PERSONAL COMPUTER NETWORKING

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Although Local Area Networking technology is still at an early stage, it is already enjoying rapid growth. Computing environments increasingly require the interworking of many different data processing devices, each with its own degree of intelligence, each with its own advantages in terms of functionality and cost, each capable of operating more or less independently of any other system component, and, increasingly often, each supplied from a different source in order to take advantage of the rapid developments in information processing technology. Providing such an environment through integration within a local area network will offer the users of mini computer based systems new power and versatility, with which they will be able to offer a real price/performance challenge to traditional mainframe based systems. An integrated system based on a LAN also offers the hope of a smoother path for upgrading overall systems capability through replacement of individual functional units as newer and more powerful facilities become available.

Few areas in the data communications world have seen as much recent technological innovation and new commercial offerings, as the area of Local Area Networking.

As the cost of individual processing components falls, organizations are aquiring greater numbers of separate "specialized" computer-based systems. Each system focused on meeting specific user needs for higher worker productivity, better computer accessibility, and faster responsiveness. The benefits of conveniently interconnecting these systems to allow them to share common resources is becoming increasingly important. This includes both software resources (such as databases, development tools, reports, and office style memos), and hardware resources (such as expensive high speed printers and large plotters.)

A local area network is a data communications system that can be used to provide the level of interconnection described above -- ideally providing these services transparent to the end users of the different systems being connected.

Some general characteristics of this type of network are:

- o HIGH DATA RATES - One megabit/sec or higher. Usually, at least 10 megabits/sec. To allow fast, multiple station access with transparent network operation.
- o LOW TRANSMISSION ERROR RATES - Networks must realiably accomodate heavy data transmission traffic. Should an error occur, a network station should detect it and institute a recovery.
- o LIMITED GEOGRAPHICAL COVERAGE - Distances can vary from a few hundred feet to several miles. Generally, LAN's span less than two kilometers.
- o RELIABLITY AND HIGH AVAILABILITY - Networks are highly user interactive- LAN should have sufficient capacity to handle bursty traffic without long system delays. LAN should remain unaffected by individual failures -- and network maintenance should be done with minimal interuption of network services.
- o FLEXIBLE TOPOLOGY - Network should be flexible so that as your organization changes you can readily attach, disconnect, and delete stations without operational changes and disruption of network service.

- o SINGLE ORGANIZATION OWNERSHIP - LAN's are usually wholly owned by a single organization, with gateways to allow communications to other organizations.

There are a broad spectrum of LAN products available, and finding the one that best suits your particular needs can be difficult. Anticipated use will determine which network type best matches your application requirements. For example, some applications such as office automation, entail text editing and file processing, which can occur at adequate rates over short (room) connection distances using low cost desktop computers. On the other hand, general purpose data and message communication applications, with or without office automation, demand more expensive minicomputers interconnected over relatively long (floor) distances. Finally, for very high speed, complex engineering and scientific computations, you might need costly superminicomputers interconnected to nodes scattered throughout one or more buildings.

To select the Local Area Network that best fits your needs, you need to have a basic understanding of these LAN criteria.

1) NETWORK TOPOLOGIES

2) NETWORK ACCESS METHODS

3) MEDIA ALTERNATIVES

LOCAL AREA NETWORK TOPOLOGIES

A) STAR TOPOLOGY

A star network consists of a central node to which each of the host system devices are connected (Fig 1). The central node acts as a routing switch for data arriving at the central node from each of the host connections. A star network simplifies access control and routing decisions required within attached hosts. However, throughput performance and reliablility of the entire network relies on the operation of the single central node.

