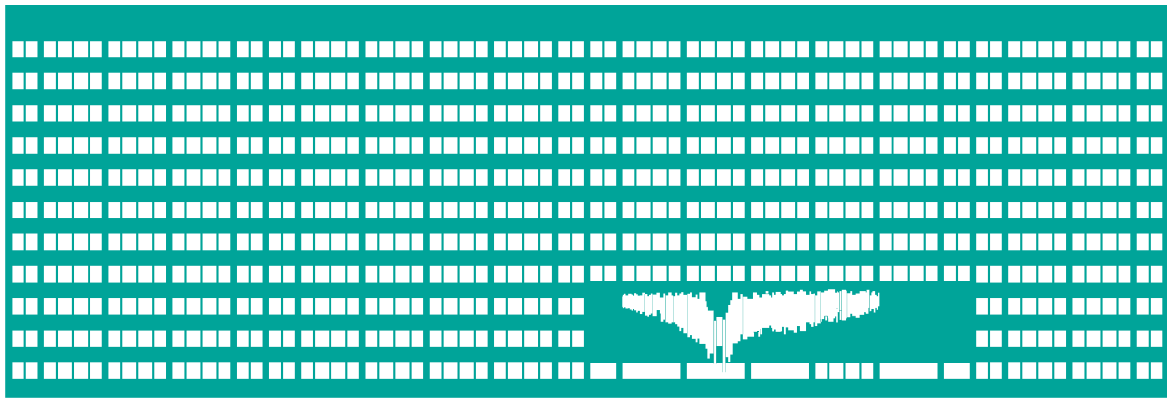
VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE | DEPARTMENT OF COMPUTER SCIENCE

LAN Interconnection and Basic Networking Devices



Computer Networks
Lecture 3

What are Networking Devices used for ?

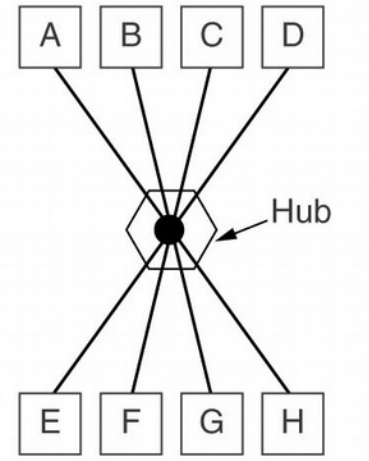
- Interconnection of (originally separate) network segments
- Division of too large (congested) networks

Reasons for Network Interconnection and Division

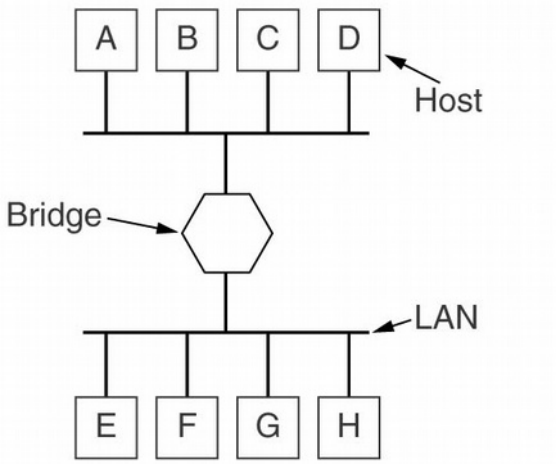
- Increase of the coverage
  - Overcoming of reach limitation of the particular network technology
  - Interconnection of originally independent and/or geographically distant networks
- Traffic separation
  - Reduction of collisions and broadcast traffic
  - Better fault resiliency (fault isolation)
  - Security (eavesdropping, attacks etc.)

