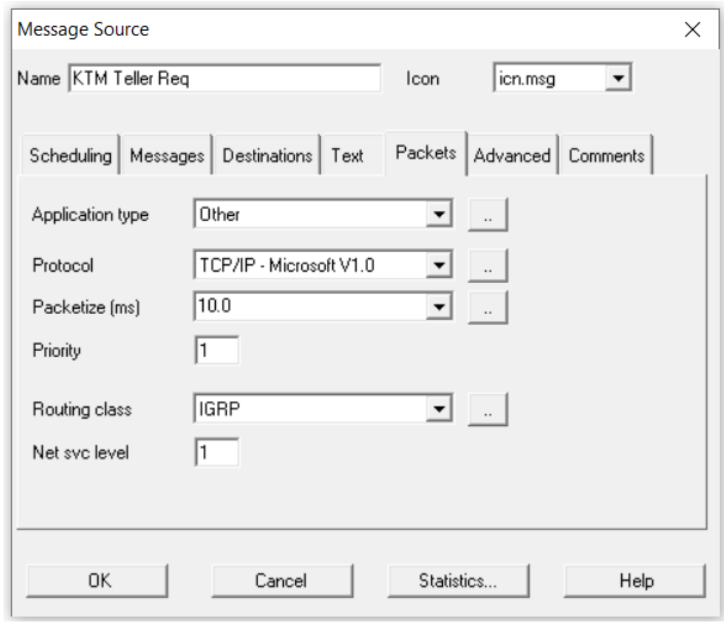


Figure 29: Kathmandu Teller Request Packets.

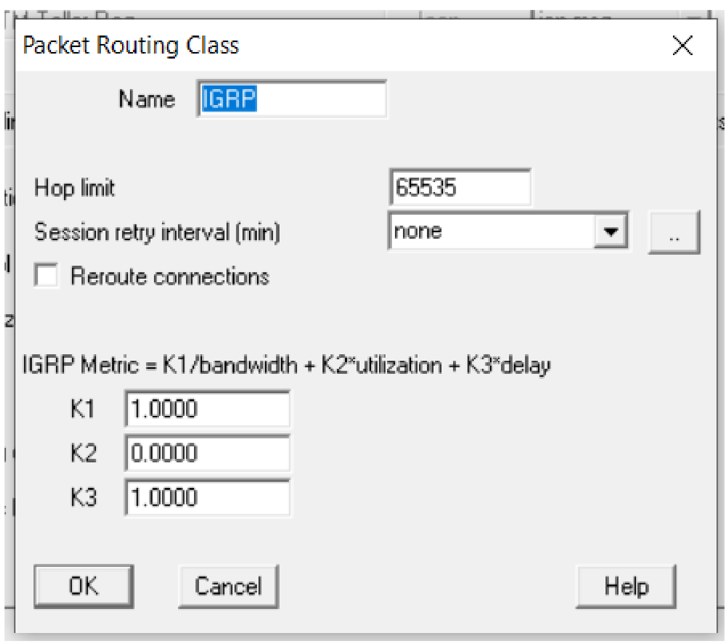


Figure 30: Kathmandu Teller Request Packet: Routing Class

2. KTM Auth Req

In order to support a busy peak of ATM device usage an estimate is made. In each ATM two transactions per minute is generated. The parameters changed to do so are given below.

Name:	**KTM Auth Req**
Scheduling	
Schedule by	Iteration time
Arrival times(seconds)	
Interarrival	Exp (0.5,3)
Messages	
Msg size calc	Probability distribution
Prob distrib	Uni (60.0,100.0,3)
Msg size units	Bytes
Destinations	
Destination type	Random list
Destination list	Manchester LAN.MCR ATM Server
Packets	
Protocol:	TCP/IP - Microsoft V1.0
Packetize (ms):	10.0
Routing class:	IGRP Hop Limit: 65535 K1 = 1.0

Table 12: Kathmandu Authorization Request Parameters.

The estimate to generate two transactions per minute in each ATM can be described with an interarrival time with an exponential distribution of 0.5 with stream 3. The size of ATM authorization requests can be defined by a uniform distribution, with the size uniformly dispersed over the range of 60 and 100 bytes with stream 3. All ATM requests will be handled by the Manchester server. A random list is created with respective destination (which stands for Manchester LAN.MCR ATM Server in this case) for the destination list of message source and response. TCP-IP Microsoft V1.0 has been used as the routing protocol with 10 ms as its packetized time. The system uses routing class defined with hop limit of 65535 with IGRP metric weight k1 = 1.

➢ Parameters:

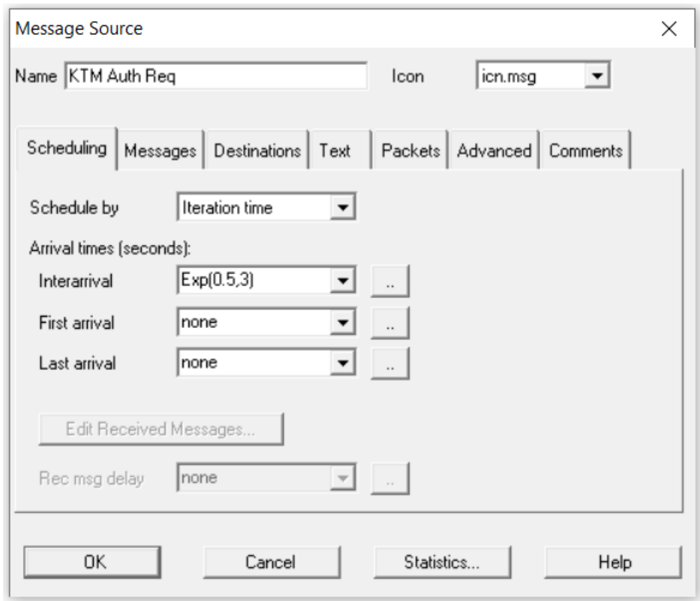


Figure 31: Kathmandu Authorization Request Scheduling.

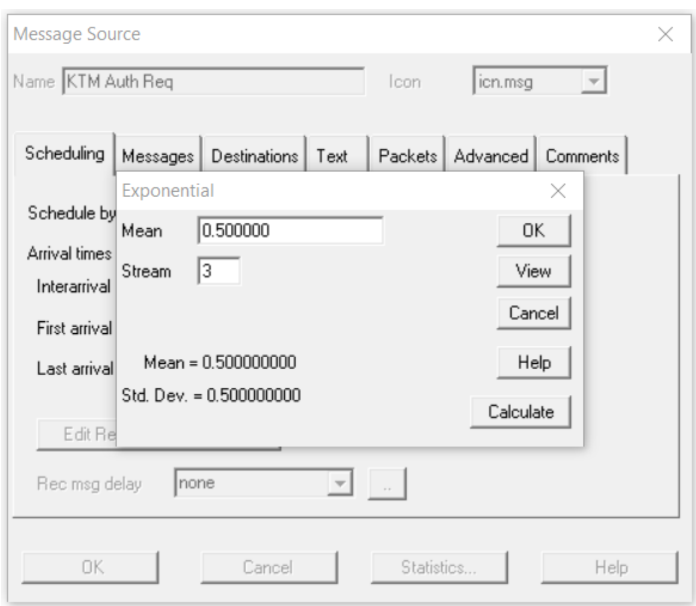


Figure 32: Kathmandu Authorization Request Scheduling: Exponential.

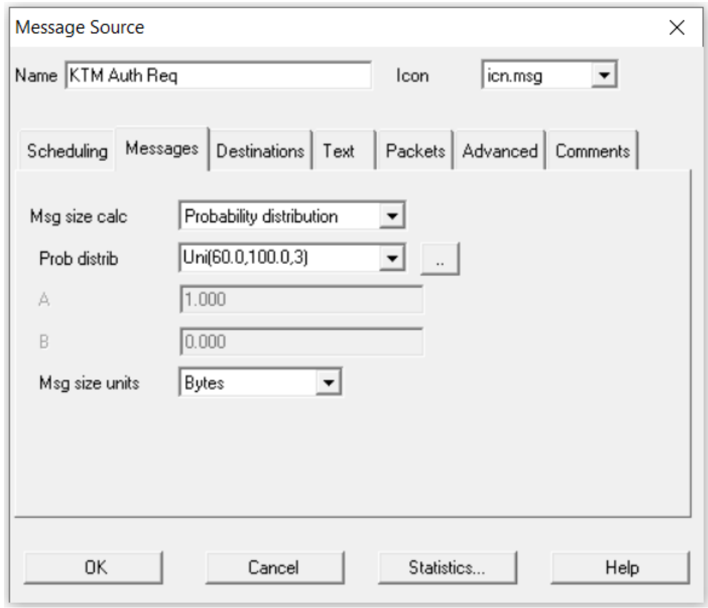


Figure 33: Kathmandu Authorization Request Messages.

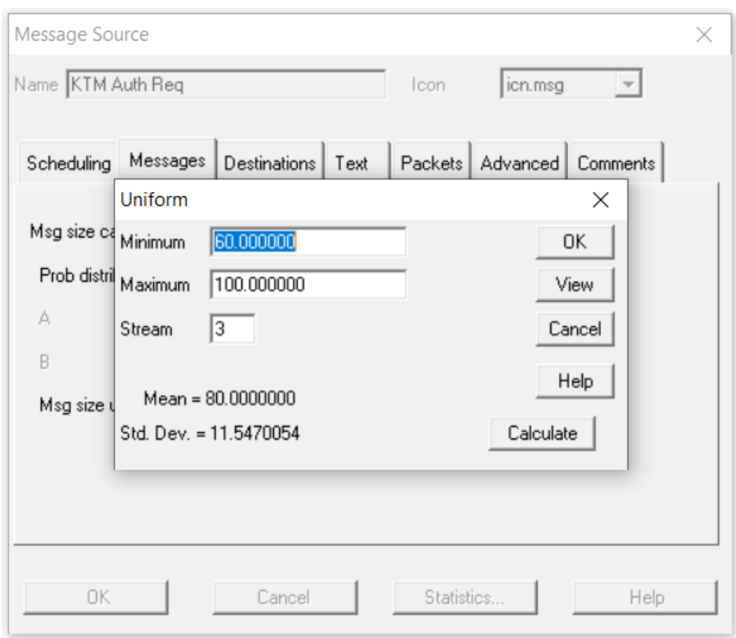


Figure 34: Kathmandu Authorization Request Messages: Uniform..

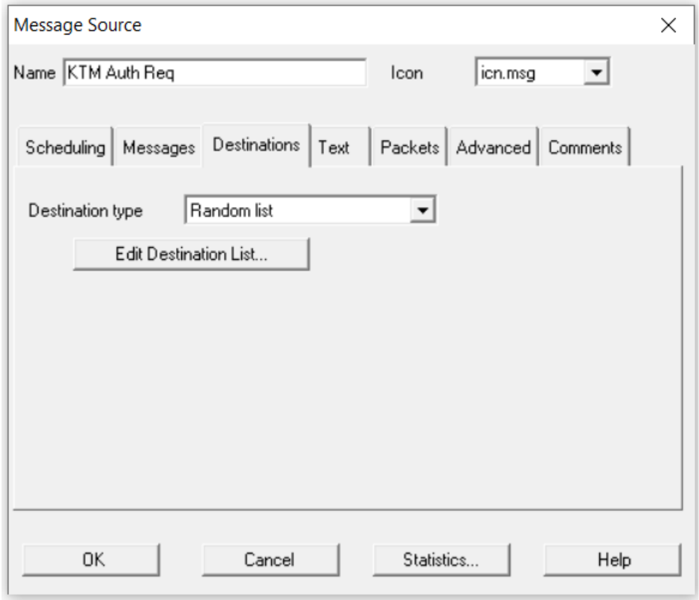


Figure 35: Kathmandu Authorization Request Destinations

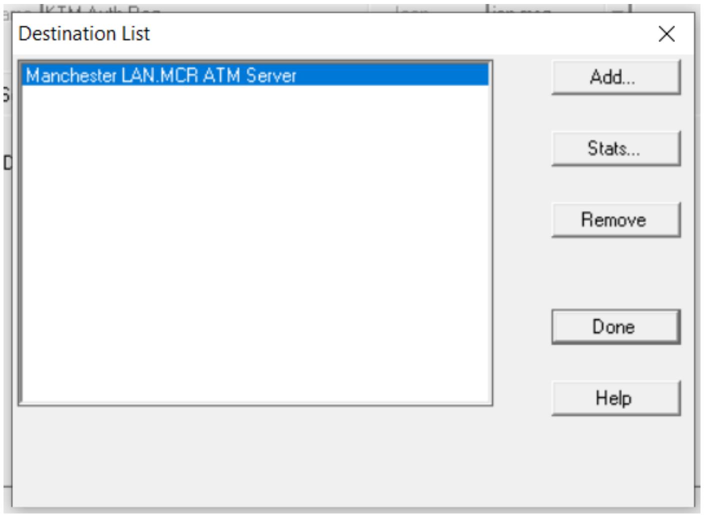


Figure 36: Kathmandu Authorization Request Destination List.

