

Internetworking

Raj Jain

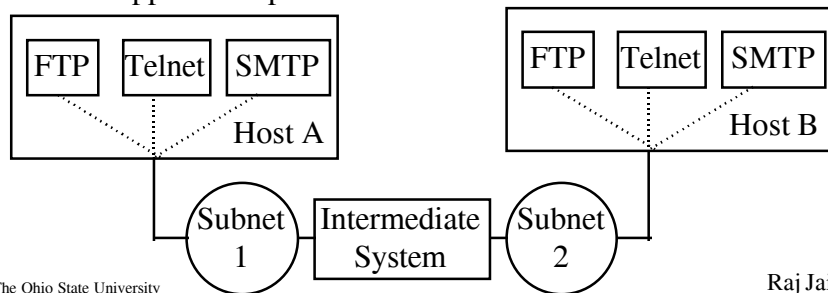
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- ❑ Internetworking terms and services
- ❑ Bridges vs routers
- ❑ How bridges work?
- ❑ Spanning Tree and source routing
- ❑ Internet Protocol (IP): Services, Header, Address format
- ❑ Other Router-level protocols: ARP, ICMP, EGP, OSPF

Internetworking Terms

- End-system: Host
- Network: Provides data transfer between end-systems
- Internet: A collection of networks
- Subnetwork: Each component of an internet
- Intermediate System: Connects two subnetworks
- Port: Application processes in the host



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Internetworking Services

- Connects two or more subnets
- May provide accounting and status information
- Accomodate subnets with
 - Different addressing schemes
 - Different maximum packet sizes
 - Different network access mechanisms
 - Different timeouts
 - May provide error recovery
 - Different routing techniques
 - Different user access control
 - Connectionless and connection-oriented subnets

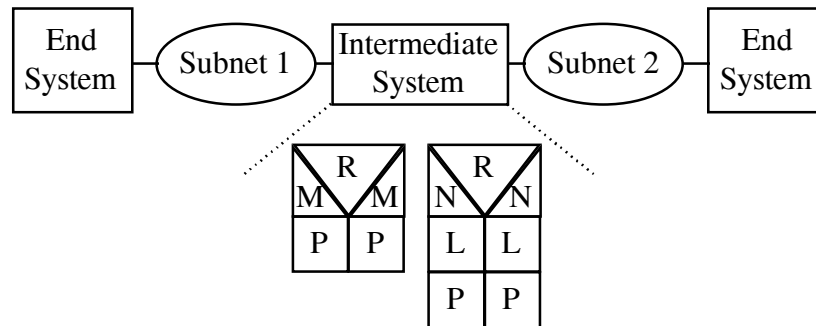
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Bridge vs Router

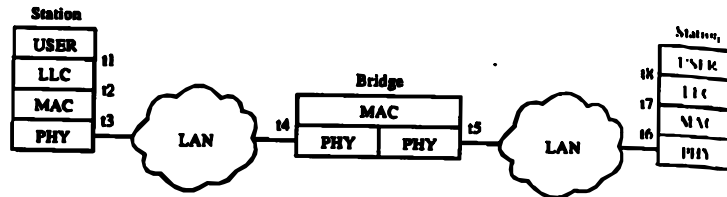
- ❑ Bridge: Connects or more identical LANs. Operates at layer 2 of the OSI model.
- ❑ Router: Connects two or more LANs that may or may not be identical. Operates at layer 3 of the OSI model



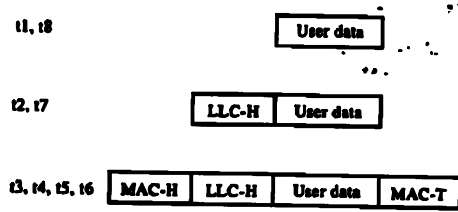
Bridge: Functions

- ❑ Monitor all frames on LAN A
- ❑ Pickup those frames that are for stations on the other side
- ❑ Retransmit the frames on the other side
- ❑ Knows or learns about which stations are on various sides
- ❑ Makes no modification to content of the frames
May change headers.
- ❑ Provides storage for frames to be forwarded
- ❑ Improves reliability (less nodes per LAN)
- ❑ Improves performance (more bandwidth per node)
- ❑ Security (Can keep different traffic from entering a LAN)
- ❑ May provide flow and congestion control