Primary Advantage(s):
- SIMPLE/LOW COST NODES

Primary Disadvantage(s):
- SINGLE POINT OF FAILURE
- PERFORMANCE DEPENDENDENT ON CAPACITY OF CENTRAL NODE

Primary Application:
- CENTRALIZED PBX TYPE SYSTEMS -- WORKSTATION TO SYSTEM COMMUNICATIONS

B) RING TOPOLOGY

A ring topology seeks to eliminate the dependency on a central, controlling node of the star network without sacrificing the relative simplicity of the other nodes (Fig 2). In a ring network a single communications path is shared amongst, all attached nodes. This path is unidirectional and provides for the transfer of discrete packets of data. Each packet of data is injected into the ring from one node to the next in a predefined direction. There are no routing decisions to be made in this topology. The sending node simply transmits its message towards its next neighbor node in the ring and the message then passes around the ring until it reaches the node for which it was intended. Each node acts as a regenerative repeater of receiving packets, generally introducing one or more bits of delay as it does so. The only routing requirement made of each node is that it be able to recognize those messages that are intended for it, by examination of the node address contained in each data packet. Then, dependent on the control strategy and implementation, the receiving node may remove the packet from the ring or pass the packet on back to the transmitting node with an acknowledgement field marked to indicate whether or not the packet was accepted. In this case, the original transmitting node removes the packet from the ring.

The inherent weakness in this structure is that the transmission path relies not only on the integrity of the transmission medium, but also on that of the ring interface which is an active component of the network. A failure in either of these two areas could paralyze the entire network. Techniques have been devised which can detect repeater failures and switch those units out, while allowing the remainder of the network to function normally -- however these devices increase both the cost and the complexity of each node.

Primary Advantage(s):
- ELIMINATE DEPENDENCY ON CENTRAL NODE
- NODES REMAIN RELATIVELY SIMPLE

Primary Disadvantage(s):
- SUSCEPTIBLE TO NETWORK FAILURES DUE TO SINGLE NODE FAILURE
- BUILDING PREWIRING CONSTRAINTS DUE TO CIRCULAR GEOMETRIES

Primary Application:
- HIGHSPEED SYSTEM TO SYSTEM COMMUNICATIONS

D) BUS TOPOLOGY

The bus or broadcast network structure is conceptully simpler than that of the ring. The basic structure is linear and derives essentially from traditional computer architecture of input/output channels (Fig 3). The bus medium itself is passive and allows bidirectional transfer of messages. Like the ring, the bus structure does not require any of the attached nodes to make routing decisions. A message simply flows away from the originating node in both directions towards the ends of the bus. The intended destination node must be able to recognize messages that are intended for it and then read the message as it passes by. Each node is attached to the bus medium in a 'T' fashion so that the message signal continues to propagate down the bus whatever the action in or by the attached nodes; there is therefore no requirement for a bus node to absorb and regenerate the message, and no modification or delay is imposed on the information in transit. It is this intrinsic feature of the bus topology which offers the great attraction of simplicity and 'fail safe' operation.

Primary Advantage(s):
- DECENTRALIZED CONTROL
- BUS MEDIUM IS PASSIVE (NO ACTIVE REPEATERS)
- EASY TO PREWIRE BUILDINGS; VERY FLEXIBLE GEOMETRY

Primary Disadvantages(s):
- SIGNAL DEGENERATES OVER DISTANCE (UNLESS REPEATERS ARE INSTALLED)

Primary Application:
- `BURSTY TRAFFIC' SYSTEM TO SYSTEM COMMUNICATION

NETWORK ACCESS METHODS

Currently, there are two dominant but widely varying network access control schemes that have proven successful: carrier sense multiple access with collision detection (CSMA/CD) and token passing.

A) TOKEN PASSING

Token Passing is used predominantly in ring networks. By design, only the node that holds the token at any time can transmit on the network; therefore no access control conflicts can arise. In a ring network, a message token passes from node to node in one direction during the idle network periods. Under strict timing rules, any node wanting network access must acquire the token within a defined interval by altering one of the token's bits on the fly. This node then transmits its message. The sequence for aquiring control of the network using token passing is as follows:

1) node wanting to transmit, waits for token

2) node removes token from network

3) node transmits "information" packet onto network

4) packet travels around network in predefined path

5) receiving node(s) read packet and may set an acknowledgement field on packet trailer

6) packet travels back to transmitting node

7) transmitting node removes packet

8) transmitting node reinserts token onto network

Token passing is highly deterministic and predictable. One can calculate the maximum delay that a station will encounter in gaining network access (this is not possible with CSMA methods, whose channel access times fluctuate randomly).

