CS 4/55231
Internet Engineering

Kent State University
Dept. of Computer Science

LECT-5

WAN

- Extending LAN
  - Techniques for extending LAN
- WAN
  - Scalable Technologies to over come distance & number limitation
  - Routing in WAN

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EXTENDING LAN winning the distance limitation

Extending LANs

- Why LANs are distance limited?
  - Signal loss at physical level
  - Coordination at logical level
- Engineers have developed a variety of ways to extend LAN connectivity.
- Most extension mechanisms use standard interface hardware and insert additional hardware components that can extend signals at longer distances.
- Fiber optic extensions, repeaters, bridges or switches and hubs can be used for extending LANs.

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Fiber Modems

- The simplest LAN extension mechanism uses optical fibers and a pair of fiber modems extend the connection between a computer and a trans-receiver. Fibers have low delayed and high bandwidth.

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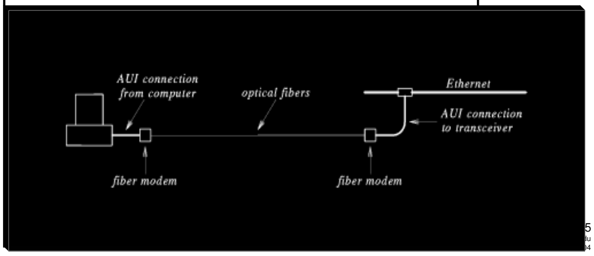

Repeaters

- Repeaters connects a pair of cables and is an analog device.
- Its main job is to repeats every signal that it hears on one side to the other.

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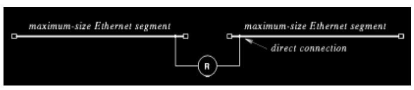

Extended Ethernet LAN with Repeaters

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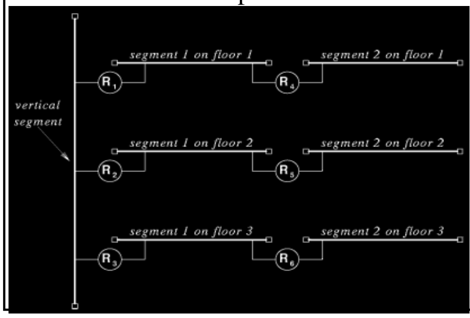

Repeater repeats everything, collision, noise, even thunderstorm!

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Bridges

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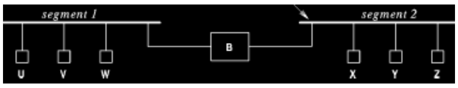
- Bridges also connects two networks,
  - but they understand frame format.
  - Has a separate HW address.
  - Can talk to each other.
- Listens to both the networks in promiscuous mode and can copy every frame it receives intact to the other network.
- Thus two LANs can work as one LAN.
- Computers would not know on which segment they are in.



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Bridges

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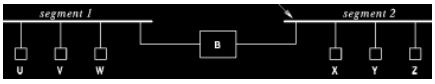
- Bridges can also perform frame filtering.
  - It looks into hardware address in the frames.
  - Relays the frames only if it is for a computer in other segment.



Event	Segment 1 List	Segment 2 List
Bridge boots	–	–
U sends to V	U	–
V sends to U	U, V	–
Z broadcasts	U, V	Z
Y sends to V	U, V	Z, Y
Y sends to X	U, V	Z, Y
X sends to W	U, V	Z, Y, X
W sends to Z	U, V, W	Z, Y, X

How do they know which computer is in which side?

How Bridges know about the computer which did not talk?

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Bridging Between Buildings

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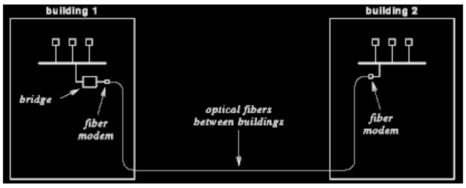

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Bridging Across Long Distance

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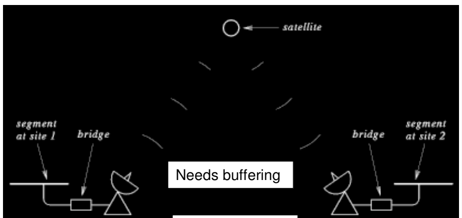

Needs buffering

Each site has a bridge. Why?