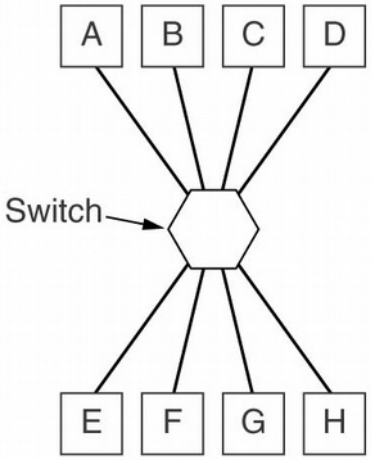
Network Devices for LAN Interconnection

- **Hub**



- **Bridge/switch**



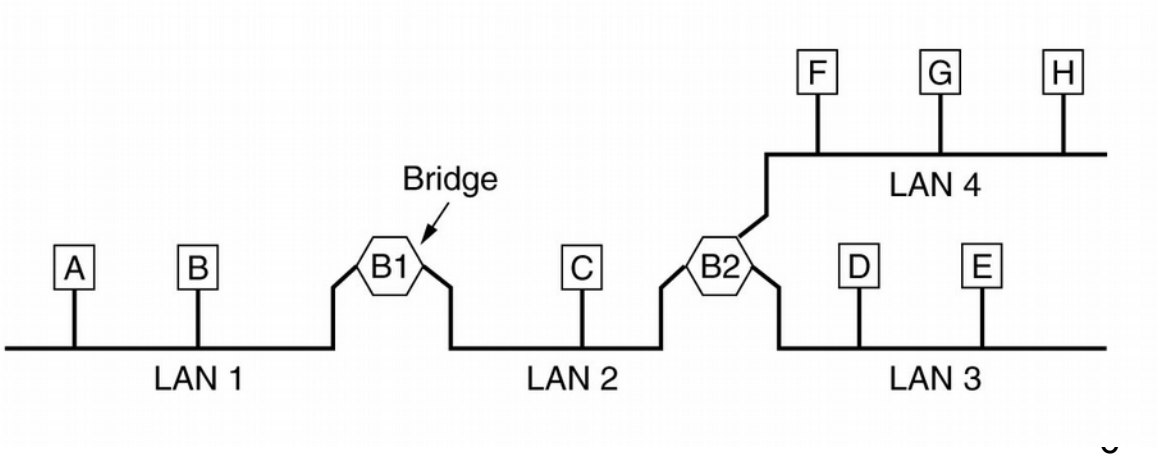


Collision and Broadcast Domains

Bridge

- Operates at OSI RM layer 2
- Bound to a single network LAN technology
  - the same frame format on all interfaces
- Transparent (self-learning) or source-route bridging
- May convert media, encoding, etc.

In today's wired LANs, bridges have been replaced by switches



Transparent Bridging

- Forwards frames according to bridging table
  - Set of <MAC_address, port> records
- Bridging table is filled according to source MAC addresses and incoming ports of incoming frames
- Records of bridging table have a limited lifetime
  - Expiration counter of a record is reset whenever a frame with a particular MAC address arrives
- Frames with unknown destination MAC address are flooded to all ports
- Broadcast frames are forwarded to all ports
  - but **not** the one they came from
- A "Plug-and-Play" device
  - its presence is transparent to the stations

