A Study Paper on Communication Network and overview of Packet Switching Technology

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Abstract— In this paper,we highlight some of the principal events that led up to the revolution in communications among information processing systems. We devote most of this presentation to a brief summary of the communication networks experience, emphasizing the description, functions, analysis, design and performance measurement of packet-switching networks. We also discuss some recent advances in radio packet switching for long-haul.

.Index Terms— **ARPANET, communication networks, computer networks, networks, packet switching.**

I. INTRODUCTION

It is widely assumed that, for reasons of efficiency, the various communication networks (Internet, telephone, TV, radio, ...) will merge into one ubiquitous, packet switched network that carries all forms of communications. This view of the future is particularly prevalent among the Internet community, where it is assumed that packet-switched IP is the layer over which everything else will be carried[1]. A packet switching system uses statistical multiplexing in which communication from multiple sources competes for the use of shared media.[2] The chief difference between packet switching and other forms of statistical multiplexing arises because a packet switching system requires a sender to divide each message into blocks of data that are known as packets. The size of a packet varies; each packet switching technology defines a maximum packet size .Or in other words we can say Packet switching, which forms the basis of the Internet, is a form of statistical multiplexing that permits many- to-many communication. A sender must divide a message into a set of packets; after transmitting a packet, a sender allows other senders to transmit before transmitting a successive packet.

II.HISTORY

The concept of switching small blocks of data was first explored by Paul Baran in the early 1960s. Independently, Donald Davies at the National Physical Laboratory (NPL) in the UK had developed the same ideas a few years later (Abbate, 2000).

Baran developed the concept of message block switching during his research at the RAND Corporation for the US Air Force into survivable communications networks, first presented to the Air Force in the summer of 1961 as briefing B-26 then published as RAND Paper P-2626 in 1962 and then including and expanding somewhat within a series of eleven papers titled On Distributed Communications in 1964. Baran's P-2626 paper described a general architecture for a large-scale, distributed, survivable communications network. The paper focuses on three key ideas: first, use of a decentralized network with multiple paths between any two points; and second, dividing complete user messages into what he called *message blocks* then third, delivery of these messages by store and forward switching.[12]

Baran's work was 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 UK wide network.. A member of Davies' team met Lawrence Roberts at the 1967 ACM Symposium on Operating System Principles, bringing the two groups together.[11]

Interestingly, Davies had chosen some of the same parameters for his original network design as Baran, such as a packet size of 1024 bits. In 1966 Davies proposed that a network should be built at the laboratory to serve the needs of NPL and prove the feasibility of packet switching. The NPL Data Communications Network entered service in 1970. Roberts and the ARPANET team took the name "packet switching" itself from Davies's work.

The first computer network and packet switching network deployed for computer resource sharing was the Octopus Network at the Lawrence Livermore National Laboratory that began connecting four Control Data 6600 computers to several shared storage devices in 1968 and an IBM Photostore in 1970 and to several hundred Teletype Model 33 ASR terminals for time sharing use starting in 1968.(5)

In 1973 Vint Cerf and Bob Kahn wrote the specifications for Transmission Control Protocol (TCP), an internetworking protocol for sharing resources using packet-switching among the nodes.

III. PACKET SWITCHING

Packet switching is a digital networking communications method that groups all transmitted data regardless of content, type, or structure – into suitably sized blocks, called packets. Packet switching features delivery of variable-bit-rate data streams (sequences of packets) over a shared network. When traversing network adapters, switches, routers and other network_nodes, packets are buffered and queued, resulting in variable delay and throughput depending on the traffic load in the network.

Packet switching contrasts with another principal networking paradigm, circuit_switching, a method which sets up a limited number of dedicated connections of constant bit rate and constant delay between nodes for exclusive use during the communication session. In case of traffic fees (as opposed to flat rate), for example in cellular communication services, circuit switching is characterized

by a fee per time unit of connection time, even when no data is transferred, while packet switching is characterized by a fee per unit of information.

Two major packet switching modes exist; (a) connectionless packet switching, also known as datagram switching, and (b) connection-oriented packet switching, also known as virtual circuit. switching

Connectionless and connection-oriented packet switching

Connection-oriented communication includes the steps of setting up a call from one computer to another, transmitting/receiving data, and then releasing the call, just like a voice phone call. However, the network connecting the computers is a packet switched network, unlike the phone system's circuit switched network. Connection-oriented communication is done in one of two ways over a packet switched network: with and without virtual circuits.