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Cycle of Bridges

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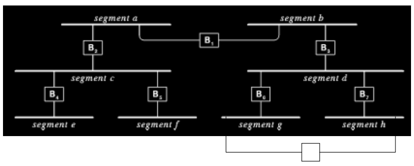

How to avoid Cycles? (DST)

•Parallelism
•How computers should be distributed at two segments?

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WAN
how to win the limit on the number of computers?

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Problem of Scale: WANs

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- The techniques shown in last few slides show how the distance limitation of LANs be extended.
- But, they do not solve the problem of Scale. What if we have too many computers scattered across long distances, at different places?
- Solution:
- Packet Switches
  - moves packet from one network to another.
  - Not only one or two but, many switches creates a network of networks.
  - Distributed routing.

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Switching

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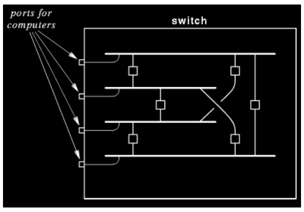

Computers can communicate in parallel. But costly. Thus a combination of Switch & Hub is used.

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Packet Switching

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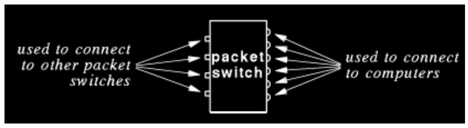

- One side connects to computers, other side connects to other packet switches.

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Back Bone WANs with Packet Switches

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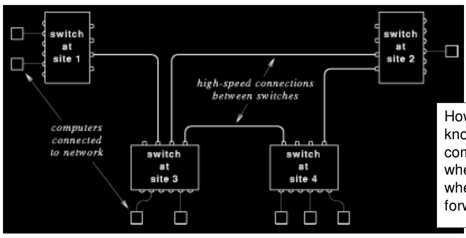

How do they know which computer is where and where to forward?

- Computers now talk in parallel.
- Switches does store and forward.

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Visit to ABILANE Switch

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- ABILENE
  - ABILANE WEATHERMAP
  - ROUTER TRAFFIC STATS
- OTHER INTERNET BACKBONES
  - (goto abovenet/ visualization)
  - (RUSS PAGE)

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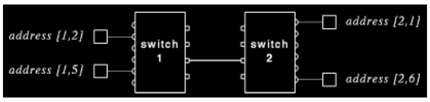
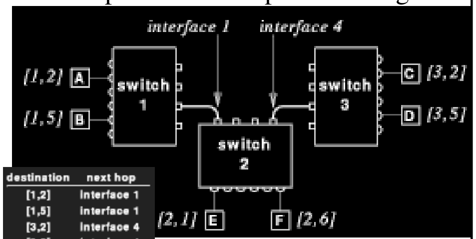
Physical Addressing in a WAN



- Each address is divided into two parts: switch address and computer address
- Each switch maintains a list of next-hop-address for each destination

Switches (except the final one) need not to read the computer address.

Example of Next Hop Forwarding



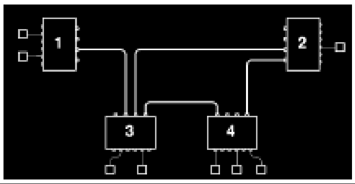
destination	next hop
[1,2]	interface 1
[1,5]	interface 1
[3,2]	interface 4
[3,5]	interface 4
[2,1]	computer E
[2,6]	computer F

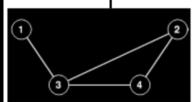
Forwarding Table of Switch#2

Further Scalable WAN

- **Scalable Network**
  - Interior and
  - Exterior Packet Switches
- **Scalable Address Table**
  - Universality
    - each should know the path to any computer.
  - Optimality
    - the path should be optimum too.

Routing in a WAN

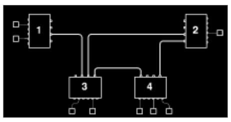




destin-ation	next hop	destin-ation	next hop	destin-ation	next hop	destin-ation	next hop
1	-	1	(2,3)	1	(3,1)	1	(4,3)
2	(1,3)	2	-	2	(3,2)	2	(4,2)
3	(1,3)	3	(2,3)	3	-	3	(4,3)
4	(1,3)	4	(2,4)	4	(3,4)	4	-
node 1		*node 2*		*node 3*		*node 4*	

Size of address Table?