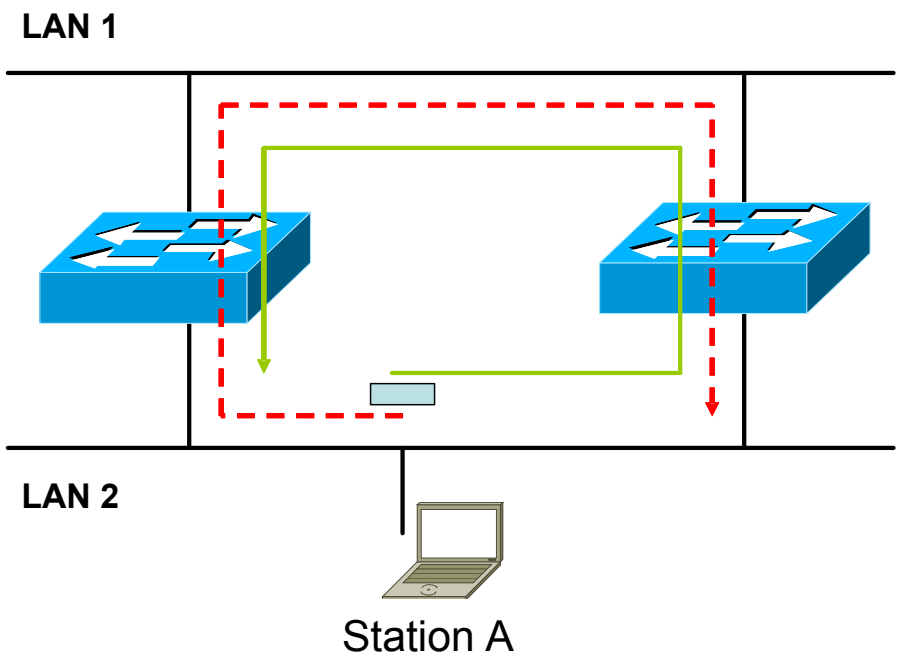
Source-route Bridging

- The path over the network is determined by the source station
- Each frame contains a list of network segments (bridge IDs) it has to travel through
  - Routing Information Field (RIF)
- Has been used in Token Ring
  - a structure of interconnected rings

Determination of the Path in SRB

- Before a source sends a data frame to a destination for the first time, it broadcasts a route discovery frame
- every bridge appends its Bridge ID to the RIF in discovery frame and forwards it to all ports
  - to avoid loops, bridge ignore discovery packets that already contains its Bridge ID in the RIF
- After the intended destination station receives the discovery frame, it reverses RIF and sends the discovery frame back to the source
  - along an already known path
- The source uses the RIF of the returned discovery frames as a path to the destination for subsequent data packets
  - it chooses one of the alternative paths multiple discovery packet responses arrive

Problem with Looped Frames in Transparent Bridging



- In case of 3 parallel bridges extra frames are also generated
  - The number of frames grows exponentially
- **A solution:** The Spanning Tree Protocol

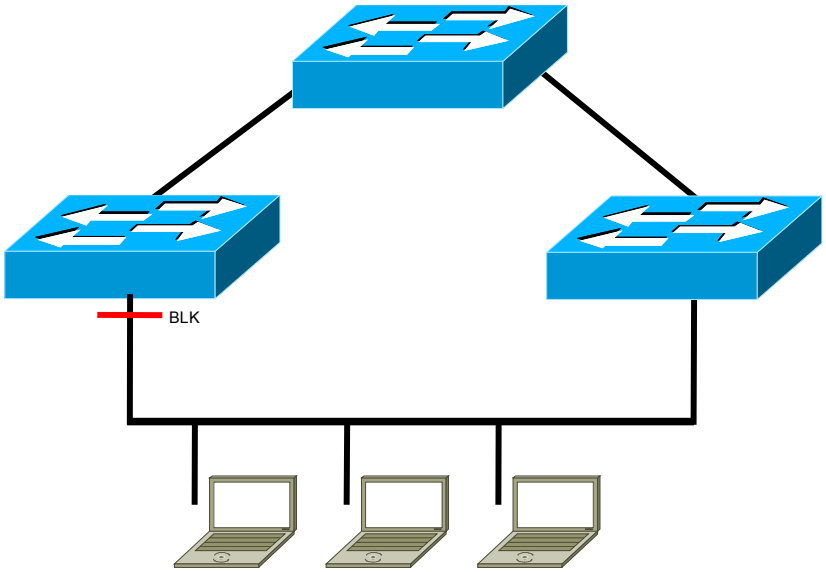
Spanning Tree

- Bridges and switches implement an algorithm according to IEEE 802.1d
- A tree that spans a whole network topology graph is continually constructed
- One of the ports on redundant links will be blocked
- In case of link/port/bridge failure, the tree will be recalculated automatically
  - Some blocked port(s) will be unblocked

Stages of Spanning Tree Algorithm

- Election of the tree root (root bridge)
  - Selected according to configured bridge priorities or factory-set Bridge ID in case of equal priorities
- Creation of the shortest paths tree (from the root bridge to every other bridge)
  - Preferences of links may be influenced by configuration of link costs
    - A link cost is set in reverse proportion to the link speed by default (faster link → lower cost)
- Ports on the tree will forward frames, other ones will be blocked

An Example:
Result of STP Operation



Terminology:

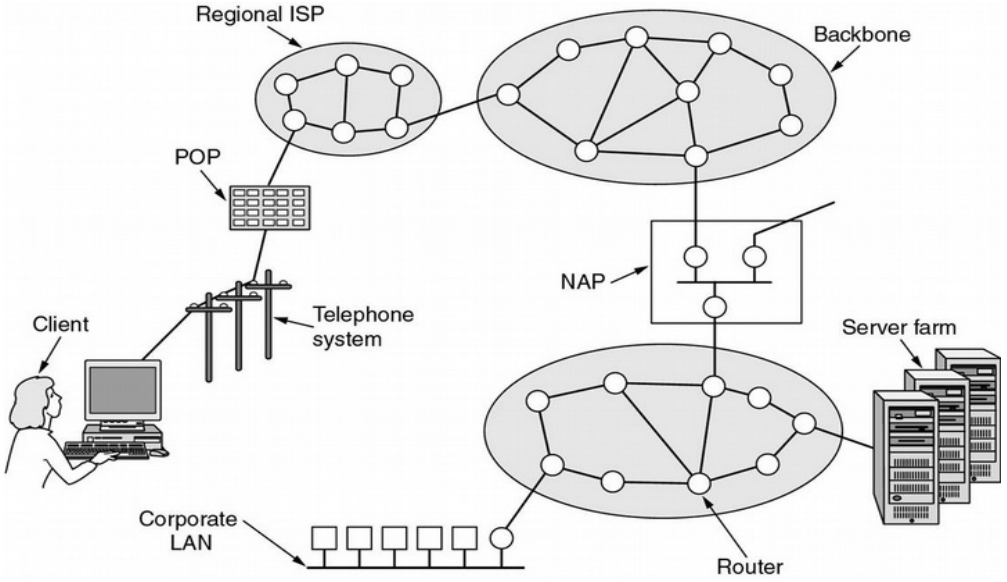
- Root port, Root Path Cost
- Designated Port
- Blocked Port

Spanning Tree: Operation in Converged State

- Root bridge generates BPDU message every 2 seconds
  - it travels down the tree
- Every bridge checks presence of BPDUs on its root port
- SPT algorithm defines transient port states (learning, listening)
  - needed to avoid temporary loops during re-convergence
- After a failure, a re-convergence may take up to 50 seconds

Networking Devices used in WAN

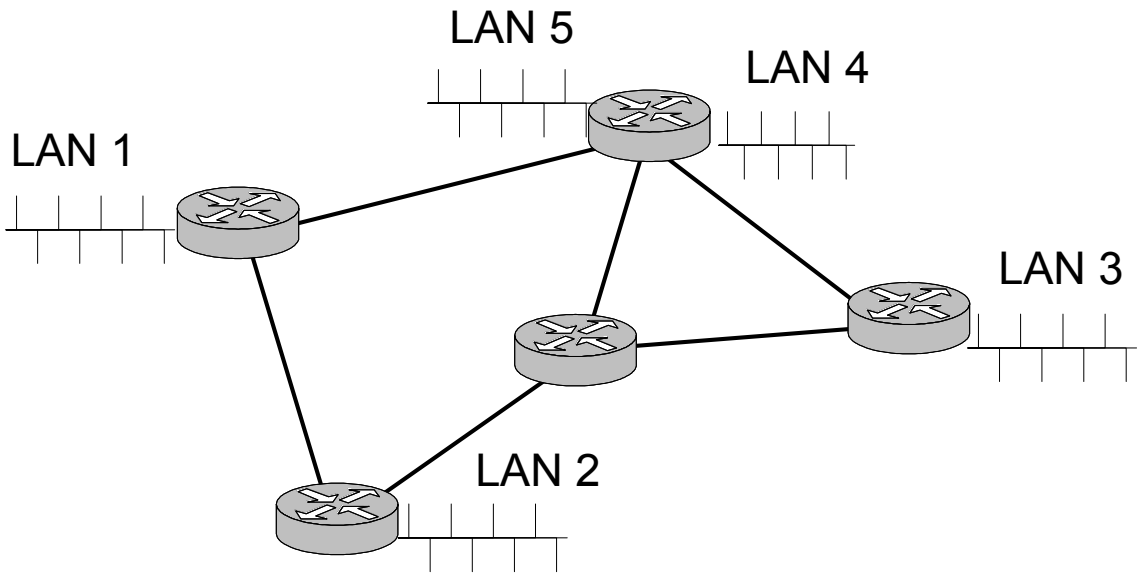
- **Router**



What is routing ?