Another token passing advantage stems from the high transmission efficiency achieved for varied message/packet sizes and data rates. Other key advantages include guaranteed maximum access times to accomodate real time applications, reliable operation under all load conditions and media independence without collision detection mechanisms. However, tokens travel only in one direction in a ring network; if a node misses a token, it must wait until the token makes a complete ring revolution. Additionally, a break in the enclosed ring opens the circuit and destroys the token. The asynchronous operation of token passing can allow message tokens to get lost, destroyed, or degraded in a distributed control topology. Furthermore, strict timing requirements translate into design complexity.

B) COLLISION SENSING MULTIPLE ACCESS/COLLISION DETECTION (CSMA/CD)

Just as token passing dominates in control accessing ring networks, the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) method governs virtually all bus networks. It involves two major operational rules. First when the bus or data channel is busy -- attending to a nodes's message transmission needs -- all other nodes must wait until the channel clears before trying to send their own messages. Second, if multiple nodes then try to transmit simultaneously resulting in message interference or collision, these nodes must stop transmitting and wait for varying delay times before transmitting again. This access method's chief advantages lie in 1) its simplicity - reflected in lower costs per node because the scheme needs no complex or expensive priority access circuits, and 2) its variable length message handling efficiency - more than 99 percent of all messages get through in bursty or intermittent applications (such as office automation). Conversely, for heavy traffic applications such as busy data or reservation processing systems, CSMA/CD incurs higher message collision levels, longer access delays and reduced thoughput. Moreover, it doesn't suit real time needs because no priority mechanism exists: Messages with different degrees of importance compete equally for bus access. In the ultimate worst lockout condition, a node's message continually collides with those of competing nodes and never gains bus access. Several bus networks do not use the collision detection aspect of CSMA/CD because their lightly loaded applications result in extremely low collision rates. Using collision avoidance instead, these networks save cost and complexity in their bus interface boards. In collision avoidance, message collisions get detected by the sending and receiving nodes' circuits. In a common detection technique, the receiving node delivers an acknowledgement signal back to the sender. Should the sender not receive the acknowledgement, it usually retransmits until successful.

TRANSMISSION MEDIA

Transmission media fall into three fairly distinct cost/performance categories:

a) TWISTED PAIR
- low cost, easy to install
- bandwidth limitations
- distance limitations (less than 1 mile at 256 Kbps)

b) COAX CABLE
- heavy shielded cable
- high bandwidth (greater than 10 Mbps)
- Good noise immunity

c) FIBER OPTICS
- very high data rates (greater than 100 Mbps)
- Excellent noise immunity
- difficult to make tap connections

Twisted pair provides an excellent media for integrating voice and data through a digital PBX system. This type of PBX based network allows for the low cost interconnection of a large number of workstations (terminals/ personal computers), all through existing twisted pair phone wiring. Fiber optics, although currently exhibiting the highest transmission medium price, possesses inherent point to point performance capabilities that outclass all other transmission media. Its key characteristics include virtually unlimited bandwidth, high gigabit per second data transmission speeds, insensitivity to electromagnetic interference, complete electrical ground isolation between transmitter and receiver, high voltage isolation, nonelectronic radiation, small size and light weight. Despite these impressive properties, though, fiber optics is still too costly for multi-tapped connections. Compared with low cost twisted pair wiring, shielded coaxial cable's moderate cost, high performance, ready availability, easy configurability and wide bandwidth make it the most popular transmission medium for interconnecting local networks. Because it maintains low level capacitance in lengths to several miles, coax allows high megabit per second data rates without signal regeneration, echoes or distortion. These features reflect a field proven technology with more than 20 years of use in data communication networks and CATV applications.