Default Routing



destin-ation	next hop	destin-ation	next hop	destin-ation	next hop	destin-ation	next hop
1	-	1	(2,3)	1	(3,1)	1	(4,3)
2	(1,3)	2	-	2	(3,2)	2	(4,2)
3	(1,3)	3	(2,3)	3	-	3	(4,3)
4	(1,3)	4	(2,4)	4	(3,4)	4	-
node 1		*node 2*		*node 3*		*node 4*	

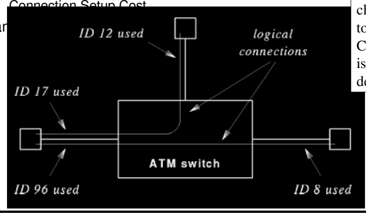
destin-ation	next hop	destin-ation	next hop	destin-ation	next hop	destin-ation	next hop
1	-	2	-	1	(3,1)	2	(4,2)
*	(1,3)	4	(2,4)	2	(3,2)	4	-
		*	(2,3)	3	-	*	(4,3)
				4	(3,4)		
node 1		*node 2*		*node 3*		*node 4*	

How to Determine Best Path?

- Disktra's shortest vector algorithm is used.
- How to collect Routing Information needed for Disktra's algorithm?
  - Distance Vector Algorithm
  - Link State Algorithm.
  - Refresh these up!

Connectionless vs. Connection-oriented Switching

- A packet can explicitly carry the destination address. However, if lots of packets are going to the same destination, they can carry a small label.
  - Cost of Address field
  - Connection Setup Cost
- Exam
  -



Path idetifier can change from switch to switch
Channel identified is used only by the destination switch.

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Example WAN Technologies

- ARPANET
  - A defense initiative started in 1960s.
  - Legacy of Internet. Based on 56Kbps Leased serial lines.
- X.25
  - Developed by ITU,popular in Europe
  - Used for remote terminal placement of computers.
  - Not suitable for computer-computer communication.
- ISDN
  - Objective: data networking on voice system.
  - 64 Kbps date+ 16 Kbps control channel.

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Example WAN Technologies -2

- Frame Relay
  - Appropriate for long distance LAN bridging
  - Supports upto 8K frames on 1.5 Mbps or 56Kbps.
- SMDS (switched multi-megabit data service)
  - Designed to carry data.
  - Higher bandwidth than FR
- ATM
  - most promising in WAN
  - ensures quality of service.
  - Available in 155 Mbps/ 622 Mbps

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Summary

- LAN technology can connect a community of computers.
- Solution to Distance Limitation
  - Repeaters & Bridges.
- Solution to Scale Limitation
  - Packet Switch for connection scaling.
- New Issue
  - routing

10s of thousands of computers can be connected with the above Networking Infrastructure!

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Summary (cont..)

- Technologies:
  - LANs: Ethernet, AppleTalk, IBM Token Ring
  - Fast LANs: FDDI, Fast Ethernet, HIPPI, ATM, Fiber Channel.
  - WANs: ARPANET, X.25, ISDN, SMDS, Frame Relay, ATM.

Technology	Connection-Oriented	Connectionless	used for LAN	used for WAN
Ethernet		•	•	
Token Ring		•	•	
FDDI		•	•	
Frame Relay	•			•
SMDS		•		•
ATM	•		•	•
LocalTalk		•	•	

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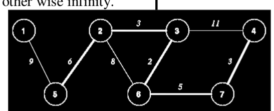
Computing Shortest Path (Dijktra's Algorithm)

```
W[i][j]=link cost between node i and j
S[i]=all nodes except source;
R[i]= source for all connected nodes otherwise zero.
D[i]=W[source][i] for nodes  connected from src other wise infinity.
while( set S is not empty) {
    choose u from S closest to source;
    if (D[u]==infinity) no path in S, exit;
    delete u from S;
    for each v such that W[u][v] is an edge {
        if (v is still in S) {
            c=D[u]+W[u][v];
            if (c < D[v]) {
                R[v]=R[u];
                D[v]=c;
}}}}
```



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Distributed Vector Distance Routing Table Computation

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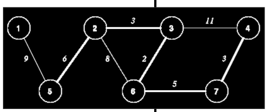
Given a local routing table with weight and an incoming message;




```
Repeat forever {
    wait for next message from N;
    for each entry in the message {
        if V is destination and D is cost;
        c=distance to N  + D;
        if  V is a new destination
            add a new entry, for V with next hop = N and D =c;
        if  V is there and next-hop is also N
            replace local D with c;
        if V is there but next-hop is not N but D > c
            replace next-hop = N and local D=c;
    }
}
```


Link-State Routing

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- Step-1: Every Switch broadcasts the status of links attached to it in regular interval.
- Step-2: Each Switch collects the incoming messages and builds its own network graph.
- Step-3: In parallel, they independently compute the best path.