- Forwarding packets hop by hop along the shortest path through the network to the destination
- Includes methods of finding shortest paths

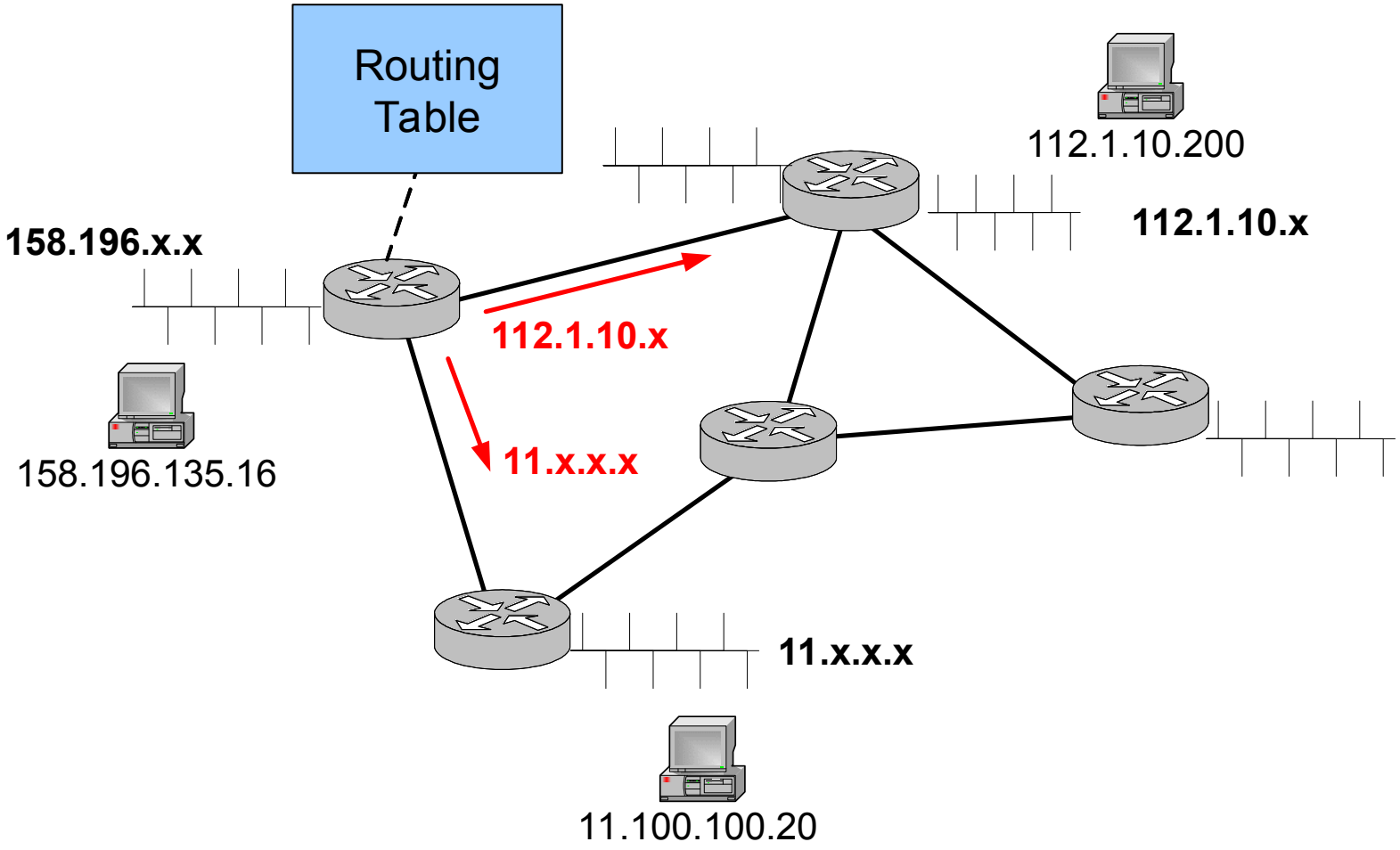
Usage of Routers



Interconnects LANs at layer 3 of OSI RM

- allows interconnection of LANs with different networking technologies (Ethernet, WiFi, ...)