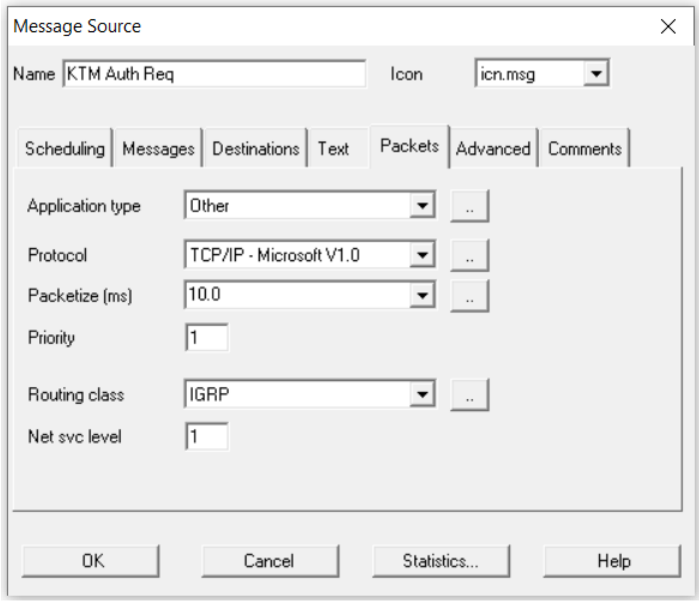


Figure 37: Kathmandu Authorization Request Packets.

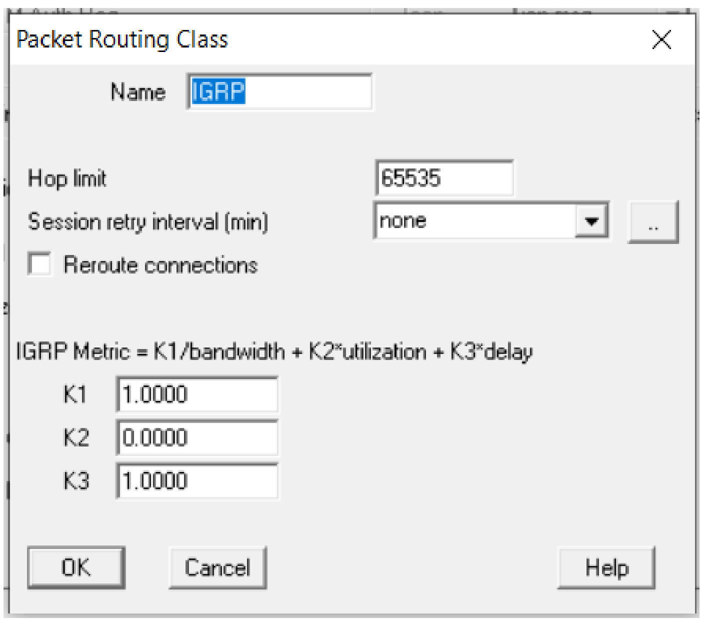


Figure 38: Kathmandu Authorization Request Packet: Routing Class

1.3. DESCRIPTION OF REPORTS

Results obtained from running a simulation of a model is the main goal of creating one. It is generated to describe the performance of the modelled network. A network simulator isn't perfect, but it's close enough to give researchers a useful knowledge of the network under test and how each change would affect its operation. The model should be verified to detect any errors and the simulation used to analyse the problem was designed to run for 120 seconds. Before commencing to gather statistics, a 60-second warmup period was employed to allow message flow to grow up. Only one replication was done for this simulation. (CACI, 1996)

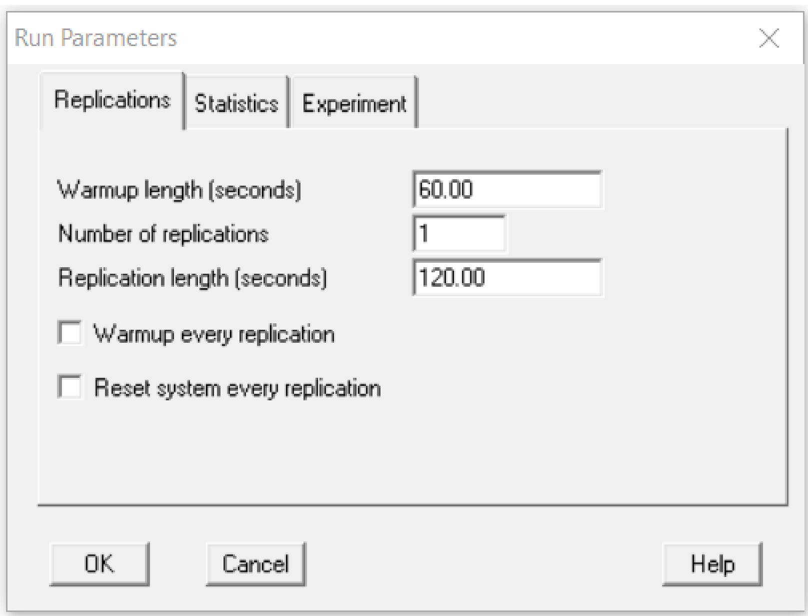


Figure 39: Run Parameters

A set of reports is produced at the end of replication which will be saved in file Stat1.rpt. The reports collecting statistics must be established before the simulation is launched. The reports used for this simulation are listed below:

- Node reports: Received message counts for all nodes.
- Link reports: Channel utilization for all links.
- WAN cloud reports: Frame Delay by VC, Frame count by VC, and access link stats.
- Message and Report response: Message delay for all nodes.

1.3.1. NODE REPORT: RECEIVED MESSAGE COUNT

The received message count report which falls under the node reports presents a count of received messages for each destination node listed by the message name.

NODES: RECEIVED MESSAGE COUNTS		
REPLICATION 1 FROM 60.0 TO 180.0 SECONDS		
RECEIVER	**COUNT**	**MESSAGE NAME**
Manchester LAN.MCR ATM Server	113	KTM Auth Req
Manchester LAN.MCR ATM Server	110	PKR Auth Req

Table 13: Nodes: Received Message Counts.

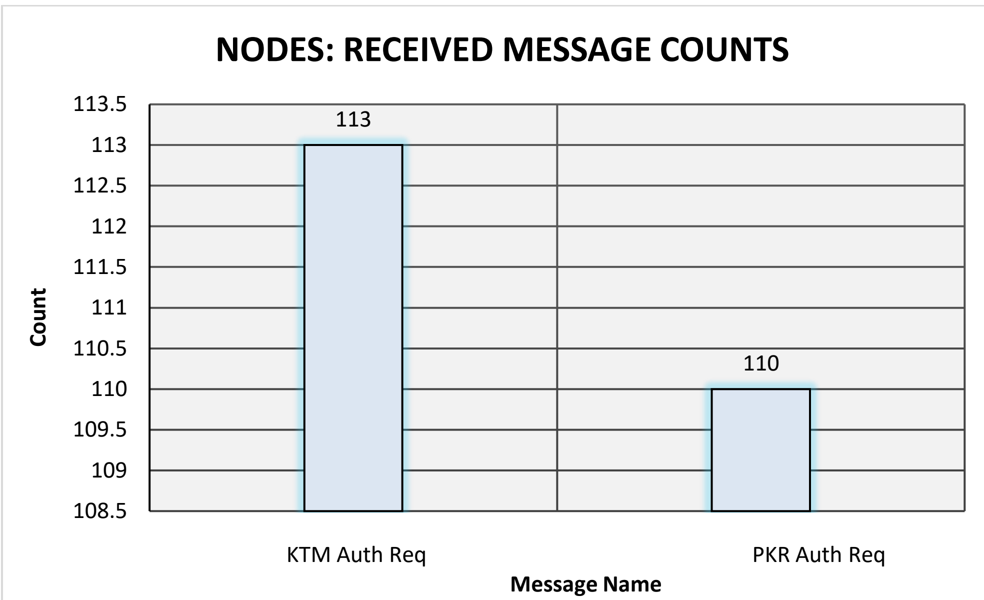


Figure 40: Receiver (Message Name) vs Count.

Receiver shows us the name of the receiving node, in this case the receiving node is Manchester LAN.MCR ATM Server. The count column represents the number of messages received by the receiver during the simulation. The message name represents the name of the received messages i.e., KTM Auth Req and PKR Auth Req, it is not a message text but the name of the message, session, answer or the transport command that sent the message. From the graph given above, we can see that the number of messages received by Manchester LAN.MCR ATM Server is 113 and 110 sent by KTM Auth Req and PKR Auth Req respectively. KTM Auth Req's message count is slightly higher compared to the PKR Auth Req. (COMNET III, 2014)

1.3.2. LINK REPORT: CHANNEL UTILIZATION

The utilization rate for the links used to carry out connectionless and VC messages is provided by link report's channel utilization.

LINKS: CHANNEL UTILIZATION						
REPLICATION 1 FROM 60.0 TO 180.0 SECONDS						
	FRAMES		**TRANSMISSION DELAY (MS)**			**%**
LINK	**DELIVERED**	**RST / ERR**	**AVERAGE**	**STD DEV**	**MAXIMUM**	**UTIL**
Kathmandu LAN.KTM TOKEN RING	11966	0	0.036	0.012	0.082	0.3549
Manchester LAN.ETHERNET	4860	0	0.065	0.013	0.136	0.2447
Pokhara LAN.PKR TOKEN RING	11989	0	0.036	0.012	0.082	0.3562

Table 14: Link Report: Channel Utilization.

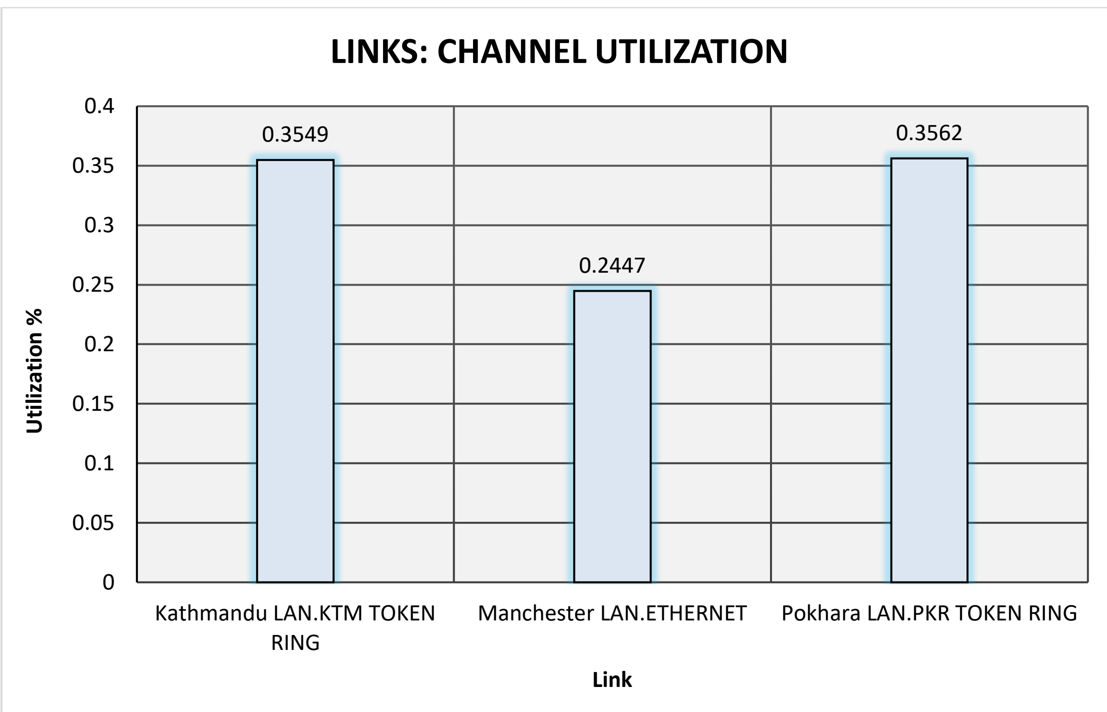


Figure 41: Link Vs % Utilization.

The first column link in the table consists of Kathmandu LAN.KTM TOKEN RING, Manchester LAN.ETHERNET, and Pokhara LAN.PKR TOKEN RING representing the name of the link being reported. The number of frames that were removed from the transmitting node's output buffer and then placed in the receiving node's input buffer is represented by the frames delivered column whereas the frames resent/error shows the number of retransmitted frames. The columns under transmission delay provides the average, standard deviation, and maximum delay observed for any packet over the link. The utilization column exhibits the total usage time divided by the simulation run length. From the graph given above, we can see that the Manchester LAN. ETHERNET has the lowest utilization i.e., 0.2447 whereas Pokhara LAN.PKR TOKEN RING has the highest utilization; 0.3562 although Kathmandu LAN. KTM TOKEN RING with 0.3549 utilization and Pokhara LAN.PKR TOKEN RING is on a similar range. (COMNET III, 2014)

1.3.3. WAN CLOUD REPORT: FRAME DELAY, FRAME COUNT, ACCESS LINK STAT

A WAN Cloud represents a network of communication channels, often of a commercially available service, the precise details of which are unknown or unimportant to the simulation.

1.3.3.1. Frame Delay:

The statistics for the frame delay and burst size for each virtual circuit in a WAN cloud is presented in the WAN cloud report; frame delay.

WAN CLOUDS: FRAME DELAY BY VC					
REPLICATION 1 FROM 60.0 TO 180.0 SECONDS					
CLOUD:	**FRAME DELAY (MS)**			**BURST SIZE (kb)**	
VC	**AVG**	**STD**	**MAX**	**AVG**	**MAX**
WAN CLOUD					
KTM to MCR	60159	17306	90032	5	10
MCR to KTM	97	0	97	2	5
MCR to PKR	97	0	97	2	5
PKR to MCR	60157	17334	90089	5	11

Table 15: WAN Cloud Report: Frame Delay.

