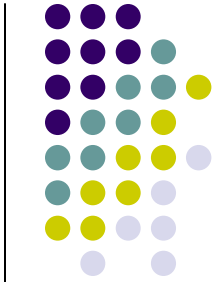
Lecture 8 : Switching



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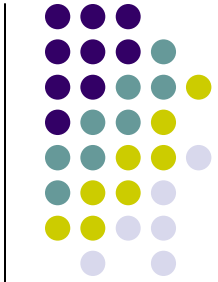
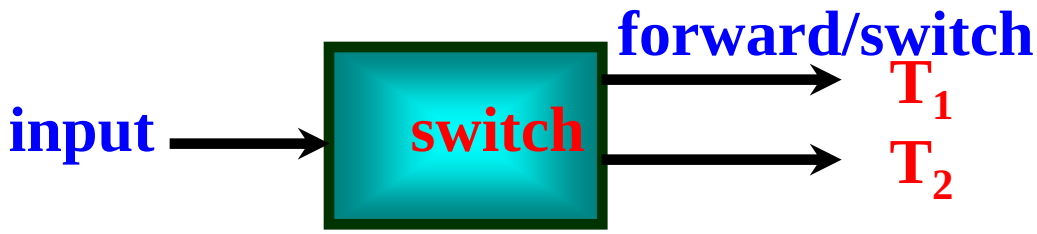
Short Term Course on “Teaching Computer Networks Effectively”. Sponsored by AICTE.

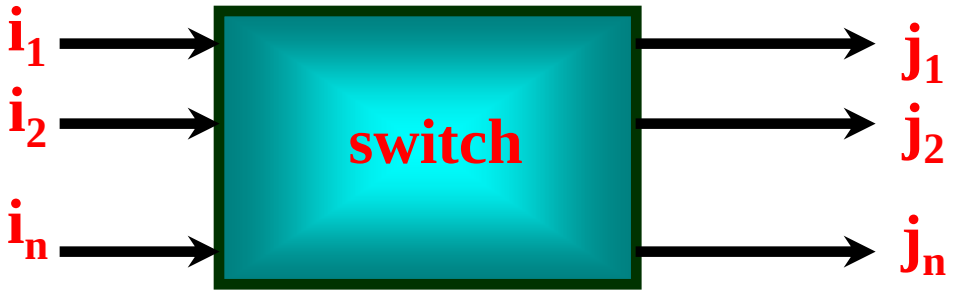
8.1 Packet Switching

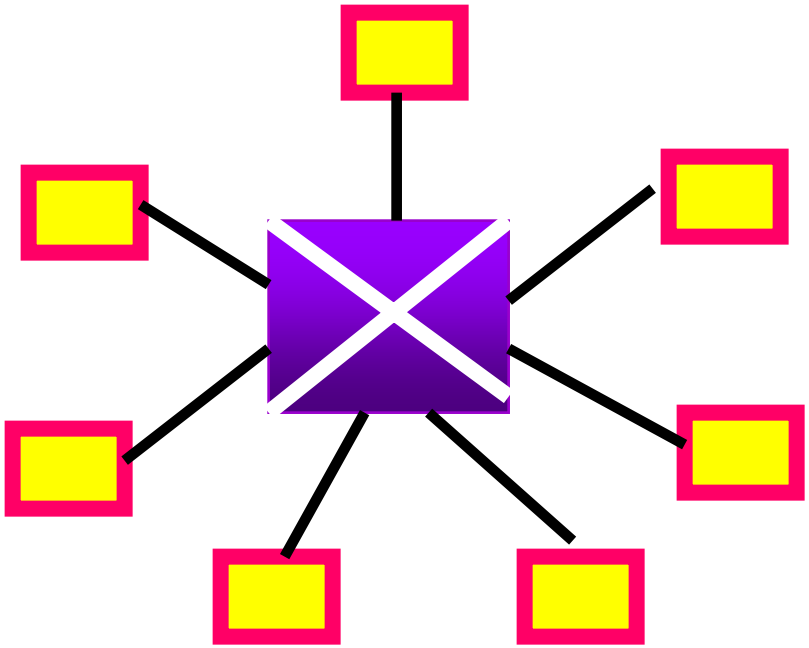


- Not all nodes connected to each other
- Need Switches
  - Packet Switches
    - Enable packets to go from one host to another that is not directly connected