Routing


Routing Table
112.1.10.200
112.1.10.x
158.196.x.x
112.1.10.x
11.x.x.x
158.196.135.16
11.x.x.x
11.100.100.20

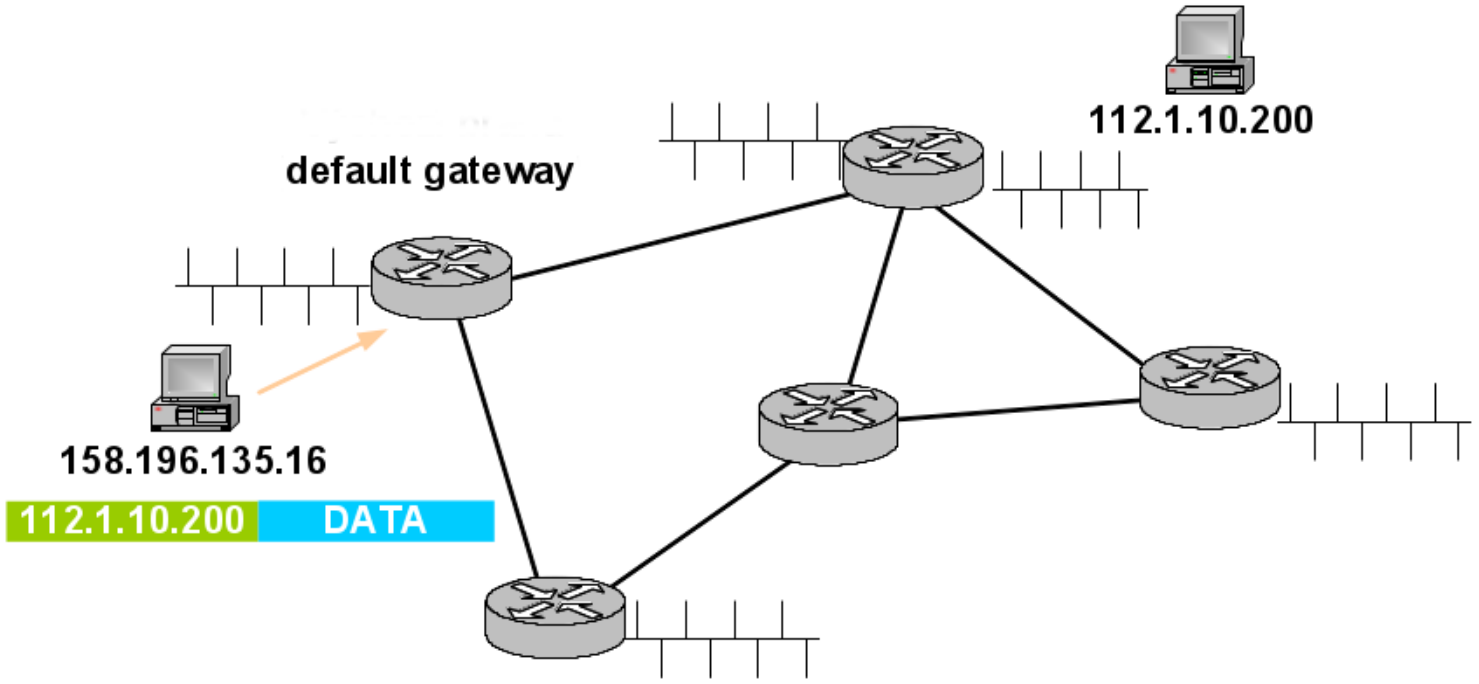
Responsibilities of a Router (1)

