Analysis of different nowadays networks

Technology, Computer

CIRCUIT SWITCHING AND PACKET SWITCHING 1) INTRODUCTION

Telecommunication networks carry information signals among entities, which are geographically for apart. Thecommunicationswitching system enables universal connectivity. Switches can be valuable asset to networking[1]. Overall, they can increase the capacity and speed of our network. Every time in computer network we access the internet or another computer network outside our immediate location, our messages are sent through a maze of transmission media and connection devices.

The mechanism for moving information between different computer network and network segment is called switching in computer network[2]. Figure 1: Switched network Long distance transmission is typically done over a network of switched nodes. Nodes not concerned with content of data. A collection of nodes and connections is a communications network. Data routed by being switched from node to node. Nodes may connect to other nodes only, or to stations and other nodes. Node to node links usually multiplexed. However, switching should not be seen as a cure-all for network issues.

There are two different switching technologies which are: 1) Circuit switching and 2) Packet switching. 1. Circuit Switching Circuit switching was the first switching technique have been used in communication network. This is due to easy to carry analog signals. Circuit switching network establishes a fixed bandwidth channel between nodes before the users may communicate, as if the nodes were physically connected with an electrical circuit. The bit delay is constant during the connection, as opposed to packet switching, where packet queues may cause varying delay.

In circuit switching, the transmission medium is typically divided into channels using Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), or Code Division Multiplexing (CDM). A circuit is a string of concatenated channels from the source to the destination that carries an information flow. To establish the circuits, a signaling mechanism is used. This signaling only carriers control information, and it is considered an overhead. Since all decisions are taken by the signaling process, the signaling mechanism is the most complex part in circuit switching.

Each circuit cannot be used by other callers until the circuit is released and a new connection is set up. Even if no communication is taking place in a dedicated circuit then, that channel still remains unavailable to other users. Channels that are available for new calls to be set up are said to be idle. Telephone network is example of circuit switching system. Virtual circuit switching is a packet switchingtechnologythat may emulate circuit switching, in the sense that the connection is established before any packets are transferred, and that packets are delivered in order.

Unlike with packet switched networks, we cannot just send a ' packet' to the destination. We need to establish and later terminate the connection. We need to have some way of transmitting control information, we can either do this in band that the same channel we use for data or out of band which is on a seperate dedicated channel. Phone networks used in band signaling a while ago we could control switching and other functionality by playing tones into the telephone. Today in band signaling is considered unsecure and is not used except for compability with old systems[3]. 2. Packet Switching

Packet switching is a communications paradigm in which packets are routed between nodes over data links shared with other traffic. In packet-based networks, the message gets broken into small data packets. These packets are sent out from the computer and they travel around the network seeking out the most efficient route to travel as circuit become available. This does not necessarily mean that they seek out the shortest route. Each packet may go different route from the others. Each packet contains a " header" with information necessary for routing the packet from source to destination.

The header address also describes the sequences for reassembly at the destination computer so that the packets are put back into the correct order. Each packet in a data stream is independent. To be able to understand packet-switching, we need to know what a packet is. The Internet Protocol (IP), just like many other protocols, breaks data into chunks and wraps the chunks into structures called packets. Each packet contains, along with the data load, information about the IP address of the source and the destination nodes, sequence numbers and some other control information.

A packet can also be called a segment or datagram. Once they reach their destination, the packets are reassembled to make up the original data again. It is therefore obvious that, to transmit data in packets, it has to be digital data. The packet switching can broadly be divided into two main categories, first is the virtual circuit approach and other is the datagram approach. In the virtual circuit approach to packet switching, the relationship between all packets belonging to the message or a session is preserved. A single route is chosen between the sender and the receiver at beginning of the session.

When the data are sent, all packets of transmission travel one after another along that route. The wide area networks use the virtual circuit approach to the packet switching. The virtual circuit approach needs a call setup for establishing a virtual circuit between the source and destination. A call teardown deletes virtual circuit. After the setup, routing takes place based on the identifier known as the virtual circuit identifier. This approach can be used in the WANs, frame relay and an ATM. In the other approach of packet switching that is the datagram approach, each packet is treated independently of all others.