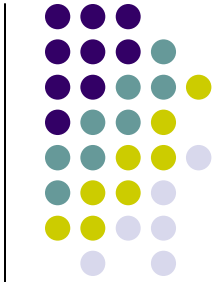


Switch: Multi-input Multi-output



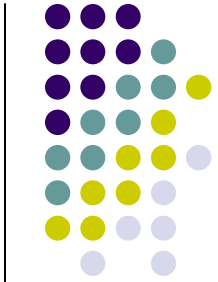


Switches: Functions



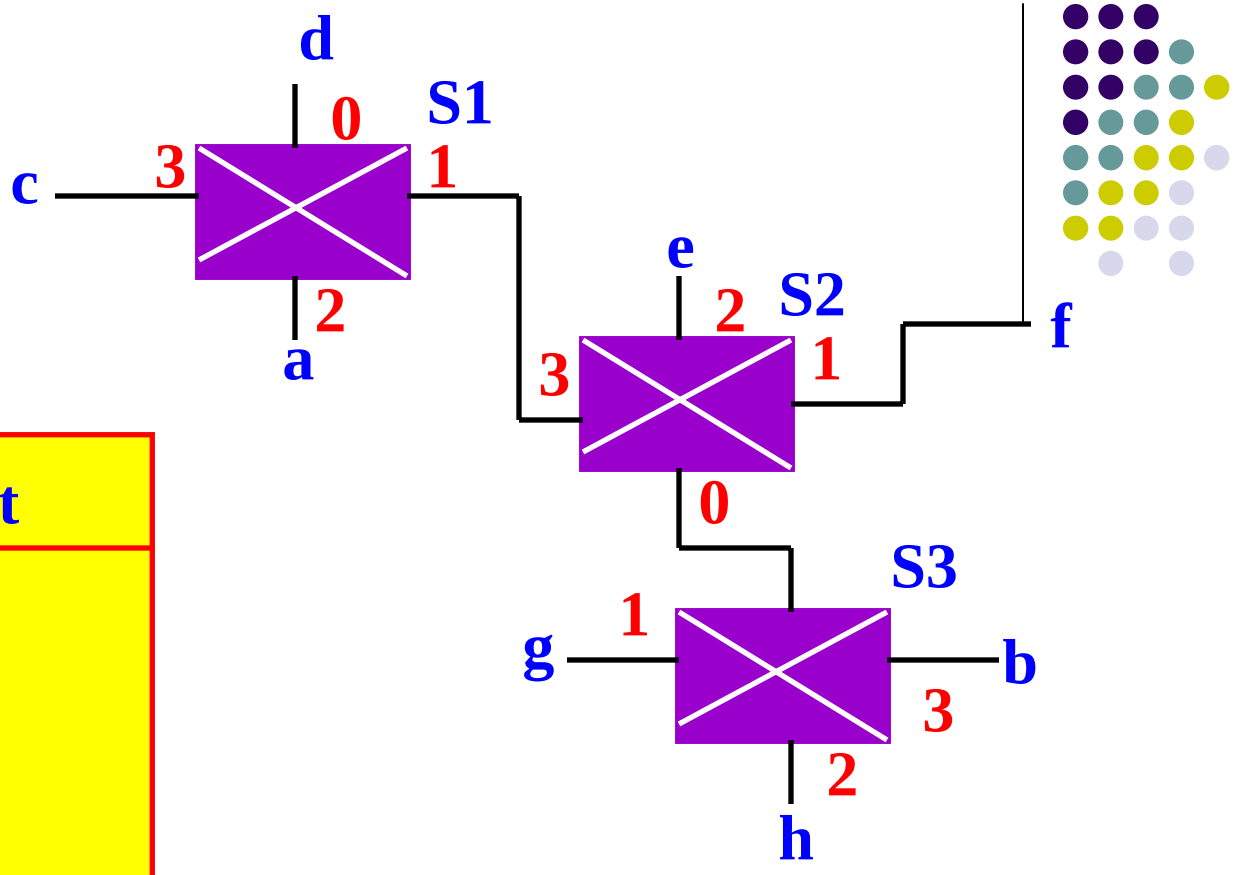
- Receive incoming packets on incoming ports
- Forward on to outgoing ports
- Not forward all traffic
- Switch must have aggregate capacity
- Help build large networks