- Routes packets of a particular network protocol (s)
  - e.g. IP, IPv6, IPX, Apple Talk,…
  - Processes headers of the passing packets
    - e.g. decreases the Time-to-Live field of IP header used to protect against loops, recalculates checksum, processes options, etc.
- Searches the next-hop router according to destination address contained in the incoming packet header in the routing table
  - Hierarchical addressing helps to limit a number of records in the routing table
  - Packets for stations on directly connected networks are encapsulated properly and sent directly

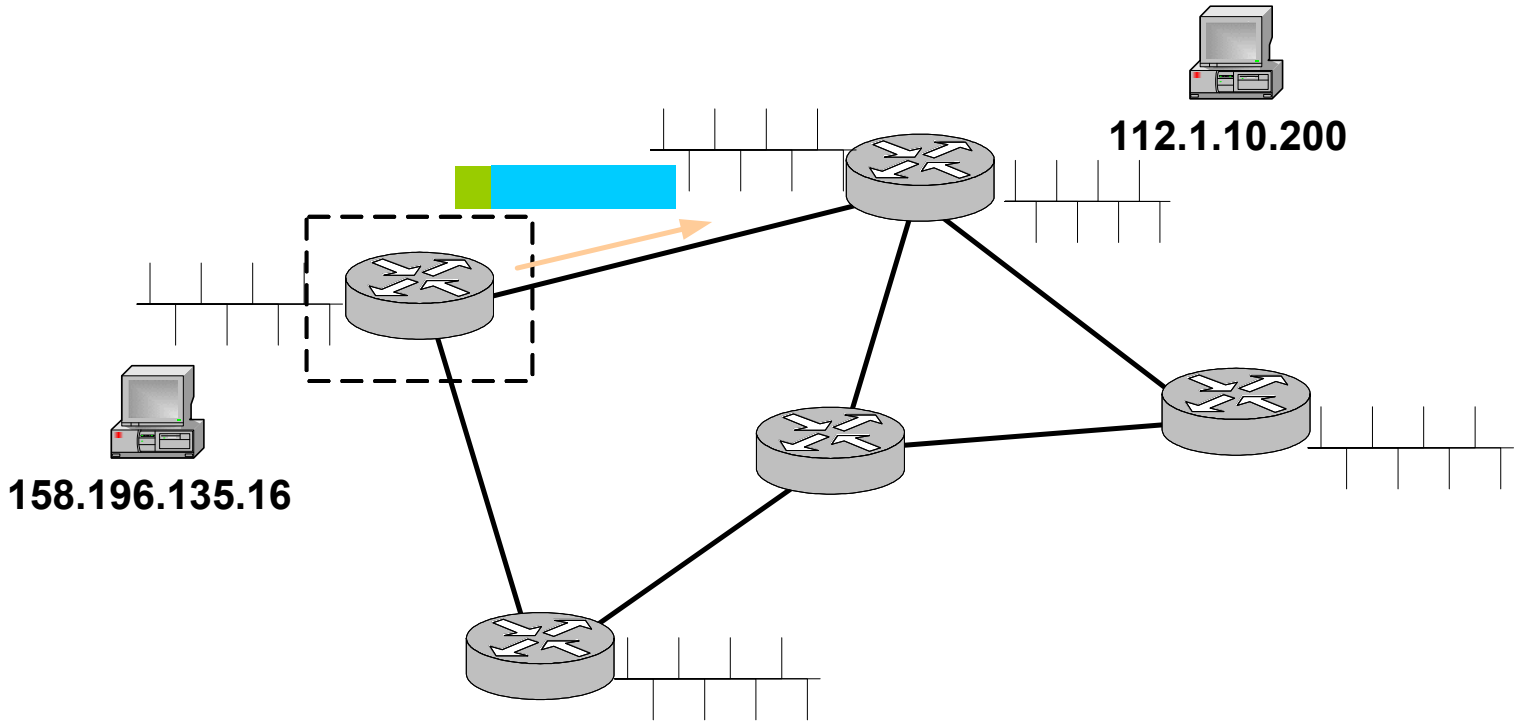
Responsibilities of a Router (2)

- The routing table may be configured manually (**static routing**) or calculated automatically based on the routing information exchange between neighboring routers (**dynamic routing**)
  - the routing information exchange is called a **routing protocol**
- A router may perform a lot of additional functions
  - Network Address Translation
  - Firewalling, IDS/IPS
  - VPN Termination
  - ...