Even if one packet is just a piece of a multi-packet transmission, the network treats it as though it is existed alone. Packets in this approach are known as the datagram. The internet has chosen datagram approach to switching in the network layer. It uses the universal addresses defined in network layer to route packets from the source to destination. In packet-switching, the packets are sent towards the destination irrespective of each other. Each packet has to find its own route to the destination. There is no predetermined path; the decision as to which node to hop to in the next step is taken only when a node is reached.

Each packet finds its way using the information it carries, such as the source and destination IP addresses[4]. 2) HISTORY OF CIRCUIT SWITCHING AND PACKET SWITCHING * Evolution of Circuit Switching Switches are used to build transmission path between telephone set on a flexible basis. Without switches, each telephone set would require a direct, dedicated circuit to every other telephone set in order to be able to communicate. This is a full-mesh physical topology network. Such a full mesh network clearly is

resource-intensive, impractical and even impossible, as early experience proved.

Circuit Switching were developed for voice communications. Contemporary circuit switches provide continuous access to logical channels over high-capacity physical circuits for the duration of the conversation. In January 1878, the first telephone switch went into operation in New Haven Connecticut. Switching technology had advanced drastically over the intervening decades, yet the basic function had remained the same: interconnect users of telephones by creating circuits between them. Every telephone has a line, or circuit, that connects physically to a telephone switch.

In the simple case of both the person making the call and the person being called are connected to the same switch, the caller dials the number of the desired person, the switch checks to see if the line is available, and if it is, the two lines are interconnected by the switch. The connection is maintained until one person hangs up his or her telephone, at which time the switch terminates the connection, freeing both lines for other calls. Three characteristics of this type of switching, called " circuit switching," are important.

First, before the two parties can talk the circuit between them has to be created, and it takes time for a switch to check if a connection can be made and then to make the connection. Second, when a connection has been made, it creates a dedicated connection. No other party can reach either party of a dedicated connection until that connection has ended. Three, since switches are very expensive one accounting policy telephone companies

implemented to recover their investment was to institute a minimum charge for every telephone call, generally three minutes.

For voice calls that lasted many minutes, a minimum charge did not represent a problem. But communications between computers often last less than seconds, much less minutes. It was difficult to image how circuit switching could work efficiently for computer communications when such a system took minutes to make a connection, created dedicated connections so only one person, or party, could be in connection with another party, and had a prohibitive cost structure. Although these issues were generally understood before the experiments of Roberts and Marill in 1965, they were once again strongly confirmed.

The experiments also made it abundantly clear that the problems confronting computer communications were not only with the circuit-switching architecture of the telephone system. Host operating system software of the day assumed there was only one Host and all connecting devices were as if " slaves. " Hosts were not designed to recognize or interact with peer-level computers; the concept of peer-level computing did not yet exist. Thus, in interconnecting two computers, one had to be master and one slave. The problem only became worse if more than two computers wanted to interconnect and communicate.

Nevertheless, the problem of Host software was considered to be solvable if a suitable communication system could be designed and made to work. Fortunately, an inquisitive innovative scientist, Paul Baran, had already explored the problems of circuit switching beginning in 1959. By 1962, he had made his concept of a message-based communication system publicly

known. Independently, in 1965, an English scientist, Donald Davies reached the same conclusions as had Baran and would coin its name: packet switching. * Evolution of Packet Switching The concept of packet switching had two independent beginnings, with Paul Baran and Donald Davies.

Leonard Kleinrock conducted early research and authored a book in 1961 in the related field of digital message switching without explicitly using the concept of packets and also later played a leading role in building and management of the world's first packet switched network, namely the ARPANET. Baran developed the concept of packet switching during his research for the US Air Force into survivable communications networks, first published in 1962, and then including and expanding somewhat within a series of eleven papers titled " On distributed communications" in 1964.

Baran's earlier paper described a general architecture for a large-scale, distributed survivable communication network. His paper focused on three key ideas: 1) the use of a decentralized network with multiple paths between any two points, 2) dividing complete user messages into what he called message blocks (packets), and 3) delivery of this message by store and forward switching. Baran's study paved the way for Robert Taylor and J. C. R.