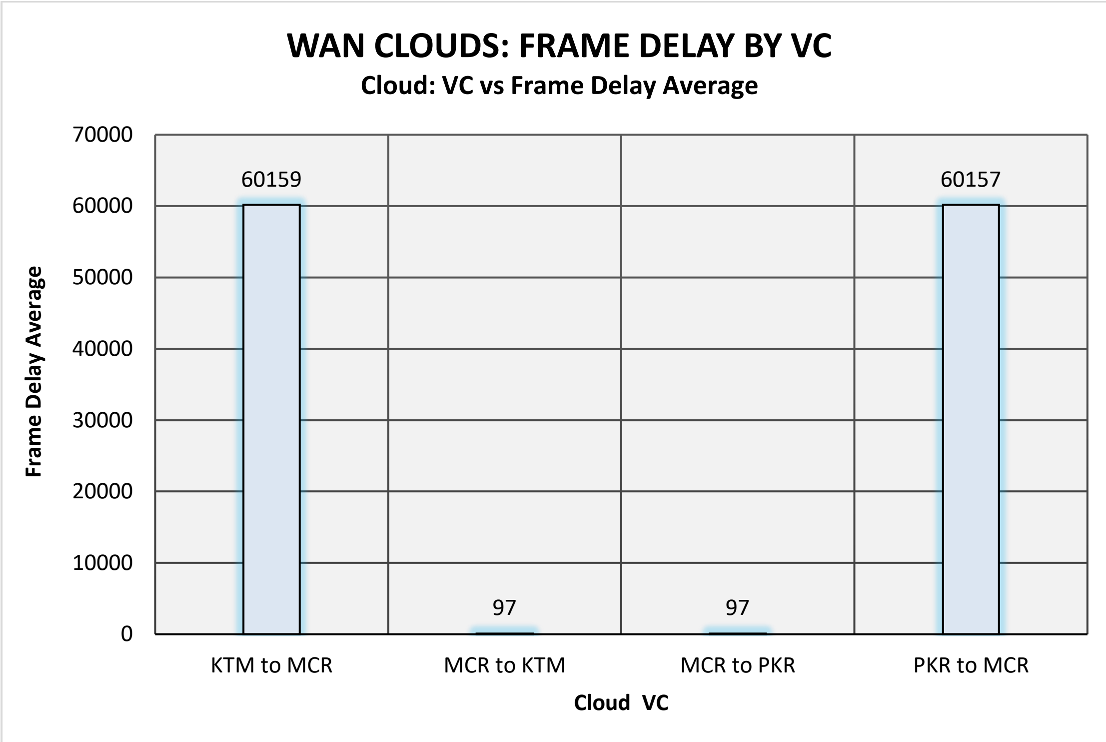


Figure 42: Cloud: VC vs Frame Delay Average.

The first column in the table shows us the name of each WAN Cloud. The average, standard deviation, and maximum frame delay; measured in milliseconds are presented in the frame delay column. From the graph given above, it is observed that the cloud VC of KTM to MCR; 60159 and PKR to MCR; 60157 are of a similar range where KTM to MCR has the highest average frame delay. The MCR to KTM and MCR to PKR has the same average which is 97 frame delay. (COMNET III, 2014)

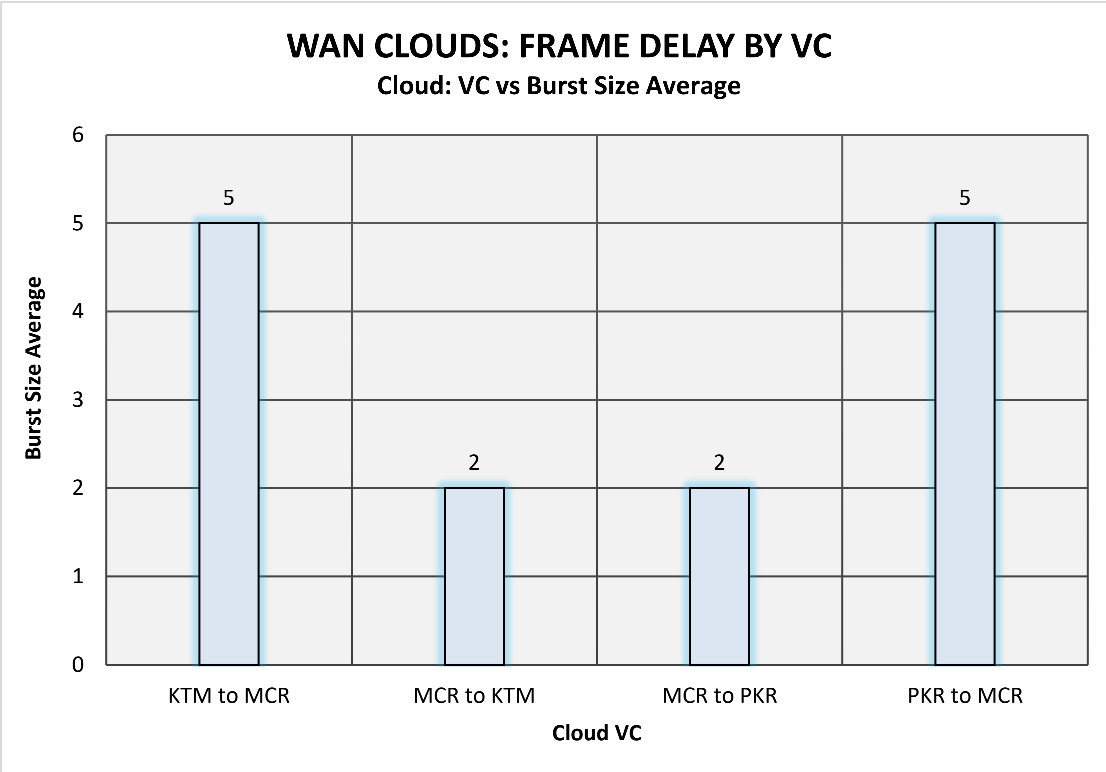


Figure 43: Cloud: VC vs Burst Size Average.

The last column which is the burst size measured in kilobits presents the average and maximum burst size of the packets transmitted across the VC. From the graph given above, it is observed that the cloud VC of KTM to MCR and PKR to MCR have the same average burst size of 5 whereas the MCR to KTM and MCR to PKR has the same average which is 2. (COMNET III, 2014)

1.3.3.2. Frame Count:

The WAN Clouds; frame count gives a throughput estimates for each virtual circuit. It is calculated in both frames accepted/dropped and kilobits accepted/dropped. It is further divided between normal and DE frames.

WAN CLOUDS: FRAME COUNTS BY VC					
REPLICATION 1 FROM 60.0 TO 180.0 SECONDS					
CLOUD:		**FRAMES / KILOBITS**			
VC: FRAMES		**ACCEPTED**		**DROPPED**	
KILOBITS		**NORMAL**	**DE**	**NORMAL**	**DE**
WAN CLOUD		(TOTAL KILOBITS TRANSMITTED =1696)			
KTM to MCR	Frm	1213	0	0	0
	kb	460	0	0	0
MCR to KTM	Frm	1212	0	0	0
	kb	388	0	0	0
MCR to PKR	Frm	1217	0	0	0
	kb	389	0	0	0
PKR to MCR	Frm	1217	0	0	0
	kb	458	0	0	0

Table 16: WAN Clouds: Frame Counts.

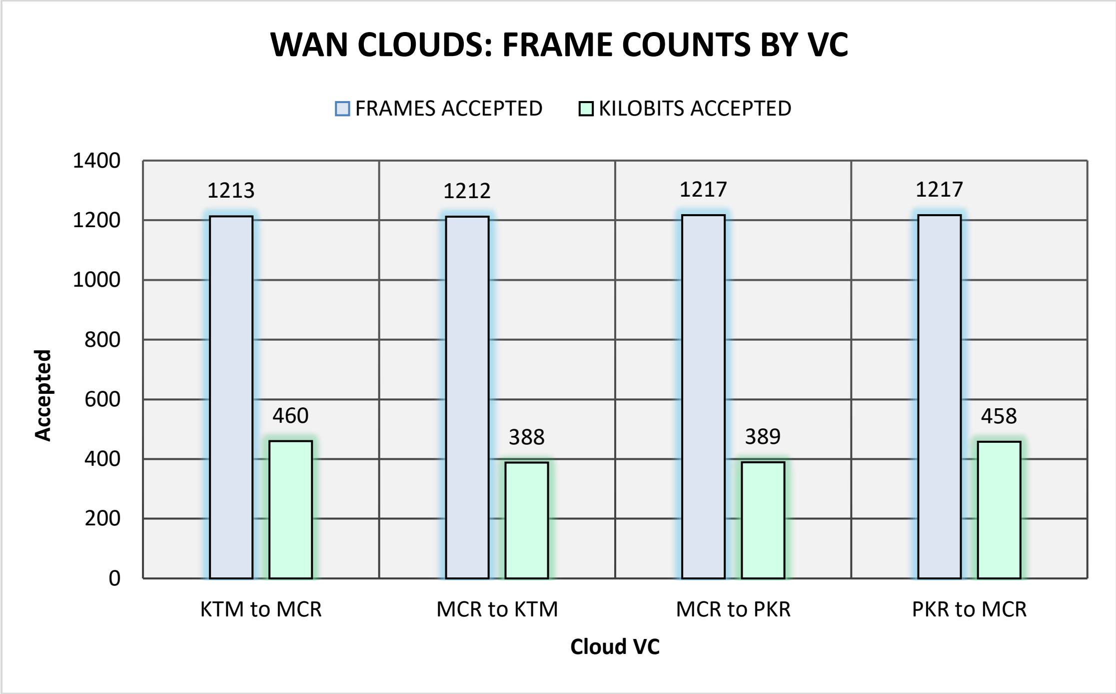


Figure 44: Cloud: VC vs Frame Accepted vs Kilobit Accepted.

The cloud, virtual circuit presents the name of the WAN Cloud and name of VC inside of the cloud respectively. There are two rows of data for each virtual circuit i.e., frames and kilobits. Two separate counts for normal and DE frames exist within frames accepted and dropped. From the graph given above, it is observed that the cloud VC of KTM to MCR and MCR to KTM has accepted frame of 1213 and 1212, the kilobits accepted is 460 and 388 respectively. PKR to MCR and MCR to PKR has the same frame accepted which is 1217 and a difference of 69 in kilobits accepted i.e., 389 for MCR to PKR and 458 for PKR to MCR. (COMNET III, 2014)

1.3.3.3. Access Link Stats:

Statistics for each access link in a WAN cloud are presented here. For each link two rows are shown i.e., entry and exit. As no buffer is modelled for the entry link the values are blank.

WAN CLOUDS: ACCESS LINK STATS							
REPLICATION 1 FROM 60.0 TO 180.0 SECONDS							
CLOUD:		**FRAMES**		**BUFFER (BYTES)**			**% UTIL**
ACCESS LINK (ENTRY) (EXIT)		**ACCEPTED**	**DROPPED**	**MAX**	**AVG**	**STD**	
Kathmandu Access	Entry	2417	0	N/A	N/A	N/A	100.00
	Exit	1212	0	40	18	20	43.76
Manchester Access	Entry	2429	0	N/A	N/A	N/A	87.74
	Exit	4841	0	172587	114915	33254	100.00
Pokhara Access	Entry	2425	0	N/A	N/A	N/A	100.00
	Exit	1217	0	40	18	20	43.95

Table 17: WAN Clouds: Access Link Stats.

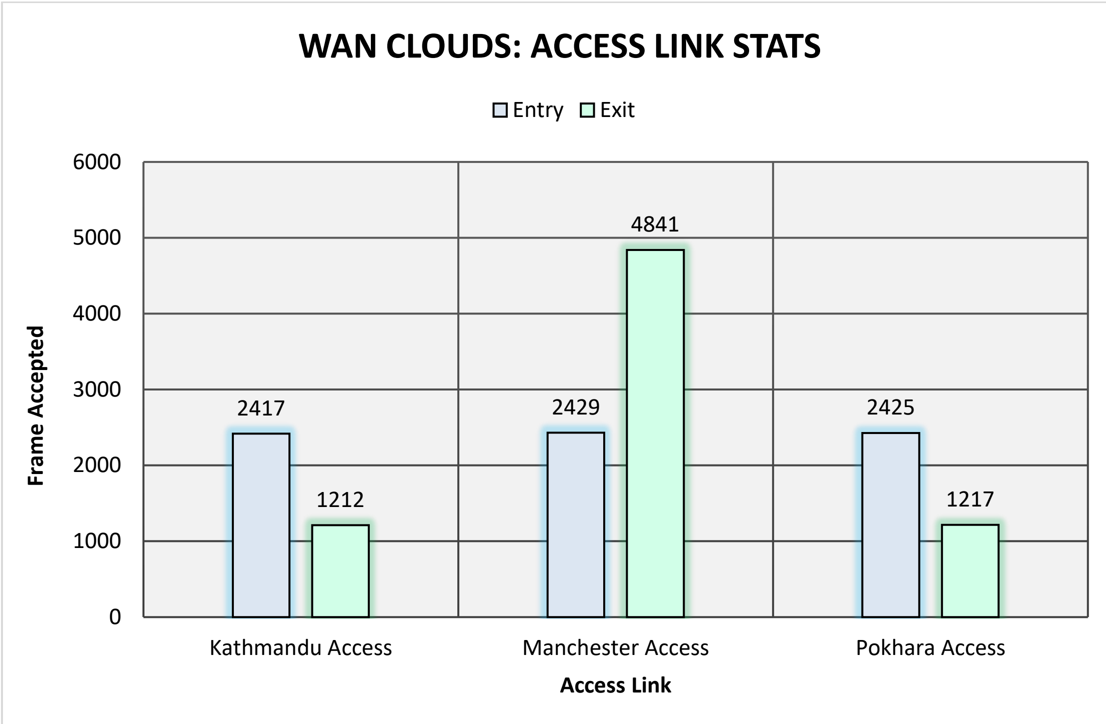


Figure 45: Cloud Access Link vs Frame Accepted Entry vs Frame Accepted Exit.