Without virtual circuits: This is what TCP does in the Internet. The only two machines in the Internet that are aware a connection is established are the two computers at the endpoints. The Internet itself--its routers and links--have no information about the presence of a connection between the two computers. This means that all of the packets flowing between the two computers can follow different routes. One benefit of establishing the connection is that the flow of packets from the source to the destination can be slowed down if the Internet is congested and speeded up when congestion disappears. Another benefit is that the endpoints can anticipate traffic between them, and agree to cooperate to ensure the integrity and continuity of the data transfers. This allows the network to be treated as a "stream" of data, as we will study later.

Virtual circuit: This is not used in the Internet, but is used in other types of networks (eg. the "X.25" protocol, still popular in Europe). The routers within the network route all packets in one connection over the same route. The advantage is that video and voice traffic are easier to carry, because routers can reserve memory space to buffer the transmission.
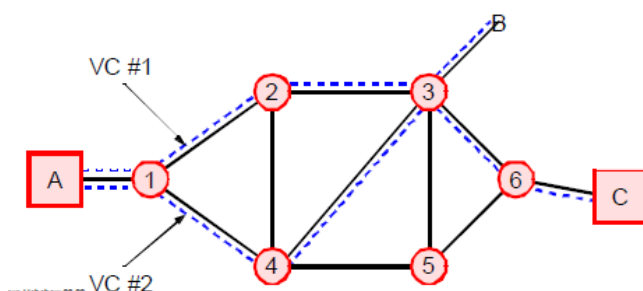

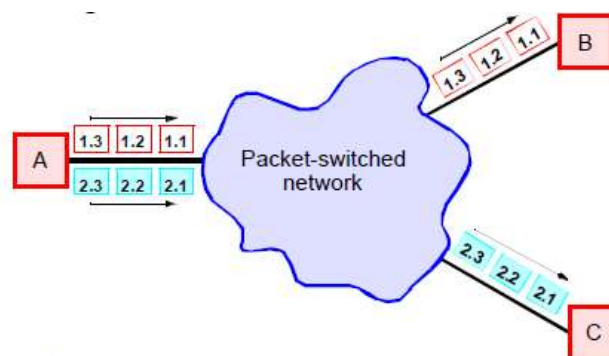Fig. 1 Connection oriented network

Fig. 2 Connectionless network

Connectionless:

Connectionless communication is just packet switching where no call establishment and release occur. A message is broken into packets, and each packet is transferred separately. Moreover, the packets can travel different route to the destination since there is no connection. Connectionless service is typically provided by the **UDP (User Datagram Protocol)**, which we will examine later. The packets transferred using UDP are also called **datagrams.**

X.25 vs. Frame Relay packet switching

Frame Relay was a best effort service that operated at layer 2 for most vendors, but there was at least one vendor that allowed Switched Virtual Circuits and Switched Permanent Virtual Circuits that operated at layer 3. Frame Relay did allow end to end flow control that almost no one utilized. Frame Relay was very popular up until about 10 years ago. Frame Relay frames could be up to 8192 bytes. . X.25 was an access service that operated at Layers 2 and 3 of the OSI model. X.25 was a reliable service that was supposed to route around failures, and errored links. The implementation of different vendors varied widely, from a connectionless reliable service to unreliable services. X.25 did not specify how the network operated only how the access operated and how networks inter-operated using the X.75 protocol. There are various differences between X.25 and Frame Relay. The most significant are:

1. Call Control

X.25 connection establishment and release (call control) use in-band signaling within the same virtual channel used for user data transmission causing additional overhead. Frame Relay call control uses separate virtual channels identified by reserved DLCI using the LMI (*Local Management Interface*) protocol.

2. Routing vs. Switching

X.25 performs packet switching on OSI layer 3 (network layer); Frame Relay performs packet switching on OSI layer 2 (data-link). Frame Relay does not use any layer 3 protocol.