Switches: Functions



- Switching
  - Connectionless (datagram)
    - Using destination address in packet consult forwarding table to decide how to forward packet
  - Connection oriented (virtual circuit)
    - First establish a circuit from source to destination
    - Then forward packets on this circuit

Table lookup for switching



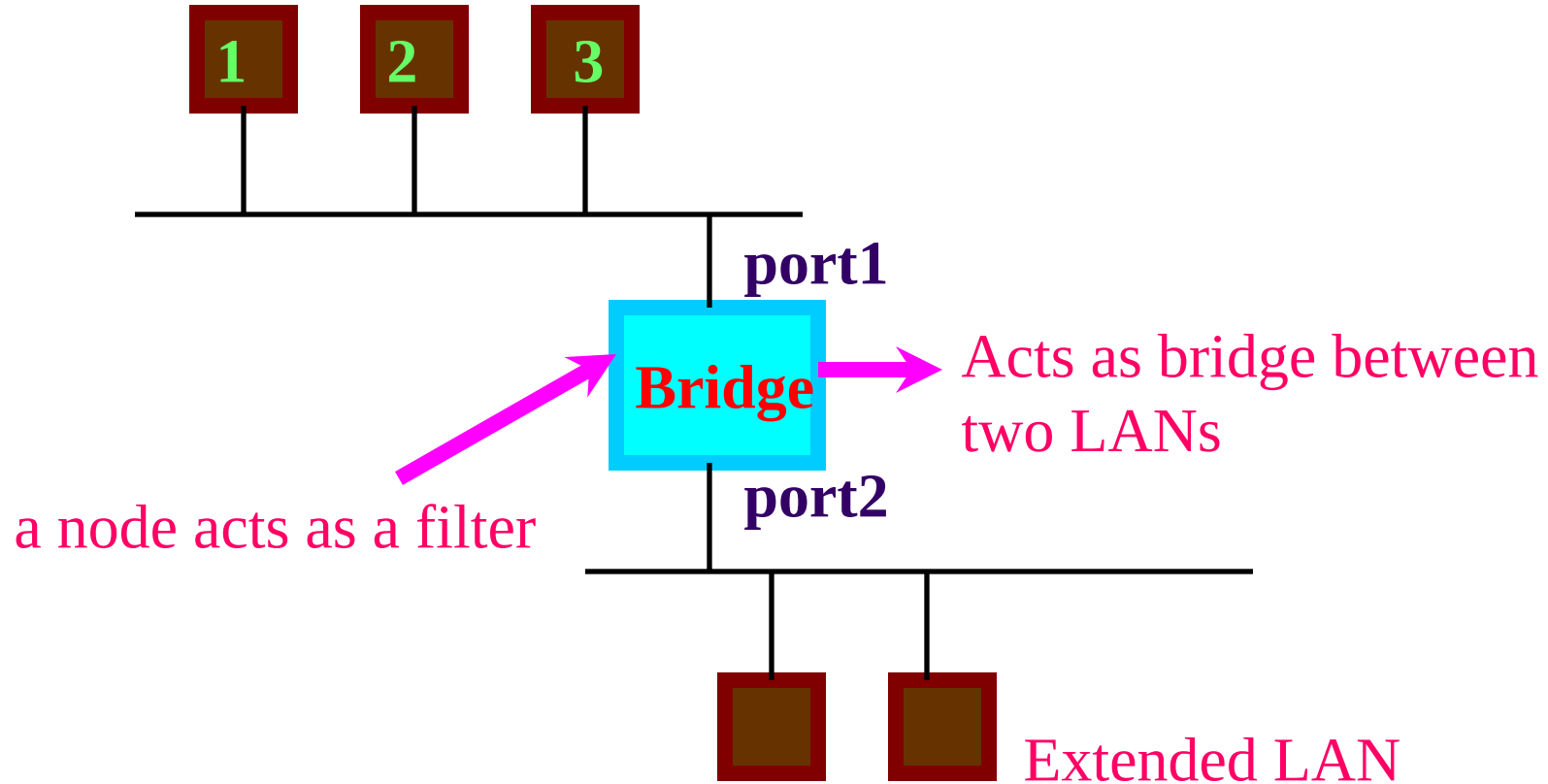
Switch 2

Destination	Port
a	3
b	0
c	3
d	3
e	2
f	1
g	0
h	0

Easy when entire map of network is Available