The cloud shows the name of each WAN cloud. Two rows are printed; entry and exit for each access link named above. The entry and exit access link accept a number of frames which is shown by the frames accepted column. The count reflects total number of the frames that found a path to the given destination. The number of dropped frames by the entry and exit access link, shown by the frames dropped column. The count reflects the total number of frames accepted or blocked by the exit. The buffer gives the maximum, average, and standard deviation of the buffer size. Utilization presents the entry and access link utilization in terms of percentage (%). From the graph given above, it is observed that the entry and exit frame accepted by the access link of Kathmandu is the lowest with 2417 and 1212 whereas the highest is of Manchester with 2429 entry and 4841 exit. The Pokhara access link has a frame accepted entry and exit of 2425 and 1217 respectively. (COMNET III, 2014)

1.3.4. MESSAGE AND REPORT RESPONSE: MESSAGE DELAY FOR ALL NODES

The message and report response; message delay report presents the statistics of the delayed messages as perceived by the sender. The model creates a report lists delay to each destination for every originating node.

MESSAGE + RESPONSE SOURCES: MESSAGE DELAY				
REPLICATION 1 FROM 60.0 TO 180.0 SECONDS				
ORIGIN / MSG SRC NAME:	**MESSAGES ASSEMBLED**	**MESSAGE DELAY**		
DESTINATION LIST		**AVERAGE**	**STD DEV**	**MAXIMUM**
Kathmandu LAN.Kathmandu ATM / src KTM Auth Req:				
Manchester LAN.MCR ATM Server	17	117.20039 S	36140.339 MS	177.90295 S
Kathmandu LAN.Kathmandu Teller / src KTM Teller Req:				
Manchester LAN.MCR ATM Server	0	0.000 MS	0.000 MS	0.000 MS
Manchester LAN.MCR ATM Server / src MCR Req Response:				
ECHO	0	0.000 MS	0.000 MS	0.000 MS
Pokhara LAN.Pokhara ATM / src PKR Auth Req:				
Manchester LAN.MCR ATM Server	17	118.51851 S	35018.643 MS	177.49400 S
Pokhara LAN.Pokhara Teller / src PKR Teller Req:				
Manchester LAN.MCR ATM Server	0	0.000 MS	0.000 MS	0.000 MS

Table 18: Message + Response Sources: Message Delay.

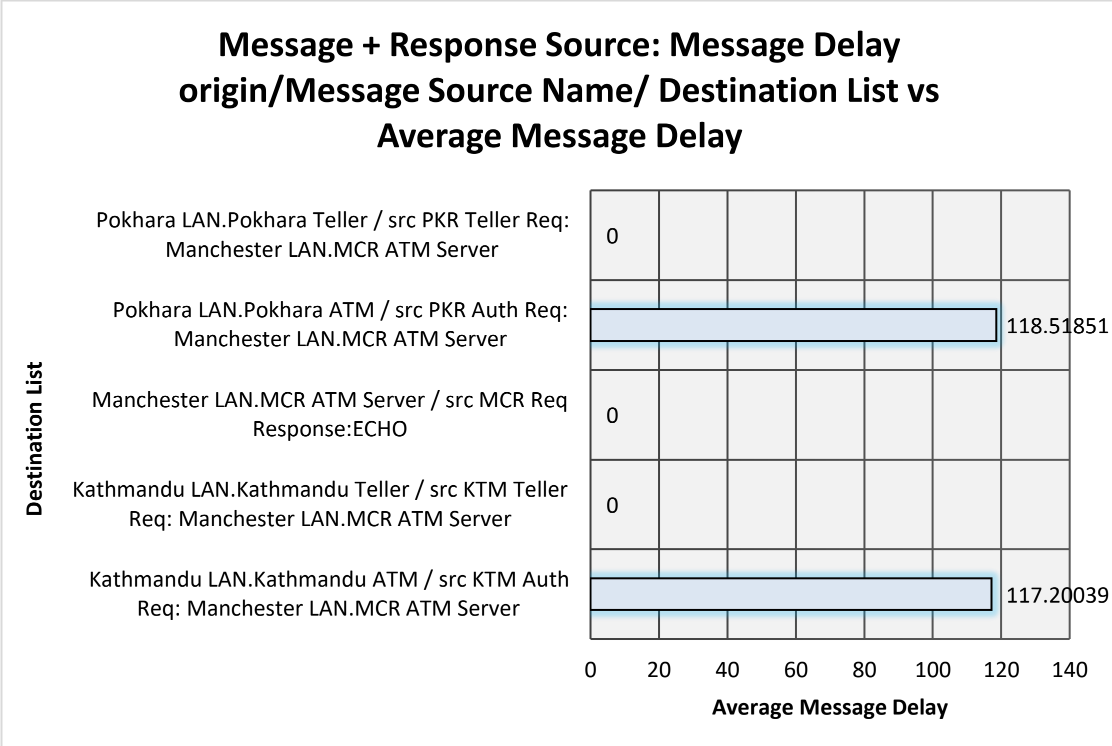


Figure 46:Message Delay Origin / Message Source Name/ Destination List vs Average.

The first column of the table contains the destination list. The number of messages which has been completely assembled at the destination is presented in the messages assembled. The message delay shows the average, maximum and the standard deviation of the delayed message. From the graph given above, it is observed that the average message delay of Pokhara LAN. Pokhara Teller / src PKR Teller Req: Manchester LAN.MCR ATM Server, Manchester LAN.MCR ATM Server / src MCR Req Response: ECHO, and Kathmandu LAN.Kathmandu Teller / src KTM Teller Req: Manchester LAN.MCR ATM Server is 0, whereas Pokhara LAN.Pokhara ATM / src PKR Auth Req: Manchester LAN.MCR ATM Server has the highest average message delay with 118.51851 and the second highest is of Kathmandu LAN.Kathmandu ATM / src KTM Auth Req: Manchester LAN.MCR ATM Server with 117.20039 average message delay. (COMNET III, 2014)

1.4. CONCLUSION

The Task A is based on a network simulation model given to the students in hopes to make the theory behind the application used for the modelling and simulation of the network more comprehensible. Each task heading provides an understanding to several objects used in the application. It also gives an idea of what needs to be analysed, the steps required to build a model, analyse the problems, and ways to present a report of the network simulation.

Through this task we were able to learn and develop our skills in the fields of simulation. The performance analysis tool used for this task which is COMNET III, had a relevant source in assisting with the design and performance analysis. It allowed users to quickly develop network models. The proposed network design in the scenario could be modelled with little to no difficulty.

At last, creating a WAN Model was interesting. It gave us an understanding of network design and its access in terms of modelling and usage so as to minimize the cost of network modifications. It exhibited the ways to build a network design prior to physically building it to reach ideal suitability and reliability. Overall, the task was tremendously beneficial from a point of view of a computing student.

2. TASK B

2.1. INTRODUCTION

The term internetwork was originally established to emphasize network interconnection, and it was later abbreviated to inter-net. People all around the globe use Internet services. A person may use it for different purposes like to monitor their health, to share stuffs, to keep in touch with one another, to attend classes or meetings, to navigate to a new place and many more. Individuals may wonder what the internet is; internet in short, is a global computer communication system that has made all the listed services and more possible. (Douglas, 2019)

The second part of the report (Task B) is to create a technical report about the Internet which includes the history, architecture, advantages and disadvantages of Internet.

2.2. AIMS AND OBJECTIVES

The aim of this task is to acquire an insightful knowledge and worth of the “Internet”.

The objectives of the task are listed down below.

- To understand the base of internet.
- To learn about the steady growth of Internet and its architecture.
- To gain an understanding of its commercial expansion.
- To make a judgment based on the advantages and disadvantages of internet.
- To present the privacy schemes that internet allows and its repercussions.

2.3. BACKGROUND

To get an extensive idea on the internet, it is very critical to realize that it is one amongst the most successful cases of the benefit of a long-term investment and commitment to information structure research and development. (Leiner , et al., 1997) The details of the internet can be analysed in the following topics.

2.3.1. INTERNET

Figure 47: How Does the Internet Work. (HP Development Company, 2019)

Internet can be considered as a network that connects the computers all across the globe and makes communication and sharing to information and intellect more feasible and affordable. It has a collection and access to a vast amount of private and public networks which makes the data accessible to anyone who is on the web. This has its own pros and cons but internet has made a smaller place to live.

It tends to work under the protocols set by IANA making the do's clear to the people on web. (Dennis , 2021)

2.3.1.1. HISTORY

Internet being a revolutionized architecture of technologies wasn't developed by a single entity but a group of individuals and organizations including figures like Robert W. Taylor; led to development of ARPANET, Vinton Cerf and Robert Kahn, who developed TCP/IP technologies.

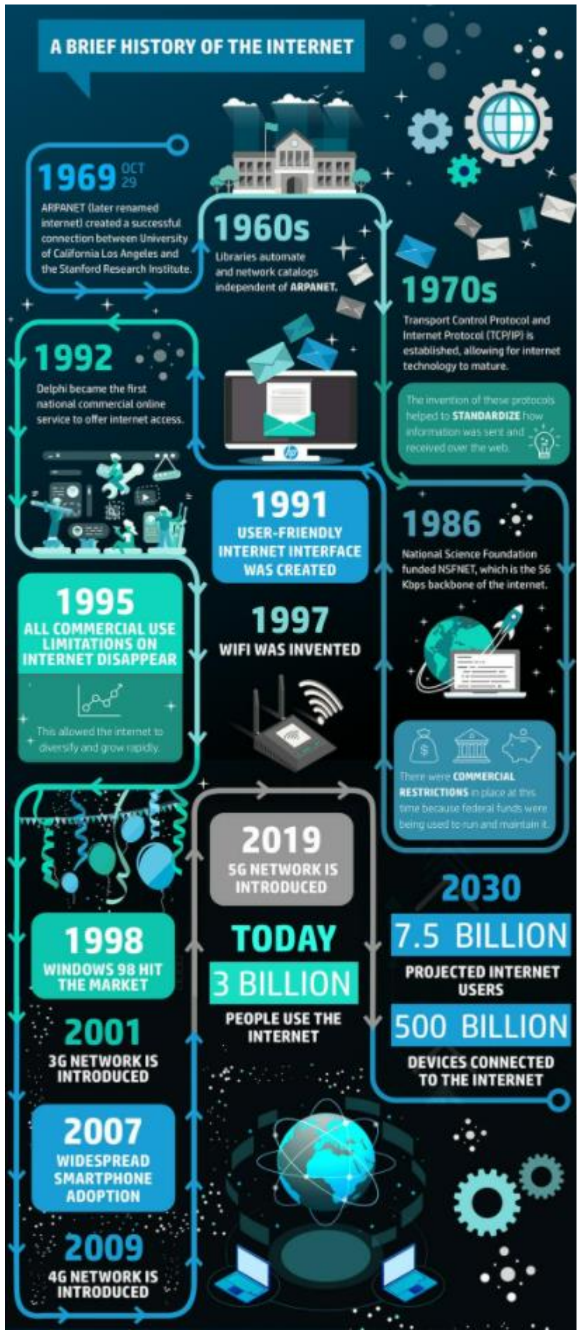


Figure 48: Brief History of the Internet. (HP Development Company, 2019)

With entities like ARPANET which had then been adopted by TCP/IP, the idea of networks of network which became the present modern internet that we know.

After 1990 Tim Berners-Lee invented the World Wide Web and gave internet a more recognizable form to an extent that people tend to identify WWW as the internet. In today's context the web has definitely popularized internet to common people.

The existence of the internet or even the web was very vague even until 1990s as it was not introduced to the general public but with it rapidly made growth with the help of telephone networks and availability of modems which helped to connect computer with network. Also, digital transmission became popular with the development of optical fibre and telephone companies were to lease for connecting routers and regional networks to the then developers of computer networks. (Douglas, 2019)

The history to Internet demonstrates the effectiveness of clearly federal support to research at the right place. The continued support for experiments led to development of protocols and applications like e-mail which was once used of ARPANET and then the Internet. Also, the fact that diverse researchers from institutions of different places were brought together to develop the internet that we know is one of the reasons for the dominant acceptance and popularity of internet. (Leiner, et al., 2009)

2.3.1.2. COMMERCIAL EXPANSION

The diverse and unexpected adoption of internet in the last 20 years has created a number of companies in the industry. Companies like Cisco Systems, Netscape Communications, Yahoo! and Amazon.com are built on the web and makes billions of dollars annually.