3. Flow Control

Frame Relay (FR) doesn't perform flow control between frame handlers (FR routers). X.25 routers have to acknowledge each frame; in case of frame errors frames

have to be retransmitted and acknowledged. Frame Relay relies on flow control performed by higher layer protocols.

IV. ARCHITECTUTE OF VARIOUS PACKET SWITCHING

A computer communication network is a collection of nodes at which reside the computing resources a paper is to introduce a new measurement technique. Authors should expect to be challenged by reviewers if the results are not supported by adequate data and critical details. (which themselves are connected into the network through nodal switching computers, i.e., "fancy" switches) which communicate with each other via a set of links (the data communication channels) [7], [8]. Messages in the form of commands, inquiries, file transmissions, and the like, travel through this network over the data transmission lines.
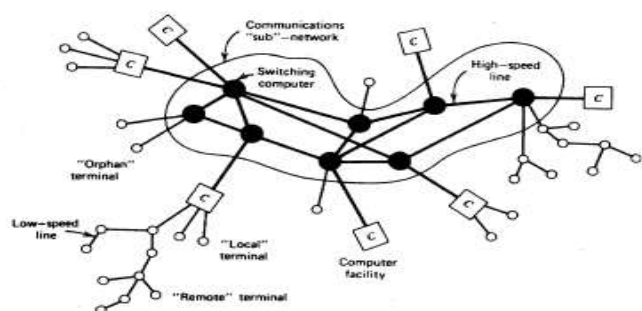

Fig. 3. The structure of a computer-communication network

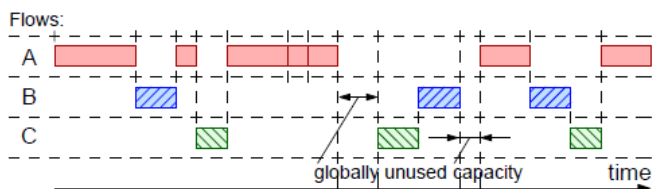The following figures shows how the data flows over the networks and the features are explained below

Fig. 4 Basic Concepts & Terminology: Packet Switching

• Varying or unpredictable traffic – like automobiles

• Self-describing packets: header provides destination address
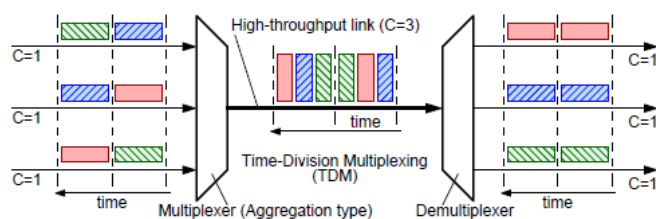
Time switching:

Fig. 5 Basic Concepts & Terminology: Time Switching

• All packets pass through a *single point* in space, at *different times*. Similar to time-sharing – multiprogramming on a single processor

• Buses are in this category (distributed multiplexor, built w. tristate drivers)

Advantage:1) Economize on datapaths, wires, memories

2) Easy to share aggregate capacity among competing flows

Disadvantage: Non-scalable: infeasible beyond technology limit for aggregate capacity
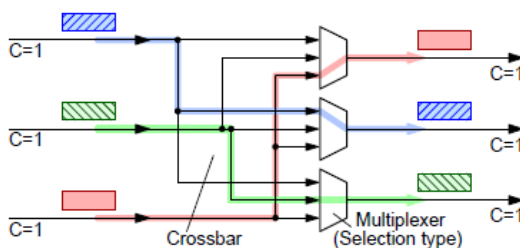
Space switching:

Fig. 6 Basic Concepts & Terminology: Space Switching

• Packets at a given time pass through *different paths in space*

• Similar to multiprocessing on parallel processors

• Crossbars are in this category (single-stage space switches)

Advantage:Scalable: use when aggregate throughput > upper limit of time switching

Disadvantage:Partitioned memories, wires ⇒ harder to route, schedule, load balance

Combination Example: Time-Space-Time Circuit Switch:

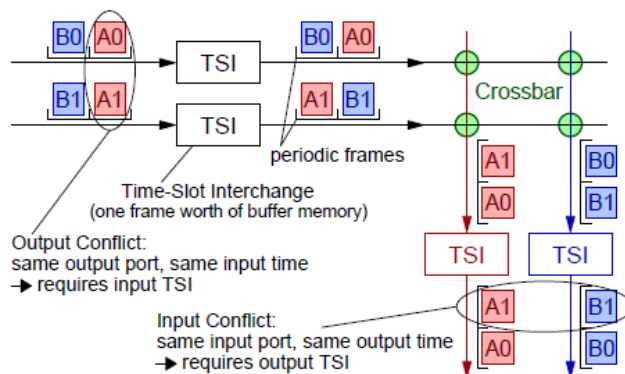Fig. 7 Basic Concepts & Terminology: Time-Space-Time Circuit Switch

Time switching (TSI's) needed to resolve output and input conflicts.