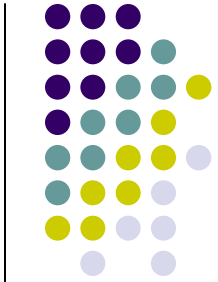
Configured at the time of network setup

Bridges and LAN Switches



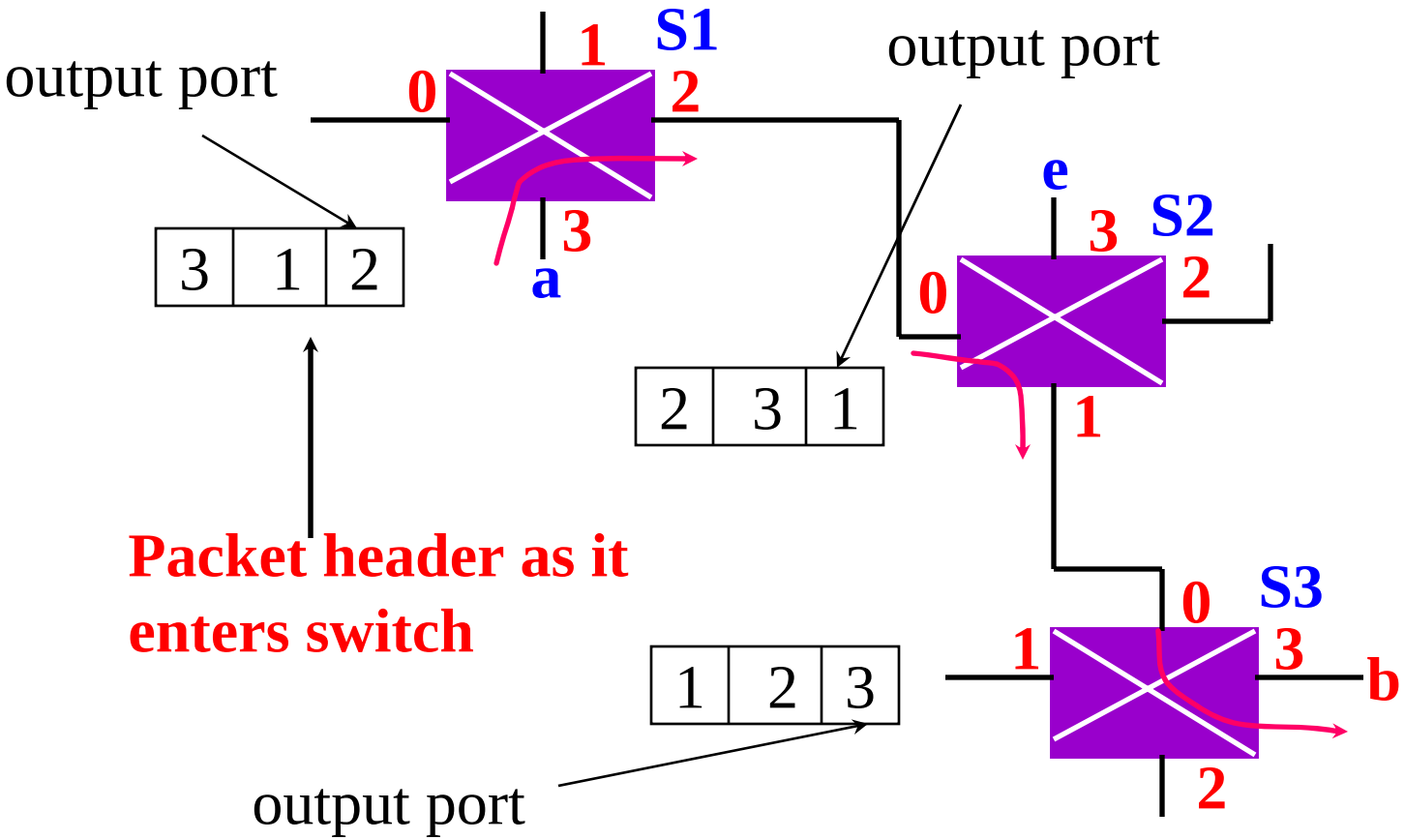
- **Bridge is also a switch**

Source Routing Bridges



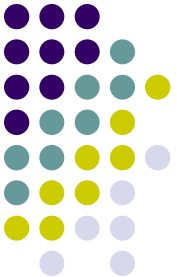
- Sender knows the location of destination address
  - LAN number, Bridge number
  - Example:
  - H11 on LAN1 wants to talk to H21 on LAN3
  - Route packets LAN1, B3, LAN2, B4
  - Each LAN has a unique number and each bridge on a LAN has a unique number