In the 1990s, when the physical infrastructure for the internet was established to an extent was the time when the foundation for the internet was laid which is now call “Internet Backbone”. The initial commercialization of internet started with network service providers via network access points by the telephone companies. This eventually gained momentum and expanded the Backbone with private businesses which in the present are the telecommunication companies. With industrialization of web these companies started to build their own backbones which faster access points. Also, smaller enterprising operators has started to provide internet. There were around 10,000 internet service providers by the year 1990’s. Another important factor to the rapid commercial expansion of internet was introduction to personal computer and workstations. (Radziukas, 2019)

Figure 49: Accelerating Business Expansion Worldwide. (Golding, 2018)

With the beginning of 21st century Web 2.0 came in emergence which emphasized on social networking and content generated by users themselves. Facebook, twitter and Instagram became popular and allowed users to share content themselves. With introduction of smart phones, mobile phones could now directly access internet which increased the user index by more than half from one sixth in 2005. (Kahn , 2021)

The commercial expansion of internet is evident to the dramatic shifts in methods of business as it has made communication and other activities instantaneous.

Even though there is no evident path to the growth of internet but it is bound to continue to evolve and affect the economy and fuel every sector with technology. In the next ten years, innovations will be fuelling business models with advances like Internet of Things, Artificial Intelligence and many more. With the present situation internet is very likely to shift every single sector of economy and no sector will soon be untouched by technology and thus will require people to adapt to it. Eye implants can be expected which can enable the use of social networking at any point of time such digital innovations will directly connect human intellect with the digital world. (Internet Society, 2017)

2.3.1.3. ADVANTAGES AND DISADVANTAGES

Through the years internet has not only made the world a smaller place to live but has also made revolutions in many sectors of economy and industry.

General advantages of the Internet:

- Communication is now as easy as ever. With platforms like Skype, zoom etc. family and friends and colleagues can easily connect to one another.
- It is basically an information hub. It has made a permanent platform for students to access any kind information on the web. (Agarwal, 2020)
- It has also intervened the entertainment market and broadened it exponentially to limit that now money can be earned on platforms like YouTube.
- Online services and E-commerce are now a part of life as nowadays online banking, online shopping can be performed. Also, E-commerce enables people to connect through goods from one part of the globe to another efficiently. (Kahn , 2021)
- Social networking has led people to advertise their experiences and share it with people and this has not only made communication easier but has also allowed global platforms like UNICEF, UN to create awareness about real issues.

Although internet has affected most of the sectors of employment, below are some advantages that internet has led to in management field:

- It has significantly reduced the costs for production and distribution of goods and services. (MIXVOIP, 2008)
- With internet the management sector has become more secure and efficient.
- It has made the making prices more transparent and broadened the market for customers and suppliers.
- It has enabled a more convenient and satisfactory platform for customers. (Business Queensland, 2016)

Disadvantages of the Internet.

Internet may not seem to have an inbuilt disadvantage but it has cons which are significant and comes with its usage:

- Easily accessibility of internet has created addiction among people and affected both physical but also psychological differences. (Agarwal, 2020)
- With so many people on web, cyber-crimes have become one of the present issues. Hackers are creating viruses to destroy critical data, and cyber bullying charges are on the rise every day. (Kahn , 2021)
- Since internet has increased the ways of self-entertainment, people who are on internet often are more likely to retrain themselves from social activities. (Quaglio & Millar, 2020)
- At times spams; unnecessary emails, advertisements tend to hamper the system.
- Dark web: It refers to sites that are not indexed and can only be opened using a distinct web browser. Even though it is not illegal, malicious software are all across the web, it makes it easier to engage in criminal activities ranging from selling of illegal drugs and weapons to even hiring of contract killers and can often violate privacy. (Kahn , 2021)

2.3.2. INTERNET ARCHITECTURE

By definition Internet Architecture can be seen as a meta-network, or a collection of continuously changeable collection of individual networks intercommunicating with a common protocol. (Living Internet, 2009)

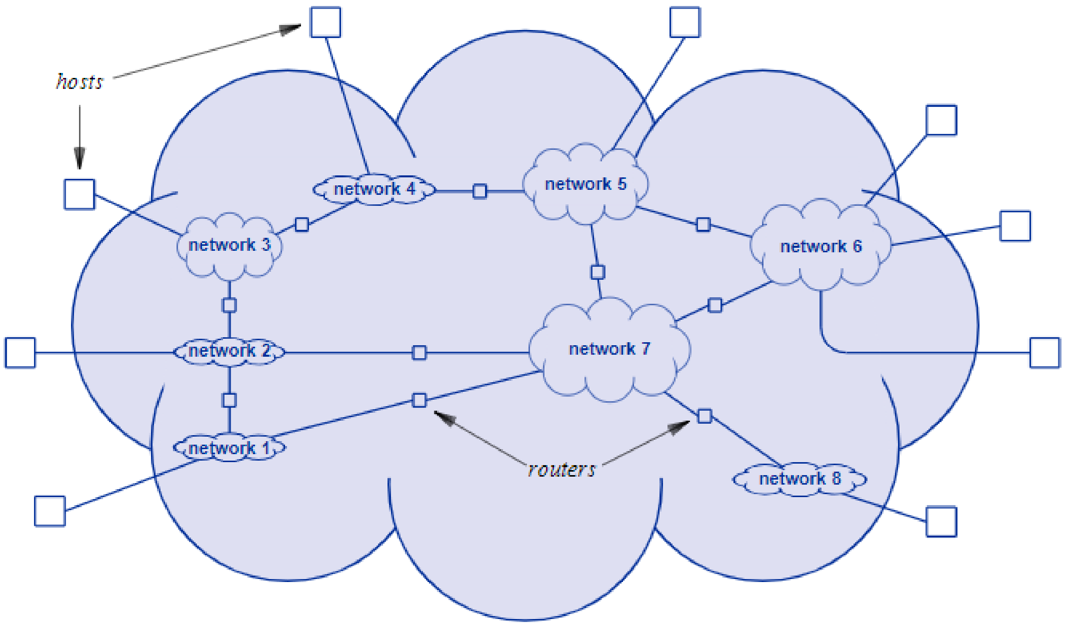


Figure 50: Illustration of the Internal Structure of the Internet with many Networks Interconnected by Routers. (Douglas, 2019)

Its network comprises of basic elements like:

- Hardware
- Software
- Protocols
- Connection medium

The architecture is based on the standard TCP/IP protocol and is designed to connect networks which may have different internal hardware, software and technical design. This candidness of design has enabled, internet architecture to experience global usage.

In practice, internet's technical architecture is very similar to that of a river system. For most people the internet access is from home by simply using a modem which is served by a local internet service provider. The local level service provider then connects to the regional network which already corporates with national network. The national networks tend to connect with large bandwidth networks on the Internet Backbone. In most cases, the internet service providers tend to have many redundant network cross-connections to ensure uninterrupted accessibility. The technical infrastructure of the architecture is very complex and often includes global connections using satellites or underwater cables to facilitate communication between countries. (Living Internet, 2009)

In case of WWW, the architecture is relatively simpler and has sufficient scalability, utility and efficiency. It has ensued a remarkable information space of correlated resources and consists of constraints and principles that influence the design of the system. (Kahn , 2021)

2.3.3. PRIVACY AND THE INTERNET

With internet being a part of the daily lives, some personal information is bound to be share for its efficient usage. In the present bank details, medical reports, permanent address and even phone number might be saved on the web.

Figure 51: Privacy and the Internet. (AccuShred, 2020)

Online privacy essentially refers to the amount of personal, financial and browsing data that remains private when the person is online. It covers the amount of online security available for financial or personal data. Also, personal information like locations may be traced online by a third device through GPS. Many people tend to underestimate and not realize the fact that personal information on web doesn't only confine to social networking sites. Even the browsing history is a very private data. (Sushko, 2021)

Some of the major privacy issues on Internet are listed below:

- Search engines: Search engines track user tracking, the problem being that they tend to track websites that we visit. They may also collect search history, cookies, and IP addresses or even click-through history.
- Social networks have this reputation of data harvesting. There are a number of cases where people have suffered as their personal info was breached and exposed to general users.
- Cookies/ online tracking: For most case cookies are considered very helpful as they collect browsing information so the website remembers login id, language settings etc. but at time vast amount of sensitive information may be collected without the user's consent which may lead to bigger problems.
- Identity theft: Online identification robbery occurs whilst a person accesses the PII to dedicate fraud. This record is probably driver's license, financial institution account details, or something that may be used to impersonate. In the worst-case scenario, the records may come to be on the market at the dark web. Some of the ways in which it may happen may include phishing, malware and pharming. (Sushko, 2021)

Here are some of the tips that can be follow to avoid such frauds:

- Secure the device by downloading antivirus software. Use Anti-tracking tools to prevent websites from accumulating the data and Anti-spyware to stop hackers from spying. (AO Kaspersky Lab, 2021)
- VPN can be helpful to hide IP addresses.
- Use DNT setting in the browser so that any third person cannot track it down.
- Browse in incognito mode as with this the history will not be saved.
- Be aware and attentive while clicking on any link. (AO Kaspersky Lab, 2021)

2.4. CONCLUSION

Task B overviews Internet based on thorough research. This task required critical thinking and proper analysis of information. Also, briefing the data was a challenge as filtering the best content for the task requires a lot of reasoning and analysis. On a better note this task was highly informative as it allowed me to learn more about internet and its history, its steady and plausible growth, its structural architecture or even its commercial expansion. Since it even carries topics like advantages and disadvantages of internet along with the privacy that it provides, the task covers topics significant for everyday users.

In the course of time internet has grown exponentially. With the numerous advantages that it has brought in our daily lives it also has proved its worth in every sector of the economy. Starting from the industries to the management, even sectors like entertainment and its subunits like television shows and music is all onto the branches of internet algorithms. The commercialization of internet has made big contributions to the world economy. It has given the world a broader outlook to independence and at the same time affected the quality making in the market. The mere existence of internet and its architecture all started with interdependence of individual researchers and government support and this is the reason that it is making the impacts like in the present. Despite the numerous advantages to internet, there are issues that are yet to be solved. These are moreover misuse of internet than a disadvantage but the only way to avoid these is to be aware and take as many precautions as possible. The growth of internet is evident, it may seem like it happened instantly but the truth being that it took a lot of time and perseverance and in the future, Internet usage will become akin to breathing.

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4. APPENDIX

4.1. APPENDIX – A (GLOSSARY)

- ATM: Automatic Teller Machine.
- MCR: Manchester.
- KTM: Kathmandu.
- PKR: Pokhara.
- sp: Service provider.
- ms: Milliseconds.
- mbps: Megabits per second.
- kbps: Kilobits per second.
- CSMA/CD: Carrier Sense Multiple Access / Collision Detection
- IEEE: Institute of Electrical and Electronics Engineers.
- 10BASET: The wiring standard for an ethernet that transmits data at 10 megabits per second bandwidth using unshielded twisted pair cabling.
- Req: Request.
- TCP/IP: Transmission Control Protocol/Internet Protocol.
- IGRP: Interior Gateway Routing Protocol.
- VC: Virtual Circuit.
- CIR: Committed Information Rate.
- Auth: Authorization.
- DE: Discard Eligible.
- IANA: Internet Assigned Network Authority.
- ARPANET: Advanced Research Projects Agency Network.
- GPS: Global Positioning System.
- PII: Personal Identifiable Information.
- VPN: Virtual Private Network.
- IP: Internet Protocol.
- DNT: Do Not Track.
- UNICEF: United Nations Children Fund.
- UN: United Nation.

4.2. APPENDIX – B (Task A)

A local area network (LAN) is a group of devices related collectively in one physical location, such as a building, workplace, or home. A LAN could also be small or large, ranging from a home network with one user to an organisation network with many users and devices in a workplace or school. (Cisco Systems, Inc., 2021) Three LANs are used in Task A i.e., Kathmandu LAN, Manchester LAN, and Pokhara LAN.

Pokhara LAN

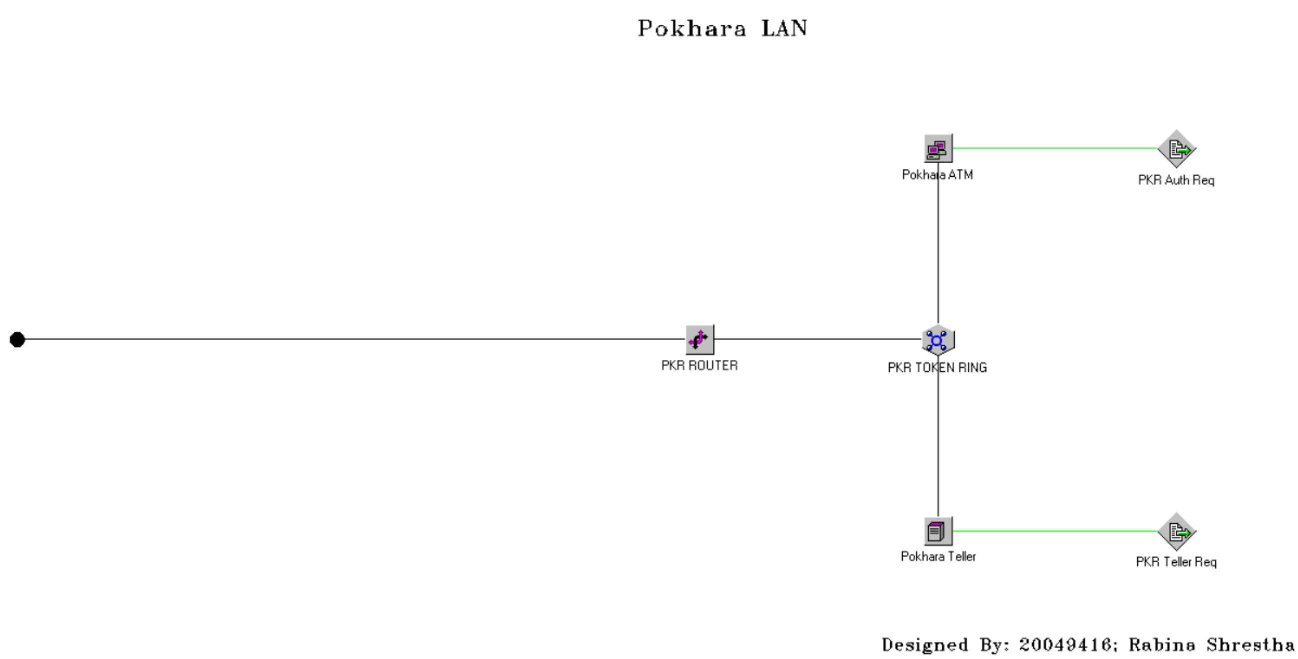

Figure 52: Pokhara LAN.