Licklider, both wide-area network evangelists working at the Information Processing Technology Office, and it also helped influence Lawrence Roberts to adopt the technology when Taylor put him in charge of development of the ARPANET. Baran's packet switching work similar to the research performed independently by Donald Davies at the National Physical Laboratory, UK. In 1965, Davies developed the concept of packet switched networks and proposed development of a U. K. wide network. He gave a talk

on the proposal in 1966, after which a person from Ministry of Defense told him about Baran's work.

At the 1967 ACM Symposium on operating system principles, Davies and Robert bringing the two groups together. Interestingly, Davies had be chosen some of the same parameters for his original network design as Baran, such as a packet size of 1024 bits. Roberts and the ARPANET team took the name " packet switching" itself from Davies work. In 1970, Davies helped build a packet switched network called Mark I to serve the NPL in the UK. It was replaced with the Mark II in 1973, and remained in operation until 1986, influencing other packet communications research in UK and Europe[5]. 3) COMPARISON BETWEEN CIRCUIT AND PACKET SWITCHING

Circuit Switching: In circuit switching a message path or data communication path or channel or circuit is dedicated to an entire message block during the process of message transmission. The entire bandwidth is dedicated to the said message as it were, and before any data transmission can take place circuit initialisation and setup has to be done to enable or determine the avalaibility of the link as in trying to make a call using the telephon line for voice messaging or even dial-up procedure where you need to establsih that the line is free for use in the first place; and then have the line engaged all through your time of use.

All the message travel through the same path and keep the link engaged all the while when the block of message is been relayed or transmitted. In circuit switching, whole of the data travels along a single dedicated path between the two terminals whereas in datagram switching data is divided into packets and each of these packets are treated indepently and travel

along different paths, source and destination being the same. Circuit switching concept is used in Telephony networks where a dedicated line is assigned to particular connection, the connection in this case is permanent during the connection.

Considerable amount of bandwidth is wasted in this process and at a time only one way communication is possible. Circuit switching is done at physical layer whereas datagram switching is generally done at network layer. Circuit switching requires the resources to be reserved before the transmission of data but datagram switching doesn't require such reservation of resources. Advantages: 1. Fixed delays, because of the dedicated circuit – no interference and no sharing. 2. Guaranteed continous service, also because of the dedicated circuit. . Guaranted the full bandwidth for the duration of the call. Disadvantages: 1. Takes a relatively long time to set up the circuit. 2. Difficult to support variable data rates and is not efficient for burst traffic. The equipment may be unused for a lot of call, if no data is being sent the dedicated line still remains open. 3. During crisis or disaster, the network may become unstable or unavailable. 4. It was primarily developed for voice traffic rather than data traffic. Packet Switching:

In packet switching the block of data is split into small units with each unit having a sequence number attached to it for orderly identification within a given message block and these different units are usaully sent across the available diffrent links or channels of data transmission from one end to the other end point where they arrvive at different times but have to be assembled together in the correct order at this location via the sequence numbers to get out the original message back without any data degredation

occuring as a result of the different paths of transmissions from source to destination.

Also no single data channel is dedicated to any given message block in the course of transmission as many units of different messages can be multiplexed and then get demultiplexed at their deffferent destinations correctly since there are codes to differentiate each unit of message, resulting to no conflict at all. Packet switching splits messages into small units and transmitting them to destination using different paths while at the same time keeping tracks or maintaining an orderliness of the units for proper and correct reassembling of the units to get the original message back.

Packet switching is generally used in Internet data transmmission where we send data without minding if the link is free or not as far as we are connected and the pieces of information that we sent are then split into smaller units and then sent in packets, with each packets switched through different data channel most times and with no loss at the end. The main advantage of packet-switching is that it permits " statistical multiplexing" on the communications lines. The packets from many different sources can share a line, allowing for very efficient use of the fixed capacity.