Data Encapsulation by Bridges



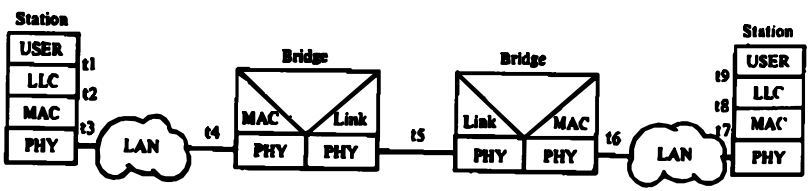
(a) Architecture



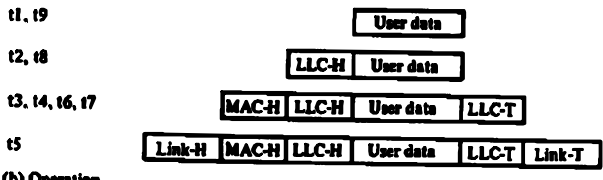
(b) Operation

FIGURE 11.5. Connection of two LANs by a bridge.

Half-Bridges for Point-to-point links

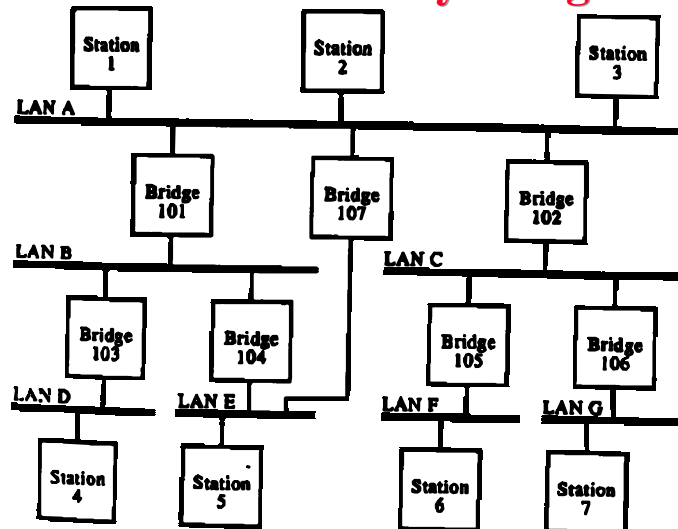


(a) Architecture



(b) Operation.

Path Determination By Bridges



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1. Fixed Routing

Control Routing Matrix

		Destination LAN						
		A	B	C	D	E	F	G
Source LAN	A	-	101	102	101	107	102	102
	B	101	-	101	103	104	101	101
	C	102	102	-	102	102	105	106
	D	103	103	103	-	103	103	103
	E	107	104	107	104	-	107	107
	F	105	105	105	105	105	-	105
	G	106	106	106	106	106	106	-

Bridge 101 table

		from LAN A	from LAN B
Dest	Next	Dest	Next
A	-	A	-
B	B	A	-
C	B	C	-
D	B	D	-
E	B	E	-
F	B	F	-
G	B	G	-

Bridge 102 table

		from LAN A	from LAN C
Dest	Next	Dest	Next
A	-	A	-
B	-	A	-
C	C	A	-
D	-	A	-
E	-	A	-
F	-	A	-
G	-	A	-

Bridge 103 table

		from LAN B	from LAN D
Dest	Next	Dest	Next
A	-	A	-
B	B	A	-
C	B	A	-
D	D	A	-
E	B	A	-
F	B	A	-
G	B	A	-

Bridge 104 table

		from LAN B	from LAN E
Dest	Next	Dest	Next
A	-	A	-
B	B	A	-
C	B	A	-
D	B	A	-
E	E	A	-
F	B	A	-
G	B	A	-

Bridge 105 table

		from LAN C	from LAN F
Dest	Next	Dest	Next
A	-	A	-
B	-	A	-
C	C	A	-
D	-	A	-
E	-	A	-
F	F	A	-
G	-	A	-