Source Routing

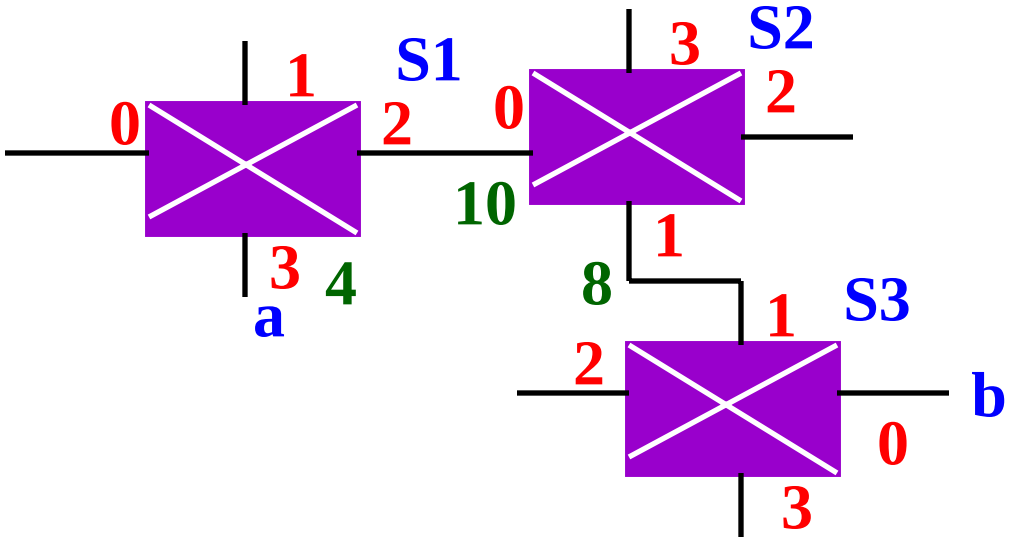


Entire route from source to destination in packet header

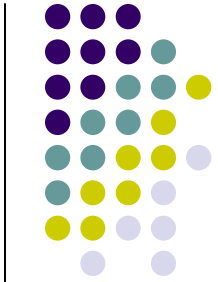
Virtual Circuit Switching



- host a wants to communicate with b

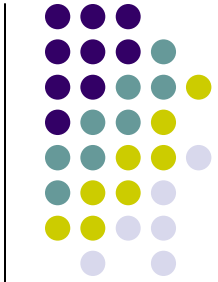


VC Tables



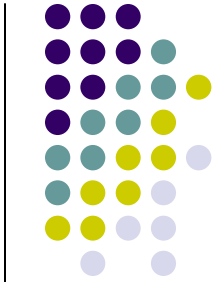
- An incoming interface
- An incoming virtual circuit identifier (VCI) for incoming packet
- An outgoing interface
- An outgoing virtual circuit identifier (VCI) for outgoing packet
- New Connection
  - Assign VCI not in table
  - Incoming VCI and outgoing VCI not globally unique

Setting up VCs



- Dynamic setting up of VC
  - Setup message all the way from a to b and back
    - Choose unused VCI 4 a to S1
    - Choose VCI 10 from S1 to S2
    - Choose VCI 6 from S2 to S3
    - Choose VCI 4 from S3 to b
    - When connection not required – tear down connection, free VCI, switches updated
- Other VCs
  - Permanent – set by network administration
  - Temporary – setup for duration of connection

VC Tables



VC Tables setup before data transmission

VC Table S1:

In IF	In VCI	Out IF	Out VCI
3	4	2	10

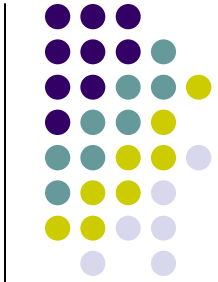
VC Table S2:

In IF	In VCI	Out IF	Out VCI
0	10	1	8

VC Table S3:

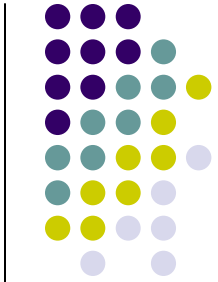
In IF	In VCI	Out IF	Out VC
1	8	0	5

VC Switching Issues



- Delays due to circuit setup
- Connection request full destination address
- Switch or link failure
  - New one has to be established again
- Route known before data being sent
- Requires flow control

VC Switching Advantages



- QoS guarantees
- Switches set aside resources
- Generally queues do not build up
  - Since traffic is delay sensitive
- Examples: X.25, Frame Relay (VPN), ATM

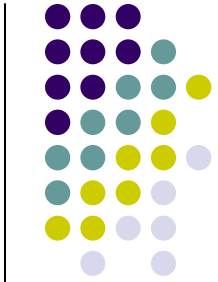
8.2 Characteristics of Connectionless Networks

- A host can send a packet anywhere at any time
  - Packet turns up at a switch forwarded
    - Provided switches table is populated
- Host sends packets does not know (connected / up) status of destination
- Each packet forwarded independent of each other
  - Successive packet can go through other switches
- A switch or link failure may not seriously affect communication

Frame Forwarding in Bridges

- Learning bridges
  - Does not forward all frames that it receives
  - Packet arrives from 1 to 2
    - Not forwarded
  - Forwarding based on Source Address in the packet

Frame Forwarding in Bridges

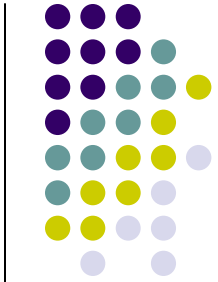


- When Bridge boots up: Table empty
- Entries are added over time
- Timeout with each entry
- Discards entries after a specified period of time
- Bridge useful for extending a LAN

Extending LANs using Bridges

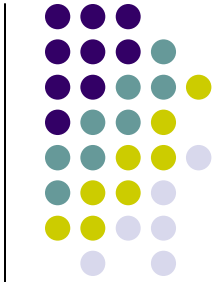
- To extend a LAN use a bridge
  - This can introduce loops
    - Packets circulate forever
    - Distributed spanning tree algorithm
      - Removes loops
- Bridges are also useful for redundancy
- Bridges exchange configuration information
- Bridges select ports on which it will forward frames

Routing Packets in a LAN



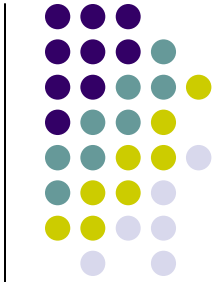
- If source and destination are on the same LAN discard frame
- If destination and source LANs are different forward to appropriate LAN
- If destination not known – flood
- Multiple bridges to improve reliability

Spanning trees



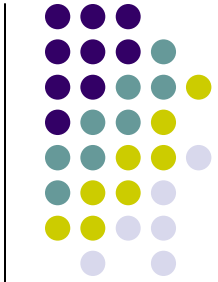
- Two bridges connecting LANs 1 and 2
  - At any point in time only one bridge is active
- Facts:
  - Each bridge unique ID – MAC address + priority
  - Special group of addresses
    - all bridges on this LAN
    - Each port of the bridge has a unique ID within the bridge
  - Concept of root bridge
    - Bridge with lowest value of bridge ID