With current technology, packets are generally accepted onto the network on a first-come, first-served basis. If the network becomes overloaded, packets are delayed or discarded (" dropped")[6]. Advantages: 1. Since packet are typically short, the communication links between the nodes are only allocated to transferring a single message for a short period of time while transmitting each packet. Longer messages require a series of packets

to be sent but do not require the link to be dedicated between the transmission of each packet.

The implication is that packets belonging to other messages may be sent between the packets of the message being sent from one node to other node. This provides a much fairer sharing of the resources of each of the links. 2. The ability to do statistical multiplexing which can exploit the inherent " burstiness" in many data applications and thereby enable sharing of the network resources more efficiently among multiple data streams is a major advantage. 3. Pipelining"- This simultaneous use of communications links represents a gain in effieciency, the total delay for transmission across a packet network may be considerebly less than for message switching, despite the inclusion of a header in each packet rather than in each message. Disadvantages: 1. Packets arriving in wrong order. 2. Under heavy use there can be delay. 3. Protocols are needed for a reliable transfer. 4. Not so good for some types data streams. Real-time video streams can lose frames due to the way packets arrive out of sequence[7].) PERFORMANCE ANALYSIS Circuit Switching In circuit switching, a unique connection is used to move data between the two end user[8]. " Circuit-Switched type networks" are most commonly portions of the ubiquitous telephone networks to which we are all accustomed. In these networks, which generally transmit voice or data, a pribate transmission path is established between any pair or group of users attempting to communicate and is held as long as transmission is required.

Telephone networks are typically circuit switched, because voice traffic requires the consistent timing of a single, dedicated physical path to keep a

constant delay on the circuit. Figure 2: Example of circuit switching Figure 3: Public circuit switching network Subcribers: The device that attach to the network. Subscriber loop: The link between the subscriber and the network. Exchanges: The switching centers in the network. End office: The switching center that directly supports subscribers. Trunks: The branches between exchanges. They carry multiple voice-frequency circuit using either FDM or synchronous TDM.

Figure 4: Circuit establishment Basic performance equation for a single link in a circuit-switched network: Let's consider a system with N circuits on a single link, with customers arriving according to a Poisson process at rate ? customers per second, and with successful customers having a mean holding time of h seconds, distributed as a negative exponential distribution with parameter ? = 1/h. If a customer attempting a new call finds all the circuits busy, there are no waiting places, so we'll assume that the customer just goes away and forgets about making the call.

Define the state of our system by the random variable K, where K represents the number of customers currently in the system, then K can take on any integer value in the range from 0 to N. With these assumptions, our model is simply a state-dependent queue, with arrival rate ?? (independent of the state), and service rate i?? when the system is in state K= i. This is known as an M/M/N/N queue: Markovian arrivals, Markovian service time, N servers, and a maximum of N customers in the system. We can draw the following Markov chain diagram to represent the system.

When there are I customers the service rate is i?? , which is due to the fact that there are i customers, each with a service rate ? , so the total service

rate is i??. Figure 5: Markov chain diagram Under conditions of statistical equilibrium, the solution is: pi= AiN! j= 0NAjj! Observe that this is simply a truncated Poisson distribution and also the result depends on the traffic A, and not the specific values of ? and ?. To establish a path in circuit switching three consecutive phases are required: 1. Connection establishment. 2. Data transfer. 3.

Connection teardown. Elements of a circuit-switch node (Figure 6): * Digital Switch: Provides a trasnparent signal path between any pair of attached devices. * Control Unit: Establishes, maintains and tears down connections. * Network Interface: Functions and hardware needed to connect digital and analog terminals and trunk lines. Figure 6: Circuit switch element Packet Switching In packet switching, data are broken into packets of fixed or variable size, depending on the protocol used. The performance of packet switching is called best effort performance.

If you transmit from sender to receiver, all the network will do its best to get the packet to the other end as fast as possible, but there are no guarantees on how fast that packet will arrive. Figure 7: Example of packet switching Packet switching is used to optimize the use of the channel capacity available in digital telecommunication networks such as computer networks, to minimize the transmission latency, the time it takes for data to pass across the network. It is also used to increase robustness of communication. These layers are introduced to break down the complexity of communications.