## v. CENTRAL ISSUES AND PROBLEMS FACED IN PACKET SWITCHING

Network sizes --the number of communicating parties, n-- vary widely among applications, ranging from small (single-digit number of nodes) to huge, like the entire Internet with many millions to (soon) billions on nodes. The hardest and most interesting problems appear for large sizes; among these is the problem of *scale*: the *all-to-all* interconnection style of the top figure is completely unrealistic, cost-wise, for large networks.

all—to—all interconnection

multi—stage interconnection
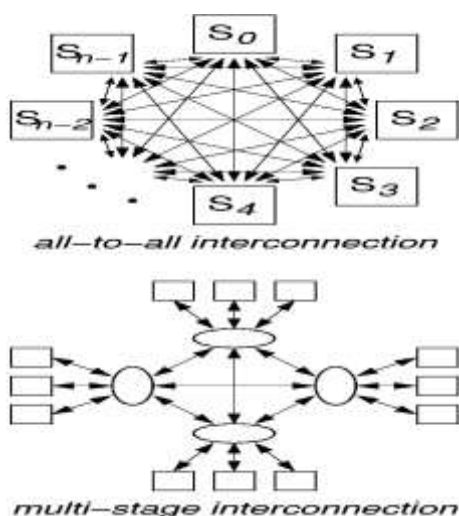
1 Output Contention:

Output contention, the first central problem, is the attempt by multiple sources to "simultaneously" transmit information to a given output (destination) party at an aggregate rate in excess of the capacity of that output. Under these circumstances, the sources (or the streams of information that they injected into the network) *contend* (compete) for access to the desired output port of the network, hence the name "output contention".

2 Elementary Case: Single Resource Contention:
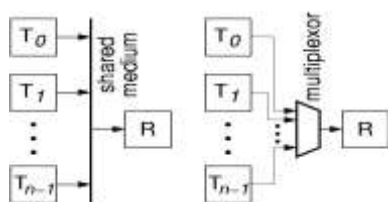
Output **contention** manifests itself even in the most elementary case: a network consisting of multiple transmitters and one receiver, as shown in the figure, where the aggregate rate of the transmitters exceeds the rate capacity of the receiver. We can study the essence of output contention using this simple case. A network like this can be built using a shared medium (e.g.traditional Ethernet), as illustrated on the left, or by running dedicated (point-to-point) links from each transmitter to the receiver, then using a multiplexor to select which piece of

information from which source will be routed to the receiver at each time, as shown in the right.

3 Short or Long Term Contention: Buffering, Dropping, Access Control, Flow Control

If the network sources want to transmit information at an aggregate rate exceeding the capacity of (a) receiver(s), then there are only three alternatives to handle this problem

a) Buffer the information in excess of the reveiver capacity, in some buffer memory, and transmit it a later time. This only applies to *short-term* contention, because if the rate mismatch persists for an unbounded period of time, an unbounded amount of memory will be needed, which is not feasible

b) Drop the information in excess of the reveiver capacity. This is simpler than buffering, but leads to poor or unacceptable QoS, depending on the application. In applications where all information is needed, some protocol is put in place (usually in the end-user stations, but can also be in the network) for retransmitting the droped information; the end result is similar to buffering, but the method, cost, and performance differ a lot.

c) Coordinate the sources so that they properly adjust their rates. By contrast to buffering, this applies mostly to *long-term* contention. Given the distributed nature of the network, such coordination inevitably involves delays. Coordination may be performed before or *after* the sources start their transmissions:

VI FUTURE

Packet Satellite

Fundamentally, a satellite provides a broadcast media which, if properly used, can provide considerable gains in the full statistical utilization of the satellite's capacity. Using ARPA's techniques, a single wideband channel (1.5 Mbit/s-60 Mbit/s) on a satellite provides an extremely economical way to interconnect high bandwidth nodes within a packet network.