Network device: Router

Parameters:

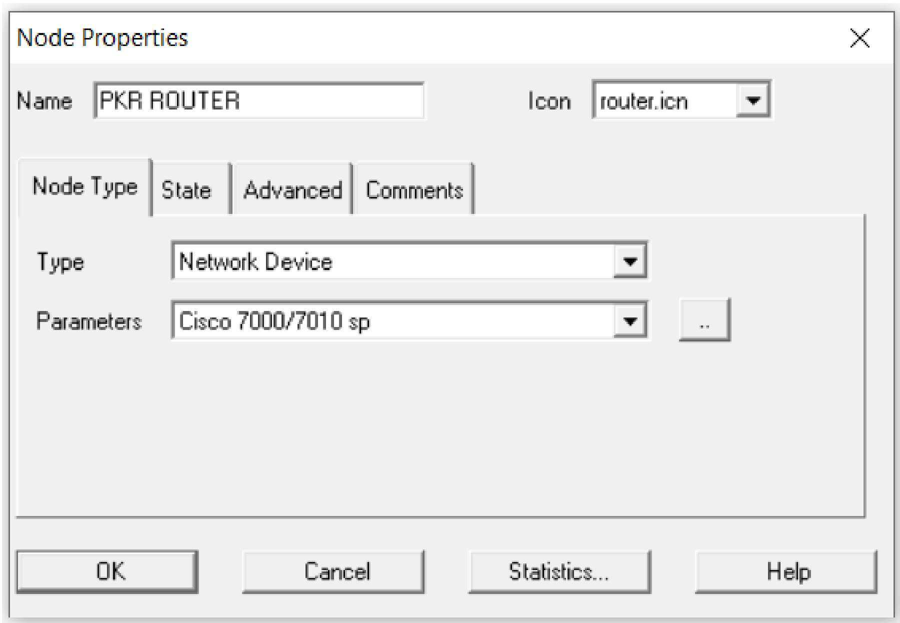

Figure 53: Pokhara Router Node Type.

Token Passing Link

Parameters:

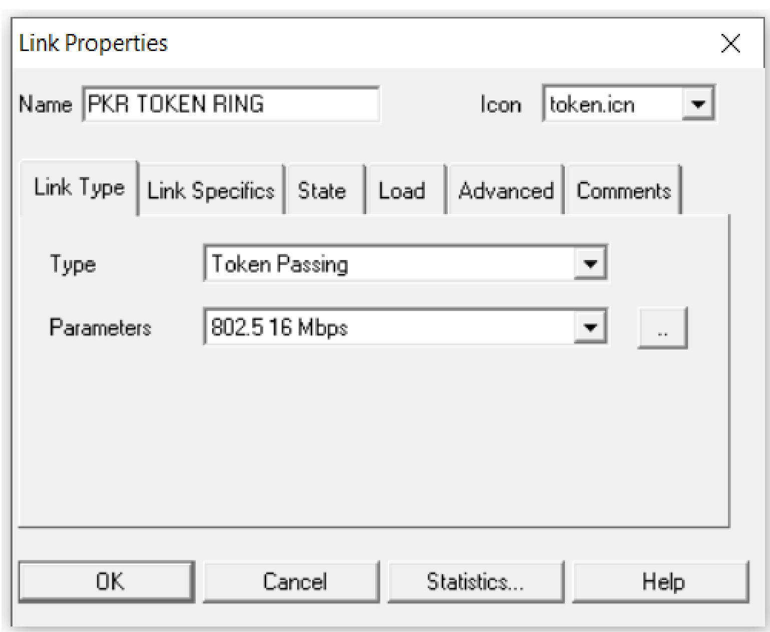

Figure 54: Pokhara Token Ring Link Type.

Processing Node

Parameters:

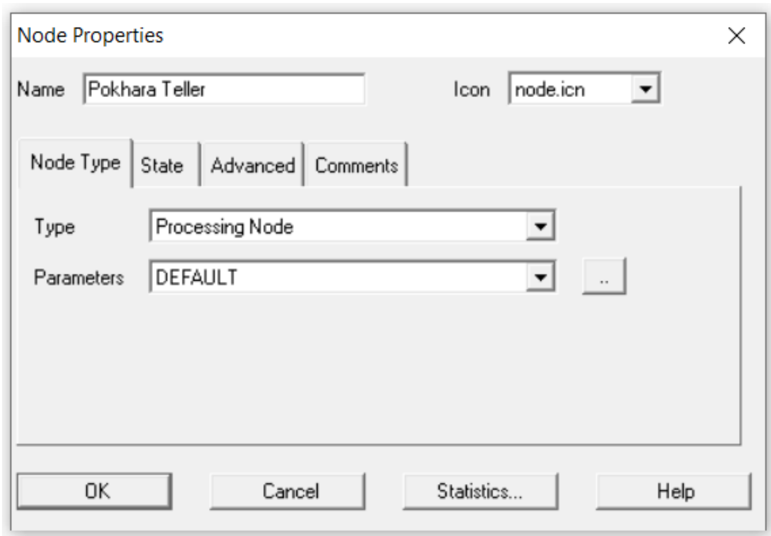

Figure 55: Pokhara Teller Node Type.

Computer Group

Parameters:

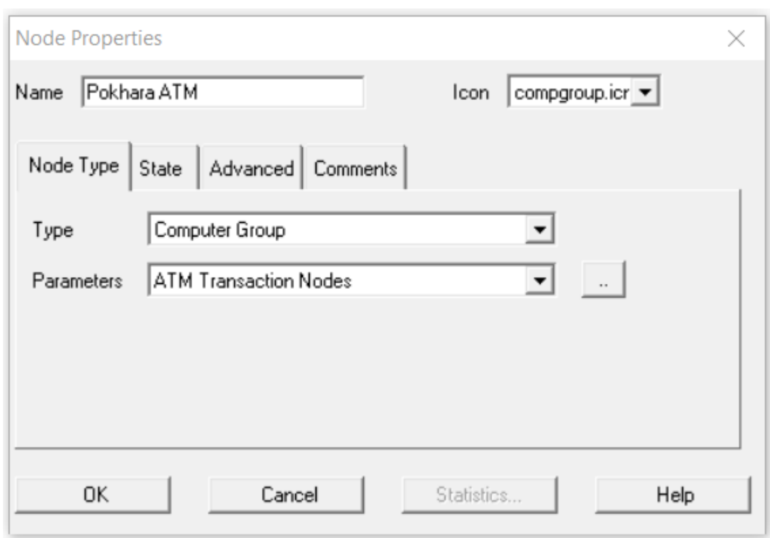

Figure 56: Pokhara ATM Node Type.

Message Source

It is a message generator that can send messages to one or more destination. (CACI, 1996)

Two message sources have been used in the Pokhara LAN. They are:

PKR Teller Req

Parameters:

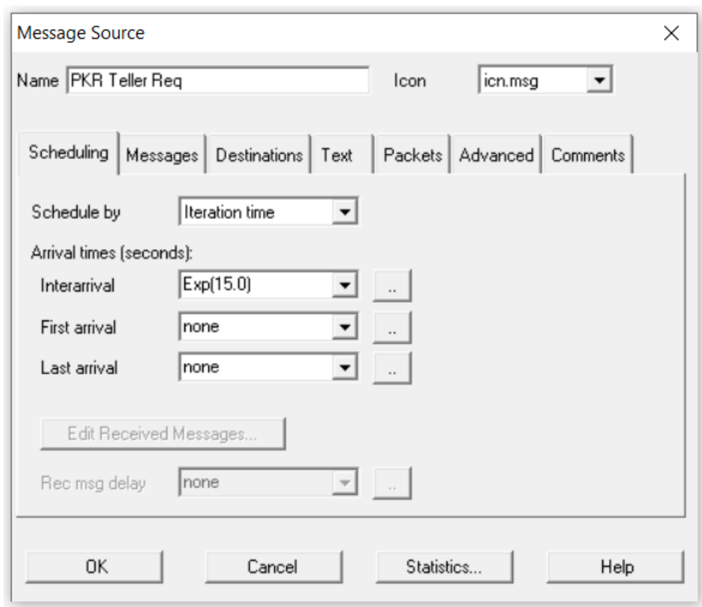

Figure 57: Pokhara Teller Request Scheduling.

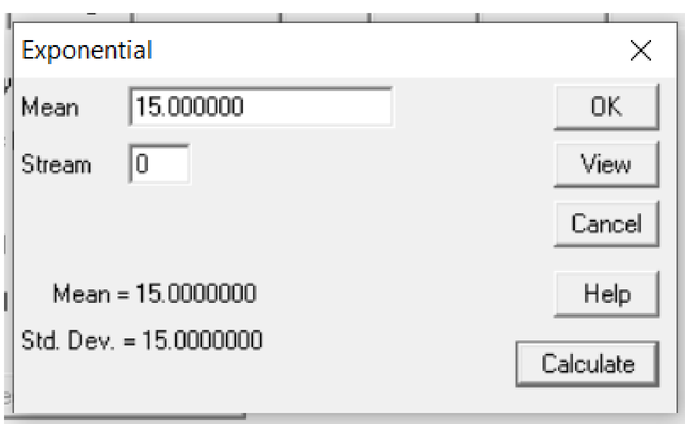

Figure 58: Pokhara Teller Request Scheduling: Exponential.

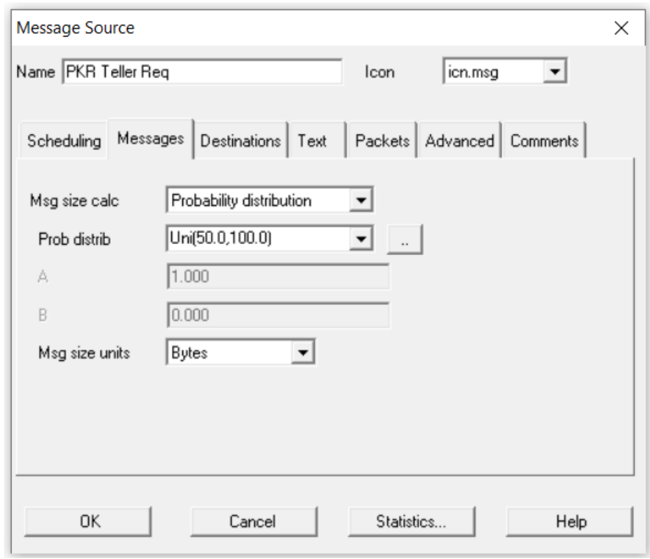

Figure 59: Pokhara Teller Request Messages.

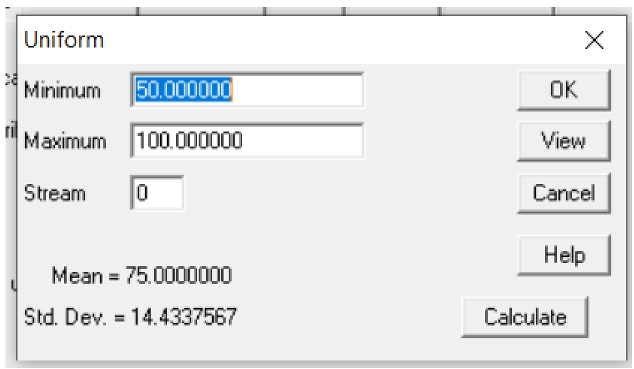

Figure 60: Pokhara Teller Request Message Uniform.