The top layer (layer 7) is the layer at user level. As the layers go down, they get increasingly primitive. Layer is most primitive from as it is just binary

numbers prepared to be transmit to the end node. Seven layers of open systems interconnection models are shown in table 1[7]: Layer Number| Name| Description| 1| Pysical Layer| Deals with physical connection between nodes in network. | 2| Data Link Layer| Maintaining and optimising actual connection. | 3| Network Layer| Deals with communication of data on a network. | 4| Transportation Layer| Sequencing, error detection and optimisation of communication. 5| Session Layer| Controls the communication between applications running on end nodes. | 6| Presentation Layer| Format data and provides syntaxes for application. | 7| Application Layer| Contains management functions. | Table 1: Layers of open systems interconnection model Every packet contain some control information in its header, which is required for routing and other purposes. Figure 8: Packet data format Initially, transmission time decreases as packet size is reduced. But, as packet size is reduced and the payload part of a packet becomes comparable to the control part, transmission time increases.

Figure 9: Variation of transmission time with packet size. As packet size is decreased, the transmission time reduces until it is comparable to the size of control information. There is a close relationship between packet size and transmission time as shown in Figure 9. In this case it is assumed that there is a virtual circuit from station X to Y through nodes a and b. Times required for transmission decreases as each message is divided into 2 and 5 packets. However, the transmission time increases if each message is divided into 10 packets[9].

The packet switched networks allow any host to send data to any other host without reserving the circuit. Multiple paths between a pair of sender and

receiver may exist in a packet switched network. One path is selected between source and destination. Whenever the sender has data to send, it converts them into packets and forwards them to next computer or router. The router stores this packet till the output line is free. Then, this packet is transferred to next computer or router (called as hop). This way, it moves to the destination hop by hop. All the packets belonging to a transmission may or may not take the same route.

The route of a packet is decided by network layer protocols. As we know there are two approaches for packet switching which are: 1. Datagram switching, 2. Virtual circuit swtiching. 1. Datagram Switching: Each packet is routed independently through network which is also called connectionless packet-switching. Datagram packet switching sends each packet along the path that is optimal at the time the packet is sent. When a packet traverses the network each intermediate station will need to determine the next hop. Routers in the internet are packet switches that operate in datagraam mode.

Each packet may travel by a different path. Each different path will have a different total transmission delay (the number of hops in the path may be different, and the delay across each hop may change for different routes). Therefore, it is possible for the packets to arrive at the destination in a different order from the order in which they were sent[10]. Figure 10: Datagram packet switching Figure 11: Delay in datagram packet switching There are three primary types of datagram packet switches: * Store and forward: Buffers data until the entire packet is received and checked for errors.

This prevents corrupted packets from propagating throughout the network but increases switching delay. * Fragment free: Filters out most error packets but doesn't necessarily prevent the propagation of errors throughout the network. It offers faster switching speeds and lower delay than store-and-forward mode. * Cut through: Does not filter errors; it switches packets at the highest throughput, offering the least forwarding delay. 2. Virtual Circuit Switching: Virtual circuit packet switching (VC-switching) is a packet switching technique which merges datagram packet switching and circuit switching to extract both of their advantages.

VC switching is a variation of datagram packet switching where packets flow on so-called logical circuits for which no physical resources like frequencies or time slots are allocated shown in Figure 12. Each packet carries a circuit identifier, which is local to a link and updated by each switch on the path of the packet from its source to its destination[10]. A virtual circuit is defined by the sequence of the mappings between a link taken by packets and the circuit identifier packets carry on this link. In VC-switching, routing is performed at circuit establishment time to keep packet forwarding fast.

Other advantages of VC-switching include the traffic engineering capability of circuit switching, and the resources usage efficiency of datagram packet switching. Nevertheless, a main issue of VC-Switched networks is the behavior on a topology change. As opposed to Datagram Packet Switched networks which automatically recompute routing tables on a topology change like a linkfailure, in VC-switching all virtual circuits that pass through a failed link are interrupted. Hence, rerouting in VC-switching relies on traffic engineering techniques[6].