With the current cost of ground stations ($150K-$300K), it appears to be marginally economic to install separate private ground stations rather than to lease portions of commercial ground stations and trunk the data to the packet network nodes. However, either way, the cost of ground station facilities are such that the use of satellites only becomes economic compared to land lines when the aggregate data flow exceeds about 100 packets/s (100 kbit/s) to and from a node or city. Furthermore, satellite transmission has an inherent one-way delay of 270 ms; therefore, the packet traffic must logically be divided between two priority groups-interactive and batch. Only batch traffic can presently be considered for satellites, since the 270 ms delay is unacceptable for interactive applications, at least if any other options are available, even at a somewhat higher price. With current economics, the long-haul land line facilities only add about $0.50/hr to the price of interactive data calls, which is far too little a cost to encourage the acceptance of slower service. Therefore,

interactive service will almost always require ground line facilities in addition to satellite facilities at all network nodes.

This introduces another factor that limits the potential satellite traffic: land lines can easily carry 10-25 percent batch traffic at a lower priority, using a dual queue, without any significant increase in cost Further, if ground lines are required and satellite facilities are optional, the full cost for the satellite capability, must be compared with the incremental cost of simply expanding the land line facilities. All these factors considered, it is probable that satellites will be used by public data network's within the next five years for transmissions between major nodal points, but that ground facilities will be used exclusively for transmissions between smaller nodes.

Packet Radio

Packet radio is another area where ARPA has been sponsoring research in applying dynamic-allocation techniques. The basic concept in packet radio is to share one wide bandwidth channel among many stations, each of which only transmits in short bursts when it has real data to send.This technique appears to be extremely promising for both fixed and mobile local distribution, once the cost of the transceivers has been reduced by, perhaps, a factor of ten. Considering the historical trend of the cost of electronics, this should take about five years; from that point onward packet radio should become increasingly competitive with wire, cable, and even light fibers for low to moderate volume local distribution requirements.

One important consequence would be the use of a simple packet radio system inside buildings to permit wireless communication for all sorts of devices..

Voice

This is the another important area where economic advantage of dynamic-allocation over pre-allocation will soon become so fundamental and clear in all areas of communications, including voice. it is not hard to project the same radical transition of technology will occur in voice communications as has occurred in data communications.

Digitized voice can be compressed by a factor of three or more by packet switching since in normal conversation each speaker is only speaking one third of the time. Since interactive data traffic typically can be compressed by a factor of 15, voice clearly benefits that less from packet switching than interactive data. This is the reason why packet switching was first applied to data communications..

Probably there will be many proposals, and even systems built, using some form of dynamic-allocation other than packet switching during the period of transition. The most likely variant design would be a packetized voice system that does not utilize sum checks or flow control. On further consideration, it becomes apparent that the flow control feature of packet switching networks can provide a substantial cost reduction for voice systems. Flow control feedback, applied to the voice digitizers decreases their output rate when the network line becomes momentarily

overloaded; as a result, peak channel capacity required by users can be significantly reduced.

In short, packet switching seems ideally suited to both voice and data transmissions. The transition to packet switching for the public data network has taken a decade, and still is not complete; many PTT's and carriers have not accepted its viability. Given the huge fixed investment in voice equipment in place today, the transition to voice switching may be considerably slower and more difficult. There is no way, however, to stop it from happening.

VII CONCLUSIONS

It is fairly clear that informaton processing has come to depend heavily upon data communications. Rather than ignore the communications problem, computer scientists are dealing with the issues involved and have already learned to take advantage of its properties. we find a number of major issues which demand considerable thought and attention. For example, the issue of adistributed operating system and large distributed data bases involves problems which are hardly defined ,much less solved. Security issues in the distributed environment provided by a network are of great concern in many communities.The current proposal is to use an optical packet switching technology in order to:

• Reduce the number of network layers, to simplify network management software and remove associated transport overheads

• Offer efficient traffic aggregation and finer service granularity (compared to current wavelength switching technology), thereby improving OTN utilization.

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