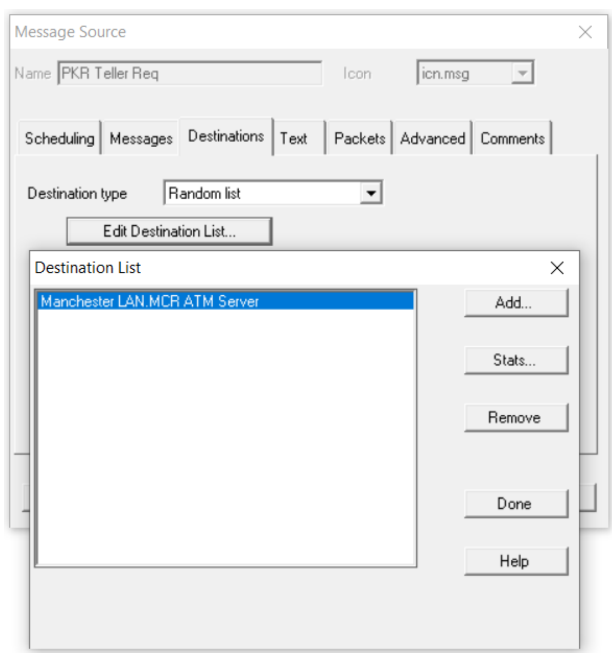

Figure 61: Pokhara Teller Request Destinations

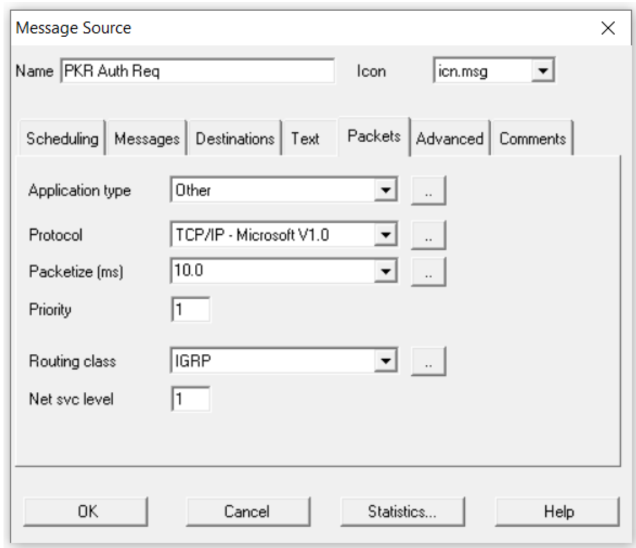

Figure 62: Pokhara Teller Request Packets.

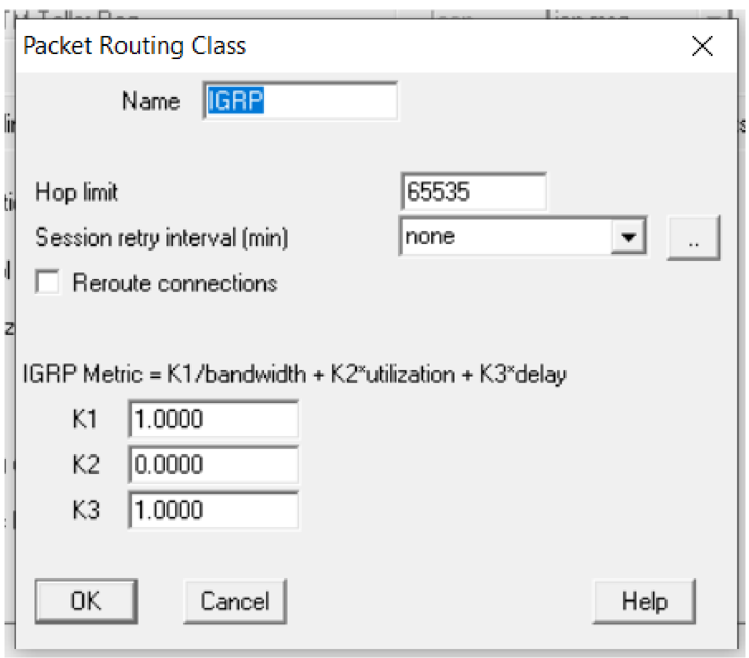

Figure 63: Pokhara Teller Request Packet: Routing Class

PKR Auth Req

Parameters:

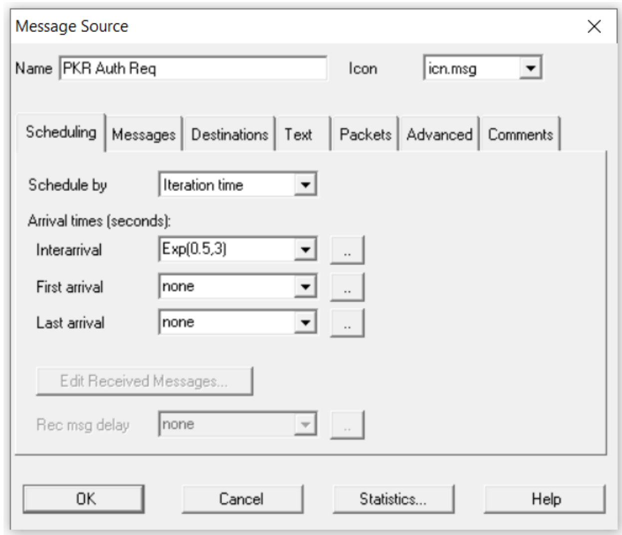

Figure 64: Pokhara Authorization Request Scheduling.

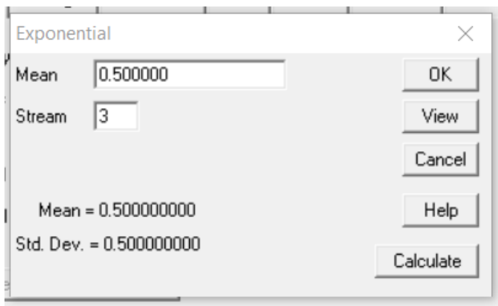

Figure 65: Pokhara Authorization Request Scheduling: Exponential.

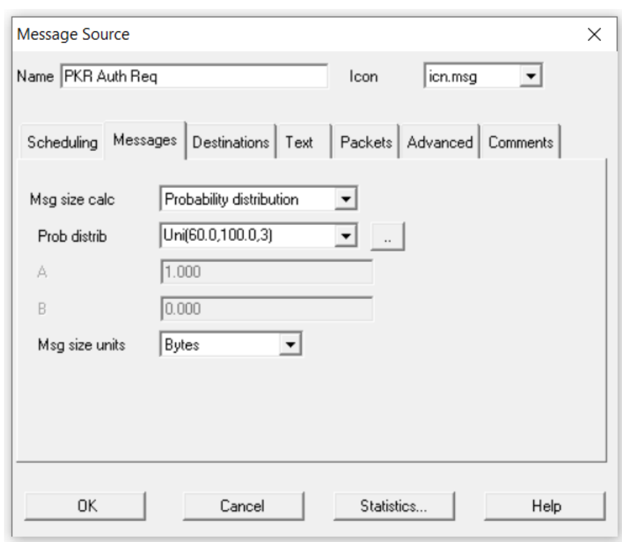

Figure 66: Pokhara Authorization Request Messages.

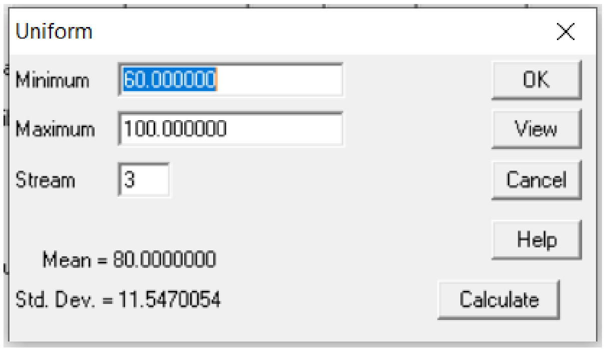

Figure 67: Pokhara Authorization Request Packets.

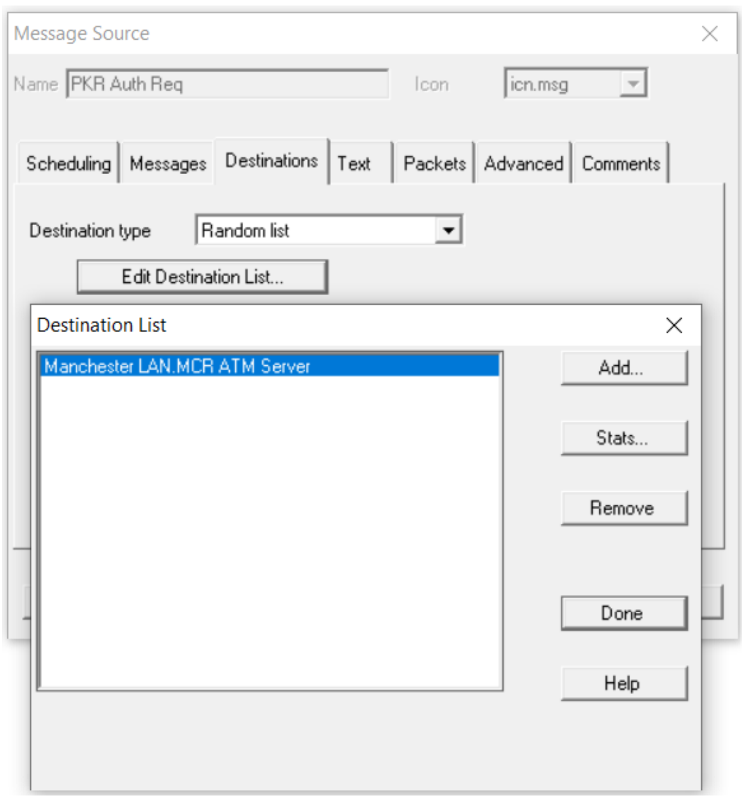

Figure 68: Pokhara Authorization Request Destinations

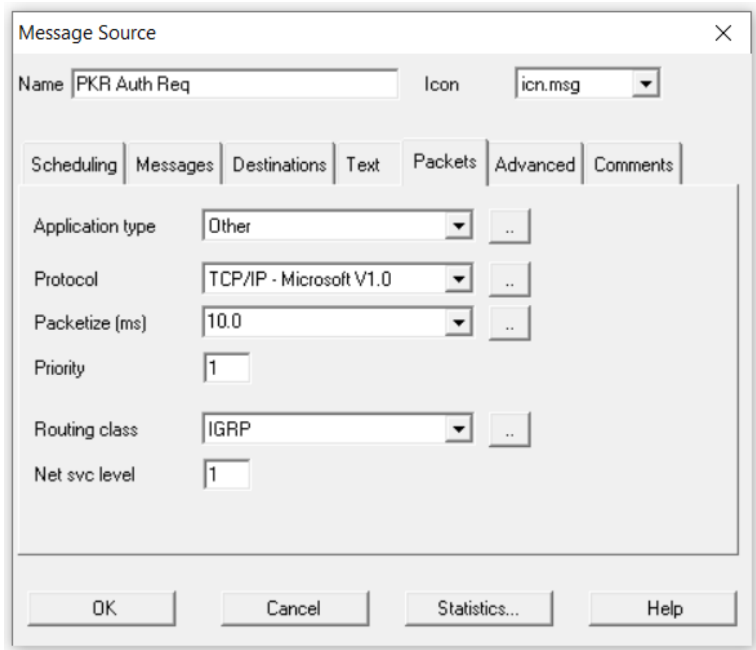

Figure 69: Pokhara Authorization Request Packets.

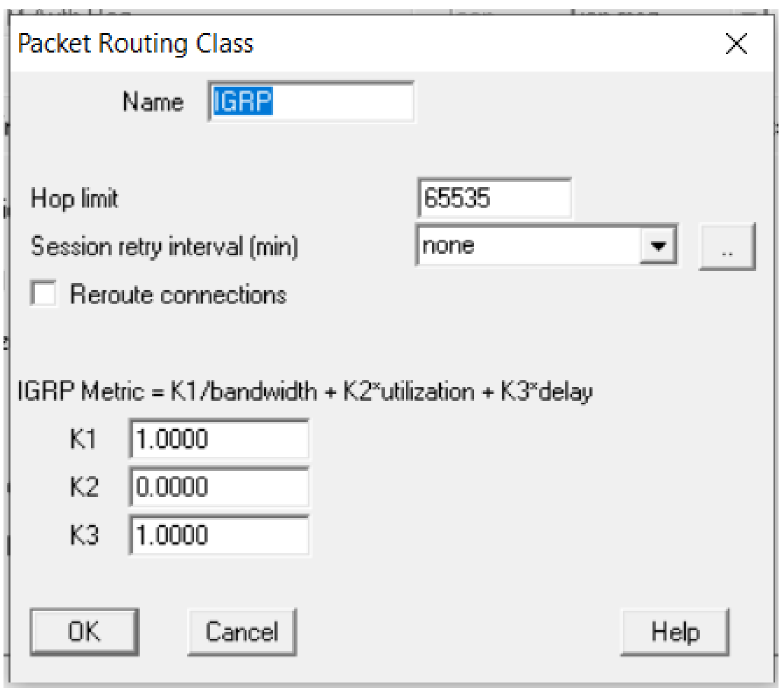

Figure 70: Pokhara Authorization Request Packet: Routing Class

Reports

NODE REPORT: RECEIVED MESSAGE COUNT

```
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                     NODES: RECEIVED MESSAGE COUNTS

                  REPLICATION 1 FROM 60.0 TO 180.0 SECONDS

      RECEIVER             COUNT                 MESSAGE NAME
______________________  __________  __________________________________________

Manchester LAN.MCR ATM       113    KTM Auth Req
Manchester LAN.MCR ATM       110    PKR Auth Req
```

Figure 71: Nodes: Received Message Counts.

LINK REPORT: CHANNEL UTILIZATION

```
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                       LINKS: CHANNEL UTILIZATION

                  REPLICATION 1 FROM 60.0 TO 180.0 SECONDS

                               FRAMES          TRANSMISSION DELAY (MS)      %
LINK                     DELIVERED RST/ERR  AVERAGE    STD DEV    MAXIMUM   UTIL
_____________________    _________ ______  _________  _________  _________ _____

Kathmandu LAN.KTM TOKE       11966      0      0.036      0.012      0.082 0.3549
Manchester LAN.ETHERNE        4860      0      0.065      0.013      0.136 0.2447
Pokhara LAN.PKR TOKEN        11989      0      0.036      0.012      0.082 0.3562
```

Figure 72: Links: Channel Utilization.

