Flooding can lead to loops!
  ○ Packet continues to circulate in network forever
  ○ Can be a large issue in networks due to overflow of packets constantly looping the network
  ○ Switches sometimes need to broadcast frames
    ■ Upon receiving frame with unfamiliar destination
    ■ Upon receiving a frame sent to the broadcast address

Broadcasting is implemented by flooding

Flooding can lead to forwarding loops
  ○ Ex: if the network contains a cycle of switches
  ○ Either accidentally or by design for higher reliability

Time to leave: carried on every internet (IP) packet
  ○ Used to drop packet after it has lived too long within the network (due to loops)

Spanning Tree Algorithm:
  ○ Ensure the topology of the network has no loops (create spanning tree)
    ■ Avoid using some of the links when flooding
    ■ Avoid forming a loop!
    ■ If edge can be reached by another destination due to another edge = there is a loop possibility (we want to prevent this)
  ○ Spanning tree:
    ■ Subgraph that covers all vertices, but contains no cycles
      ● Minimum spanning tree creation where edges are marked as “not used” to remove tree cycles
    ■ Since a network is dynamic, this algorithm will be running continuously and independently on each node.
      ● Fix when a node goes down, another is added, etc.
    ■ Each edge is given a weight of “1” when a node is directly accessible
    ■ Nodes are given numbers to be reached in a specific order (1, 2, 3, …, n)
      ● In networking, can be MAC address
    ■ Once stabilized, The edges to to be used will be marked.
• **Constructing a Spanning Tree:**
  - Need a distributed algorithm
    - Switches (nodes) cooperate to build the spanning tree
  - **Key ingredients of the algorithm:**
    - Switches need to elect a “root”
      - The switch with the smallest identifier
        - *Root election algorithm*
          - If A has a smaller identifier than B, B will recognize A as the “root”
      - Each switch identifies if its interface is on the shortest path from the root
        - Analyze all paths, choose path with smallest identifier total
          - Described as “hops” in class
  - Messages (Y, d, X)
    - From node X
    - Claiming Y is the *root*
    - *Distance* is d from *root*
  - Initially, each switch thinks it is the root
    - Switch sends a message out every interface
    - The switch then identifies itself as the root with *distance 0*
    - Ex: Switch X announces (X, 0, X)
  - Switches update their view of the root
    - Upon receiving message, check root ID
    - If the new ID is smaller, start viewing that switch as root
  - Switches compute their distance from a neighbor

• **Robust Spanning Tree algorithm:**
  - Algorithm must elect new root node with lowest identifier upon failure
  - When other switches fail, need to re-compute the entire spanning tree
  - Section 3.2.2 in textbook!

• **Evolution toward virtual LANs:**
  - Cables snaked through buildings
  - Every computer the cables passed was plugged in
  - All people were put on same LAN!
    - Whether they belonged to the network or not
  - **More recently:**
    - Hubs and switches changed all of that
    - Central wiring closets
    - Multiple LANs (k hubs) connected to network
Why group LAN by organizational structure?
- Security
  - Ethernet is a shared media
    - Isolating traffic on separate LANs improves security
  - Load: Load Balancing.
  - Organizational changes are frequent

CS315 lab is a part of the CS LAN network, however, it is on its own Virtual LAN (VLAN)

VLANs
- Bridges/switches need configuration tables
  - Which VLANs are accessible via which interfaces
- Each interface has a VLAN color
- Each MAC address has a VLAN color
- Change the Ethernet header
  - Adding a field for a VLAN tag
  - Implemented on bridges/switches

Moving from switches to routers:
- Advantages of switches over routers:
  - Plug-and-play
  - Fast filtering and forwarding of frames
- Disadvantages of switches over routers:
  - Topology is restricted to a spanning tree
  - Large networks require ARP table

Addressing:
- IP Address:
  - Dotted-quad notation (IPv4)
  - 32-bit unique number
    - Bit string is partitioned into four 8-bit long sections
  - IP prefixes for aggregation
- The internet is a “network of networks”
  - LAN (local area network) connected to router connected to WAN (wide area network)
  - Routers connect networks together, not hosts!
- IP Prefixes:
  - Divided into network and host portions (left and right)
    - All machines on same LAN have same network portion of bits
    - Host parts differ among machines
    - Ex: 12.34.158.0/24 is a 24-bit prefix(network address) with 2^8 addresses
○ **Subnet Mask:**
  - Size of network IP prefix
  - Create a value (all 1s on network part and all 0s on host part)
    - Ex: 11111111 11111111 11111111 00000000
      - 255.255.255.0
    - Will mask away the host portion of the address
    - Leaves the network portion as is
      - Used in packet forwarding