Spanning Tree Algorithm



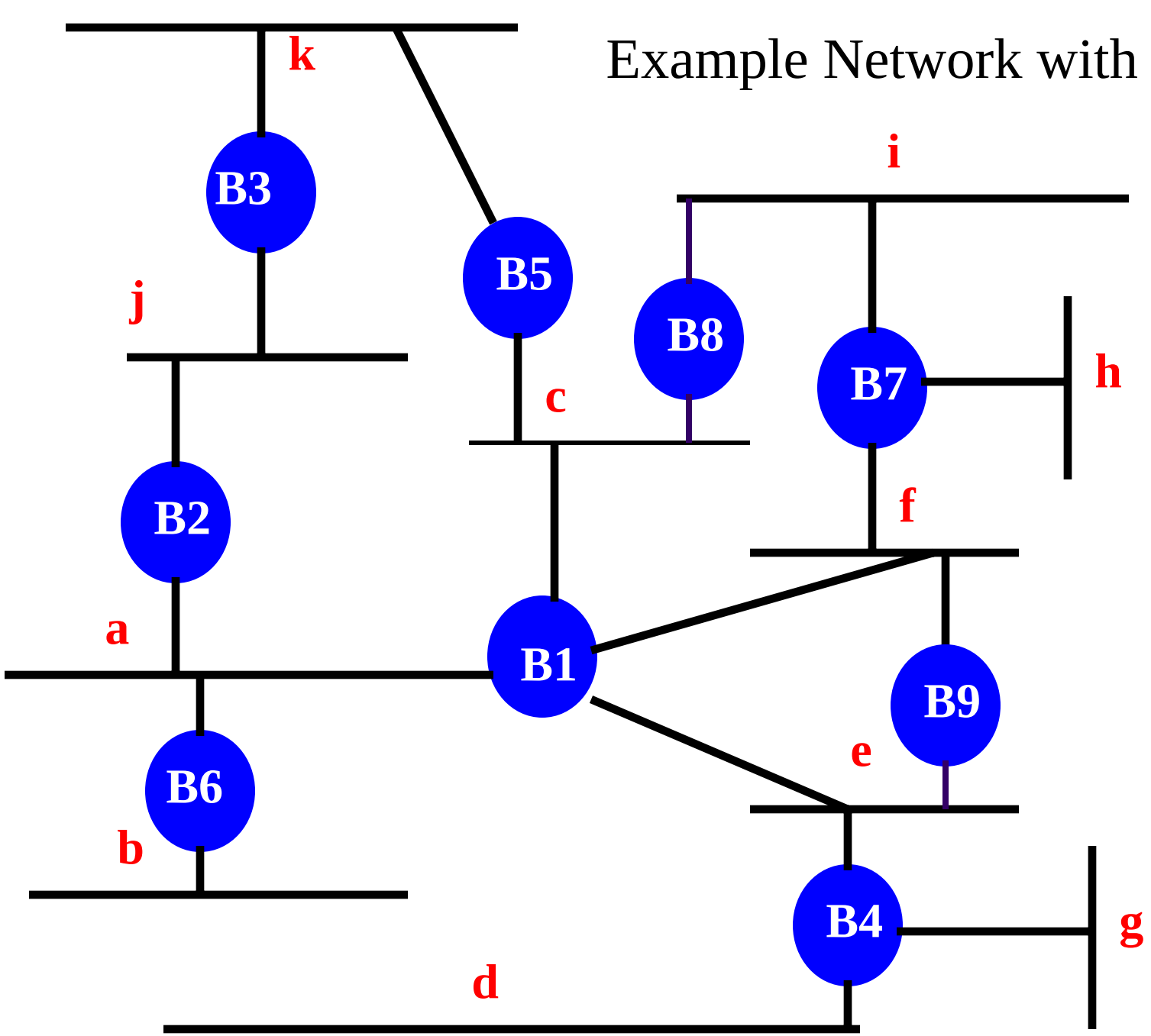
- Each bridge finds the lowest cost path to root bridge
  - If two ports have same cost, choose the one with smaller port ID
- Construct minimum spanning tree
  - Using distributed BFS

Spanning Tree Algorithm

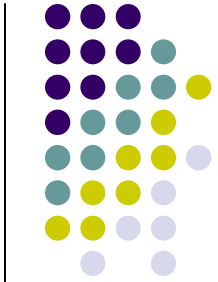


- Initially
  - All nodes think they are root bridges and send configuration information
  - Each node checks configuration information received from other nodes
    - Stops generating messages if its ID is higher
      - Send information to other nodes stating that it is one hop away from root bridge
  - Each node computes path to root
    - Discards some paths
      - i.e. the port with longer paths are made inactive
  - System stabilises only when root node generates configuration messages