WAN CLOUD REPORT: FRAME DELAY, FRAME COUNT, ACCESS LINK STAT

Frame Delay:

```
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                         WAN CLOUDS: FRAME DELAY BY VC

                    REPLICATION 1 FROM 60.0 TO 180.0 SECONDS

CLOUD:                      FRAME DELAY (MS)               BURST SIZE (kb)
  VC                      AVG      STD      MAX           AVG           MAX
______________________  _______  _______  _______    ____________  ____________

WAN CLOUD
  KTM to MCR            60159    17306    90032                5            10
  MCR to KTM               97        0       97                2             5
  MCR to PKR               97        0       97                2             5
  PKR to MCR            60157    17334    90089                5            11
```

Figure 73: WAN Clouds: Frame Delay By VC.

Frame Count:

```
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                         WAN CLOUDS: FRAME COUNTS BY VC

                    REPLICATION 1 FROM 60.0 TO 180.0 SECONDS

CLOUD:                                    FRAMES / KILOBITS
  VC:  FRAMES                    ACCEPTED                     DROPPED
       KILOBITS            NORMAL          DE          NORMAL          DE
______________________  ____________  ____________  ____________  ____________

WAN CLOUD               (TOTAL KILOBITS TRANSMITTED =         1696 )
  KTM to MCR       Frm          1213             0             0             0
                    kb           460             0             0             0
  MCR to KTM       Frm          1212             0             0             0
                    kb           388             0             0             0
  MCR to PKR       Frm          1217             0             0             0
                    kb           389             0             0             0
  PKR to MCR       Frm          1217             0             0             0
                    kb           458             0             0             0
```

Figure 74: WAN Clouds: Frame Counts By VC.

Access Link Stats:

```
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                         WAN CLOUDS: ACCESS LINK STATS

                     REPLICATION 1 FROM 60.0 TO 180.0 SECONDS

CLOUD:                           FRAMES           BUFFER (BYTES)       % UTIL
  ACCESS LINK  (ENTRY)     ACCEPTED    DROPPED    MAX     AVG     STD
               (EXIT)
________________________  __________  _________  ______  ______  ______  ______

WAN CLOUD
  Kathmandu Access Entry        2417          0     N/A     N/A     N/A  100.00
                   Exit         1212          0      40      18      20   43.76
  Machester Access Entry        2429          0     N/A     N/A     N/A   87.74
                   Exit         4841          0  172587  114915   33254  100.00
  Pokhara Access   Entry        2425          0     N/A     N/A     N/A  100.00
                   Exit         1217          0      40      18      20   43.95
```

Figure 75: WAN Clouds: Access Link Stats.

MESSAGE AND REPORT RESPONSE: MESSAGE DELAY FOR ALL NODES

```
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                     MESSAGE + RESPONSE SOURCES: MESSAGE DELAY

                     REPLICATION 1 FROM 60.0 TO 180.0 SECONDS

ORIGIN / MSG SRC NAME:  MESSAGES                MESSAGE DELAY
  DESTINATION LIST      ASSEMBLED       AVERAGE       STD DEV        MAXIMUM
______________________  _________    ____________  ____________  ____________

Kathmandu LAN.Kathmandu ATM / src KTM Auth Req:
  Manchester LAN.MCR A         17    117.20039 S   36140.339 MS  177.90295 S
Kathmandu LAN.Kathmandu Teller / src KTM Teller Req:
  Manchester LAN.MCR A          0        0.000 MS      0.000 MS      0.000 MS
Manchester LAN.MCR ATM Server / src MCR Req Response:
  ECHO                          0        0.000 MS      0.000 MS      0.000 MS
Pokhara LAN.Pokhara ATM / src PKR Auth Req:
  Manchester LAN.MCR A         17    118.51851 S   35018.643 MS  177.49400 S
Pokhara LAN.Pokhara Teller / src PKR Teller Req:
  Manchester LAN.MCR A          0        0.000 MS      0.000 MS      0.000 MS
```

Figure 76: Message + Response Sources: Message Delay.

4.3. APPENDIX – C (Task B)

History

The idea of internet hindered ever since the early 19th century with a concept of worldwide networks of information through wireless networking was proposed by Nikola Tesla himself. But the first schematic for internet was proposed by 1960s after the idea of “intergalactic network of computer" was proposed by MIT's J.C.R Licklider which eventually led to many computer scientists developing packet switching which is basically a method to transmit electronic data which later on became one of the building blocks of the internet that we know. (Dennis , 2021)

- **Conceptual Foundation for the Creation of the Internet.**

Three people and a research conference laid the conceptual groundwork for the internet, and every of them revolutionized the way we considered technology by correctly forecasting its future:

With his depiction of the "memex" automated library system, Bush became the first visionary to explain the possible possibilities for information technology. Wiener pioneered the world of cybernetics, motivating future scholars to specialise in how technology could also be used to enhance human capacities. McLuhan promoted the concept of a worldwide global linked by a network

The Dartmouth AI Conference in 1956 cemented the thought that technology was growing at an exponential rate, and it had been the first serious assessment of the implications.

The launch of Sputnik I, the Soviet Union's first satellite, in 1957 prompted US President Eisenhower to determine the ARPA agency so as to reclaim the technological lead within the weapons race. J.C.R. Licklider was named to steer the new IPTO organization, which has been tasked with advancing the SAGE program's research and assisting the US in defending against a space-based nuclear assault. Within the IPTO, Licklider preached the virtues of a nationwide communications network, persuading his successors to use Lawrence Roberts to hold out his vision.

The network was developed by Roberts, and it was based on a replacement theory of packet switching invented by Paul Baran at RAND and Donald Davies at the United Kingdom National Physical Laboratory a couple of years later. The ARPANET became operational in early October 1969, thanks to the development of a special computer called an Interface Message Processor. Leonard Kleinrock's research facility at the University of California, los Angeles, and Douglas Engelbart's facility at the Stanford Research Institute were the first to communicate.

The Network Control Program was the first networking protocol used on the ARPANET. It was displaced in 1983 by the TCP/IP system, which was created by Robert Kahn, Vinton Cerf, and others and quickly became the world's most commonly used network protocol.

The ARPANET was terminated in 1990 and replaced with the NSFNET. The NSFNET was quickly linked to the CSNET, which connected universities across North America, and later to the EUnet, which united European research institutes. The utilization of the internet surged after 1990, thanks partly to the NSF's foresight and propelled by the recognition of the web, prompting the United States government to hand over management to independent organizations in 1995. And now here we are, there are hundreds of internet service providers and innumerable websites to choose. (Living Internet, 2009)

- **Significant breakthroughs**
  - The ARPANET (later renamed the internet) established a successful link between the University of California Los Angeles and the Stanford Research Institute on October 29, 1969.
  - Libraries automate and network catalogues outside of ARPANET in the late 1960s.
  - The development of Transmission Control Protocol and Internet Protocol aided in the standardization of how data was sent and received via the internet, allowing its technology to mature. It was established in the 1970s.
  - NSFNET, the 56 Kbps backbone of the internet had commercial restrictions in place at the time because government monies were being used to administer and maintain it. The National Science Foundation funded this project in 1986
  - A user-friendly internet interface was created in the year 1991.
  - Delphi was the first national commercial online service to offer internet connectivity in the year 1992’s July.
  - All restrictions on commercial usage of the internet were lifted in the year 1995’s May. As a result, the internet has been able to diversify and grow swiftly.
  - WiFi was developed in the year 1997.
  - In the year is 1998, and Windows 98 was released.
  - Smartphone’s use was widely spread in the year 2007.
  - The 4G network was launched in the year 2009.
  - The internet is used by approximately 3 billion people nowadays.
  - There are expected to be 7.5 billion internet users and 500 billion devices linked to the internet by the year 2030. (HP Development Company, 2019)

Internet Architecture

The internet's architecture is built on a variety of data-transmission technologies. The main concept is that data is split into packets on the sender's end and then reassembled at the destination. The Internet is formed up by hosts, who are also known as end users. Computers, cell phones, servers, workstations, and mainframes can all function as hosts. In a local area network, the hosts could be connected to each other (LAN). An Internet Service Provider connects several LANs. In some cases, LANs are linked together to form a wide area network (WAN), which is later connected to an Internet service provider (ISP). The WAN could be established as a frame relay network with an asynchronous transfer mode.

IP addresses are assigned to users by ISPs. An IP address is a number that uniquely identifies a network and is used to connect to other ISP networks. ISPs only connect networks that are already connected.

➢ **Types of Network Architecture used.**

The physical and logical design of the software, hardware, protocols, and medium for data transfer is referred to as computer network architecture. Simply, it refers to how computers are arranged and duties are assigned to them. The following are the two types of network architectures that are used:

Peer-to-peer (P2P) networking

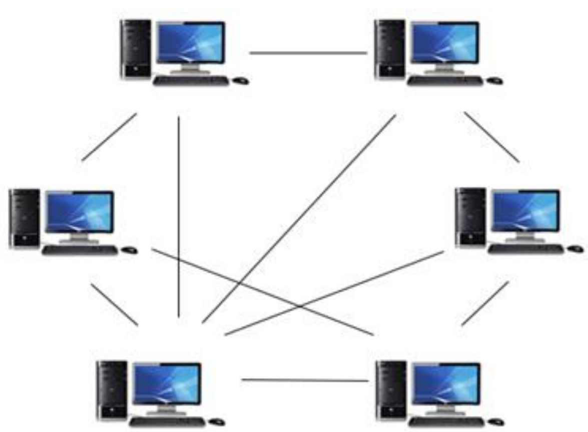

Figure 77: Peer to Peer Network. (JavaTpoint, 2020)

A peer-to-peer network is one in which all computers are connected and have the same privileges and obligations for data processing. It is ideal for small groups of up to ten machines. There is no dedicated server and each computer is given special permissions in order to share resources, but this can cause issues if the computer with the resource is down.

Network of Clients and Servers

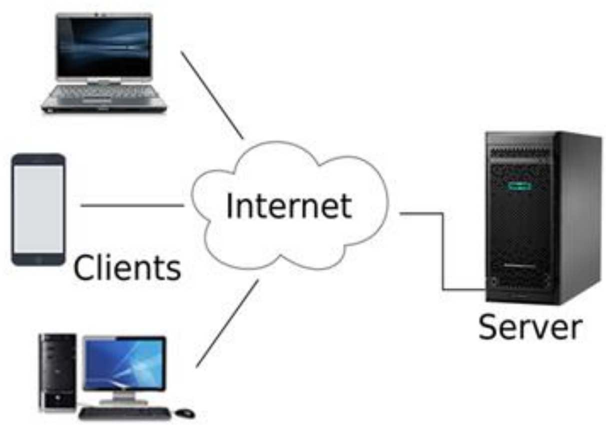

Figure 78: Client/Server Network. (JavaTpoint, 2020)

The client/server network is a network model that allows end users, or clients, to access resources such as songs, videos, and other media from a central computer, or server. All other computers in the network are referred to as clients, while the central controller is referred to as a server. All major functions, such as security and network management, are performed by a server and it is in charge of all resources, including files, directories, printers, and so on. It connects all of the clients and allows them to communicate with one another. (JavaTpoint, 2020)

- **Internet Architecture Layers**

There are three layers to the Internet architecture.

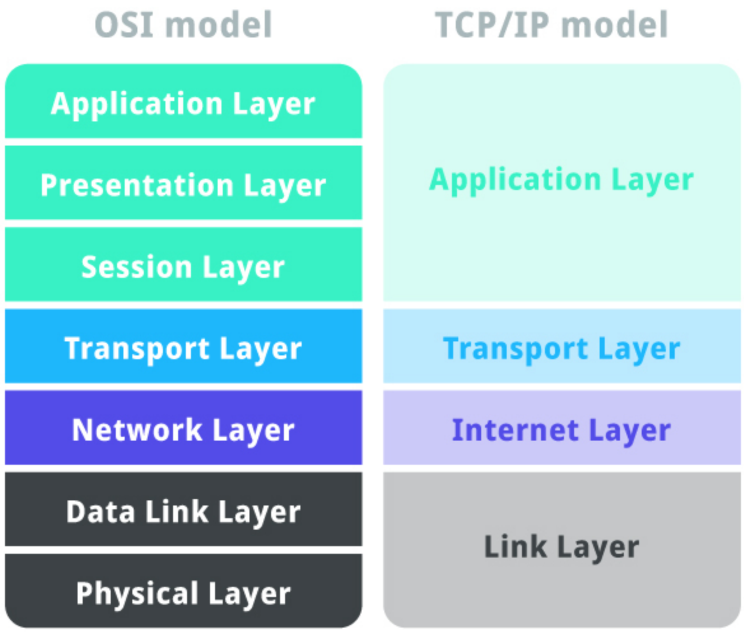

Figure 79: TCP/IP and OSI Model. (mlytics, 2021)

IP

The data must be enclosed in Internet Protocol (IP) packets so as to speak. To succeed in the destination, these IP packets undergo a network's routing system, passing through variety of hosts. IP, on the opposite hand, lacks error detection and recovery capabilities, also because the ability to spot packet loss.

TCP

TCP is an acronym for "Transmission Control Protocol." It ensures end-to-end data transfer, from source to destination. it is a complicated protocol as it allows recovering the lost packets.

Protocol for Application

The application layer is that the third layer in internet architecture, and it contains several protocols on which internet services are created. Email (SMTP supports email), file transfer (FTP promotes file transfer), and other internet services are only a couple of examples. (tutorialspoint, 2006)