Figure 12: Virtual circuit packet switching Figure 13: Delay on packets in virtual-packet switching 5) APPLICATION OF CIRCUIT AND PACKET SWITCHING Circuit Switching 1. Plain Old Telephone Service (POTS) The plain old telephone system (POTS) is the largest circuit switched network. The original GSM network is also circuit switched. Prior to the existence of new types of networks, all communication systems had to be built based on the existing telecommunications facilities, which were largely oriented to what the common carriers refer to as plain old telephone service, known as POTS.

Consequently, even today, in order to use POTS for data communications, it is necessary to use a modem to convert the data to a form suitable for voice-transmission media. The data transmission rate that can be obtained over a POTS connection is typically less than 64 Kbps. These rates are adequate for text and audio transmission. However, they are not suf? cient for good quality video transmission in real-time. 2. Switched 56 Service Switched 56 service is a dial-up digital service provided by local and long distance telephone companies. For a connection, a data service unit/data channel unit (DSU/CSU) is used instead of a modem.

Switched 56 service uses a 64 Kbps channel, but one bit per byte is used for band signaling, leaving 56 Kbps for data. This service allows the transmission of information over one or two twisted cable pairs to multiple points at a data rate of 56 Kpbs. 3. Integrated Services Digital Network (ISDN) The ISDN was designed in the 1980s to offer end-to-end digital connectivity, while providing the required QoS with data rates in the range of Kbps to Mbps over switched connections. In order to provide even higher data rates, the original ISDN was extended to broadband ISDN (BISDN) (Martin, 1985).

The ISDN services are provided to users as ISDN interfaces, each comprising a number of ISDN channels. Using 64-Kbps channels, called bearer or B channels, ISDN provides access to the digital network. ISDN provides lower error rate compared to typical voiceband modems and a relatively high bandwidth data channel[11]. Packet Switching 1. VOIP It is becoming increasingly accepted to transmit delay sensitive data through a packet switched network (rather than circuit switched). There are protocols that can create a virtually real-timeenvironment– which, for voice conversations, is sufficient.

Voice over IP is essentially a voice signal encoded into a digital format, being sent through a packet switched network (or possibly any other network) using the Internet Protocol (IP). Over recent years there have been standards developed and supported by major companies including ITU-T H. 323. VOIP has a long way to evolve before it is used as widespread as circuit switched networks, but it is well on its way. 2. IPv6 The current protocol that is employed almost everywhere IP (IPv4) has come to the end of its useful life. This is mainly because it has run out of addresses to uniquely identify every non-private computer in the world.

IPv6 has been deigned to be more efficient than IPv4 and solve the addressing problems that we face at present. Ipv6 will use 128 bits to address nodes, which provides 2128possibilities (roughly3. 4? 1038). It will incorporate a special ' option mechanism' to store optional headers in the transport layer (to maximize efficiency by reducing required space). Finally, Ipv6 will have support for resource allocation, allowing packets to be part of a ' traffic flow' which will provide better communication of data such as

video/voice streams [VOIP]. 6) CONCLUSION In large networks there might be multiple paths linking sender and receiver.

Information may be switched as it travels through various communication channels. Data networks can be classified as using circuit-switching or packet-switching. Packet switching, which forms the basis of the Internet, is a form of statistical multiplexing in which senders divide messages into small packets. The switching centers receive the control signals, messages or conversations and forwards to the required destination, after necessary modification link amplification if necessary. In computer communication, the switching technique used is known as packet switching or message switch (store and forward switching).

In telephone network the switching method used is called circuit switching. Circuit switching is a technique that directly connects the sender and the receiver in an unbroken path. In the modern and fast paced world, what we are looking for is efficiency, low costs and reliability and packet-switched networks seems to fulfill most of the criteria that the society is looking for. It would only be a matter of time before circuit switching becomes a thing of the past. 7) REFERENCES [1] Stallings, W. , Data and Computer Communications, 7th ed. 1999, Upper Saddle River, NJ: Prentice Hall. [2] Notes. com, C.

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