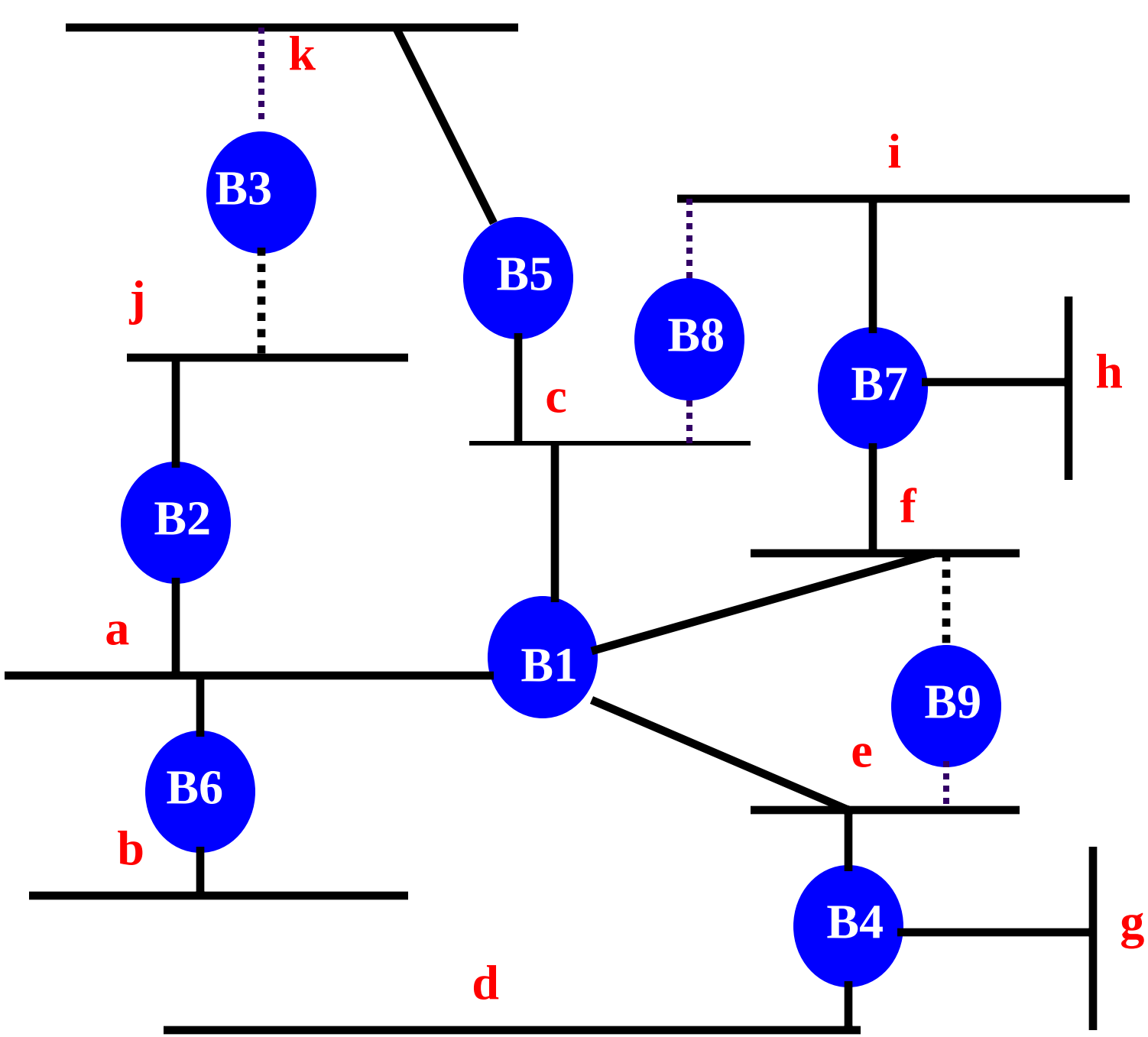
Example Network with Loops



Example



- Configuration message (root, d, node)
- Activity node B9
- B9 receives (B4, 0, B4), (B1, 0, B1)
- 1 < 9, 4 < 9, B9, B4 accept B1 as root
- B9 receives (B1, 1, B4) from B4 and (B1, 1, B8)
- B9 notices that distances to root from B4, B8 are the same as that of B9
- 9 > 8, 9 > 4, B9 stops forwarding on both its interfaces


k
B3
B5
i
j
B8
B7
h
c
B2
f
a
B1
B9
e
B6
b
B4
g
d

Remote Bridges

- Connect one or more distant LANs
- Complete MAC frame put in payload