SIGNALING TECHNIQUES

When using a coax based local area network, two primary signaling techniques are used 1) BASEBAND and 2) BROADBAND. A baseband network uses purely digital transmission techniques and usually has a maximum capacity of approximately 10 Mbps. The distance of a baseband network is usually limited to two kilometers, and the network is generally used for data transmission only. A broadband network uses analog transmission techniques, and can accomodate upto 400 Mbps of information. This information is carried through a broadband network by creating several logical cables within the one physical coax cable (Fig 4). A broadband network can handle multimode transmission (data/voice/video) simultaneously and extend for distances up to twenty miles. Broadband's principle advantage lies in its immense information handling capacity: One broadband cabled local network accomodates many thousands of connected nodes, handling nearly all the word, data, voice, video, and image communications generated by a busy high traffic system. These communications might include broadcast and closed circuit TV, video surveillance, telephone calls, facsimile, word messages, and data transactions. However broadband networks have several major shortcomings. Baseband networks can make use of clamping tap connections. When a clamping tap is used, systems can be easily and quickly connected to or disconnected from a baseband coax at any location without disturbing network operations. Currently, connections to a broadband coax must be inline. To make an inline connection, one must shutdown the network in order to sever the cable. (When installing a broadband network one should try to plan ahead by installing extra interfaces so that disruption to network services can be minimized. In addition to requiring network and station interfaces, broadband networks use expensive fixed frequency or frequency agile modems costing $500 to $1200. Not only does this double the broadband interface cost, but tunable RF modems prove difficult to check, maintain, and adjust because they are usually installed behind walls and above ceilings. Broadband networks also rely on a central transmission or head end facility in a single cable network. This facility acts as the network's technical control center. It filters incoming RF signals from multidropped sending nodes and retransmits them at higher frequencies to receiving nodes. This central transmission facility represents a point that, if it fails, can deactivate the entire network. One other major shortcoming of a broadband network is that there are no widely accepted standards in the industry for interfacing equipment to these networks. Several vendors have endorsed the IEEE 802 standard for baseband networks, and this will allow the implementor of an IEEE 802 network to select from a wider variety of equipment that will be able interface to his network. Selecting a broadband vs. a baseband network will again largley depend on your application. However, for applications where the primary use of the network is for data only, a baseband network provides significant cost/per- formance advantages.

FUTURE ISSUES FOR LOCAL AREA NETWORKS

NETWORK MANAGEMENT - As larger numbers of systems connect to the LAN, having the tools to allow effective resource management and planning will become increasingly important.

SECURITY - Most organizations want to protect the confidentiality of traffic flowing over the network. In some ways a LAN provides more security than conventional office communications, such as phone or interoffice mail. Converting voice and paper information to electronic signals makes them less accessible to the ordinary office worker. On the other hand, a communications network is a powerful tool in the hands of a sophisticated information thief or saboteur. Vendor's will have to develop new security techiques to prevent misuse of network.

TECHNOLOGY IMPROVEMENTS - The encapsulation of LAN communication systems onto VLSI silicon chips will contribute significantly to the promotion and general acceptance of LAN facilities. THe VLSI will reduce the LAN component prices and enforce a level of LAN standardization through sales of volume chips.

BRIDGES AND GATEWAYS - The creation and use of LAN facilities will demand the development of mechanisms to 1) interconnect various LAN's to each other and 2) interconnect LAN's to long haul networks to allow long distance informational exchange and resource sharing.

HYBRID NETWORKS - For many organizations, no one network topology, access method, or media may suit all of the user's needs. In these organizations hybrid networks will evolve. The management of information across these hybrid networks will continue to be a challenge during the coming years.

SUMMARY

The creation and effective implementation of a local area network is the key to unlock the full potential of the "information age". A LAN should be used to bind the distributed systems within an organization into a unified resource. The effectiveness of this total resource will then be measured by added capability and the degree of coherence that it achieves. This is turn will depend on the care and foresight put into the design of the network and the development of standards for interworking of systems at all levels.

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