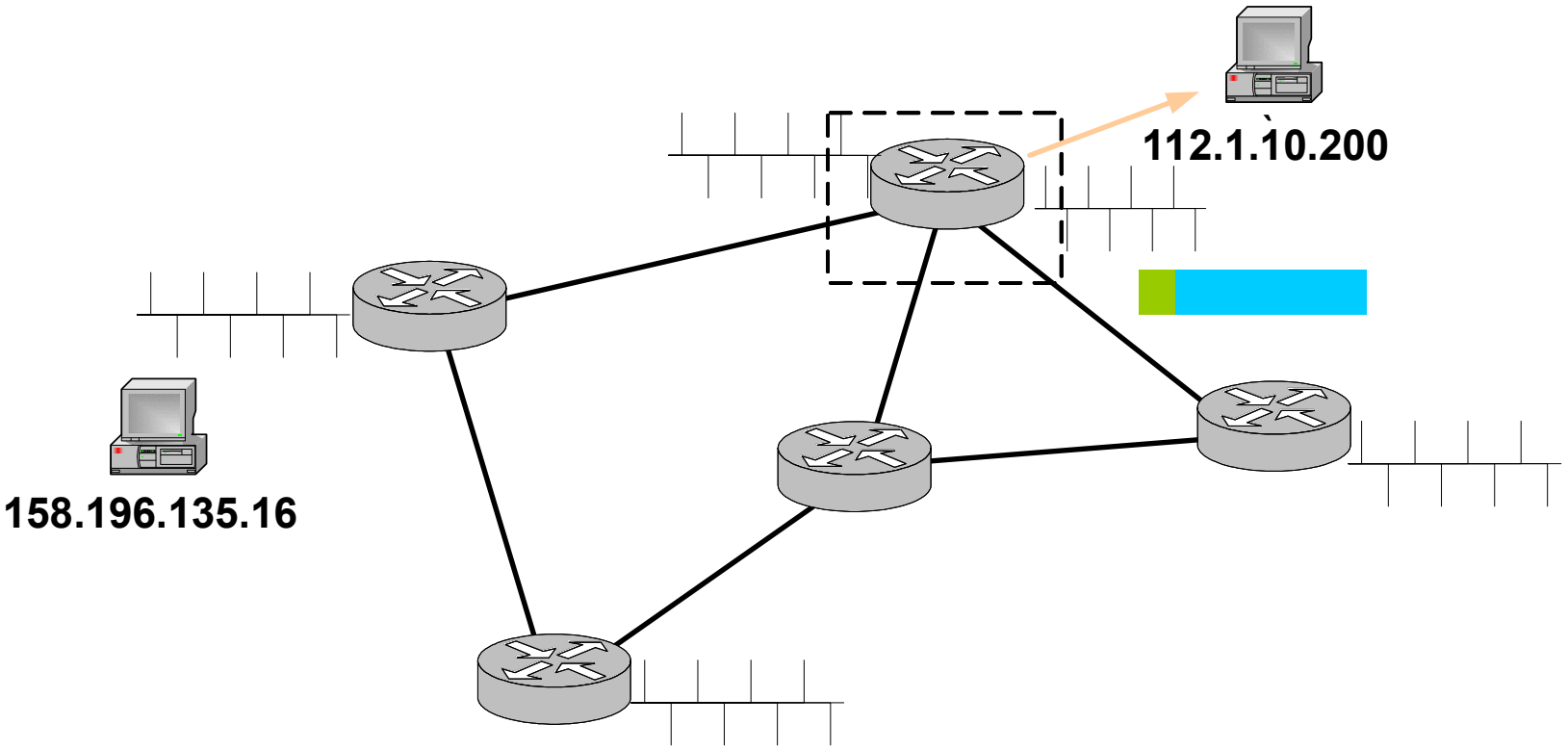
Routing of Packets over the Network (1)



Routing of Packets over the Network (2)



Routing of Packets over the Network (3)



Routing of Packets over the Network (4)