Bridge 106 table

		from LAN C	from LAN G
Dest	Next	Dest	Next
A	-	A	-
B	-	A	-
C	C	A	-
D	-	A	-
E	-	A	-
F	-	A	-
G	G	A	-

Bridge 107 table

		from LAN A	from LAN E
Dest	Next	Dest	Next
A	-	A	-
B	-	A	-
C	-	A	-
D	-	A	-
E	E	A	-
F	-	A	-
G	-	A	-

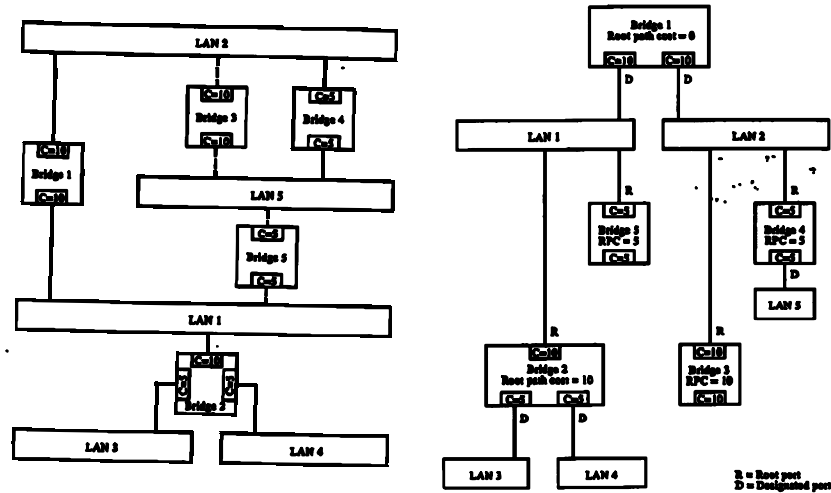
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Fig 11.10

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2. Spanning Tree



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Spanning Tree: Terminology

- Bridge Identifier: MAC address plus a priority level
- Port identifier: For each port of a bridge
- Path cost: Cost transmitting through a port
- Root Bridge: The bridge with the lowest identifier
- Root port: The port with the minimum cost to the root bridge
- Root path cost: Cost of the path to the root bridge
- Designated bridge: One per LAN. The bridge that provides minimum cost path from the LAN to the root bridge.
- Designated Port: The port of the designated bridge that connects the bridge to the LAN

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Spanning Tree Algorithm

- All bridges multicast to “All bridges”
 - My ID
 - Root ID
 - My cost to root
- The bridges use the information received to update their info using Dijkstra’s algorithm and rebroadcast
- Initially all bridges consider themselves to be the root but eventually converge to one root as they find out the lowest Bridge ID.
- On each LAN, the bridge with minimum cost to the root becomes the Designated bridge
- All ports of all non-designated bridges are blocked.

3. Source Routing

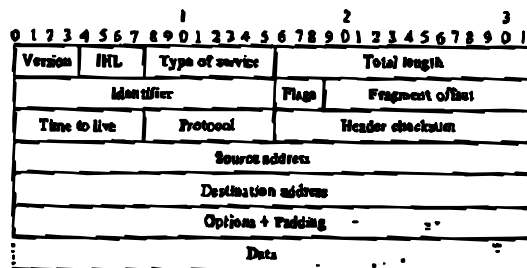
- The frame header contains the complete route:
LAN 1 - Bridge B1 - LAN 3 - Bridge B3 - LAN 2 - Dest
- Bridges are simple, end systems do the routing
- Four types of destination addressing:
 - Null: Destination on the same LAN
 - Nonbroadcast: Includes a route to destination
 - All-route Broadcast: Flooded.
Bridges record route in the frame.
 - Single-route Broadcast: Once and only once on each LAN.
Spanning tree used for broadcast

Route Discovery

- ❑ Manually on small internets
- ❑ Route server
- ❑ Dynamic route discovery
 - ❑ Transmit “All-route request frame” to destination
The destination sends back “nonbroadcast response” on each frame. Source knows all routes to the destination. Selects one.
 - ❑ Transmit “single-route request frame” to destination
The destination responds with one “All-routes response.” The source receives many responses and discovers all routes.

Internet Protocol (IP)

- ❑ IP deals with only with host addresses
- ❑ Services:
 - ❑ Send: User to IP
 - ❑ Deliver: IP to User
 - ❑ Error (optional): IP to User
- ❑ IP Header



IP Header

- ❑ Version (4 bits)
- ❑ Internet header length (4 bits): in 32-bit words.
Min header is 5 words or 20 bytes.
- ❑ Type of service (8 bits): Reliability, precedence, delay, and throughput
- ❑ Total length (16 bits): header+data in bytes
- ❑ Identifier (16 bits): Helps uniquely identify the datagram during its life for a given source, destination address
- ❑ Flags (3 bits):
 - More flag - used for fragmentation
 - No-fragmentation
 - Reserved

IP Header

- ❑ Fragment offset (13 bits): In units of 8 bytes
- ❑ Time to live (8 bits): Specified in router hops
- ❑ Protocol (8 bits): Next level protocol to receive the data
- ❑ Header checksum (16 bits): 1's complement sum of all 16-bit words in the header
- ❑ Source Address (32 bits)
- ❑ Destination Address (32 bits)
- ❑ Options (variable): Security, source route, record route, stream id (used for voice) for reserved resources, timestamp recording
- ❑ Padding (variable): Makes header length a multiple of 4
- ❑ Data (variable): Data + header \leq 65,535 bytes

IP vs ISO CLNP (Continued)

Function	IP	ISO CLNP
Options	Security Precedence bits in TOS Stricter source route Loose source route Record route Padding Timestamp	Security Priority Complete source route Partial source route Record route Padding Not present

Address Resolution Protocol (ARP)



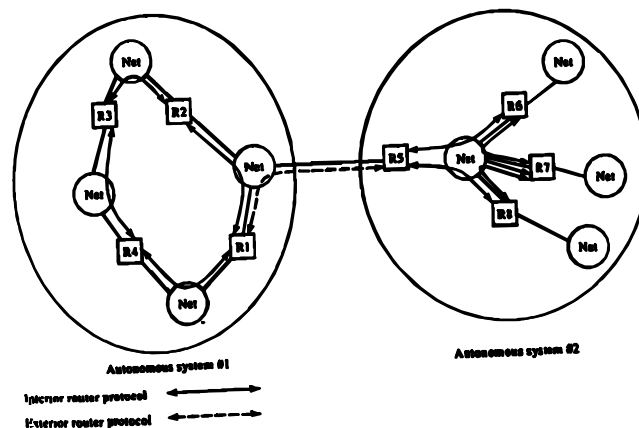
- Problem: Given an IP address find the MAC address
- Solution: Address resolution protocol
- The host broadcasts a request:
“What is the MAC address of 127.123.115.08?”
- The host whose IP address is 127.123.115.08 replies back:
“The MAC address for 127.123.115.08 is
8A-5F-3C-23-45-56₁₆”
- A router may act as a proxy for many IP addresses

Internet Control Message Protocol (ICMP)

- Required companion to IP.
Provides feedback from the network.
 - Destination unreachable
 - Time exceeded
 - Parameter problem
 - Source quench
 - Redirect
 - Echo
 - Echo reply
 - Timestamp
 - Timestamp reply
 - Information Request
 - Information reply

Autonomous Systems

- An internet connected by homogeneous routers under the administrative control of a single entity



Other Router-level Protocols

- ❑ Interior Router Protocol (IRP): Used for passing routing information among routers internal to an autonomous system
- ❑ Exterior Router Protocol (ERP): Used for passing routing information among routers between autonomous systems
- ❑ Routing Information Protocol (RIP): First generation ARPANet IRP protocol. Entire routing table sent to neighbors. Distance vector routing.
- ❑ Open Shortest Path First (OSPF): Interior routing protocol. Provides least-cost path routes using a fully user configurable routing metric (any fn of delay, data rate, dollar cost, etc.) Link costs flooded (Link-state routing)
- ❑ Exterior Gateway Protocol (EGP): Periodic hellos and responses with cost to other networks

Summary



- ❑ Subnetwork, IS, ES
- ❑ Bridges and routers
- ❑ Spanning tree, source routing, route discovery
- ❑ IP: Address, header
- ❑ ARP, ICMP, EGP, OSPF