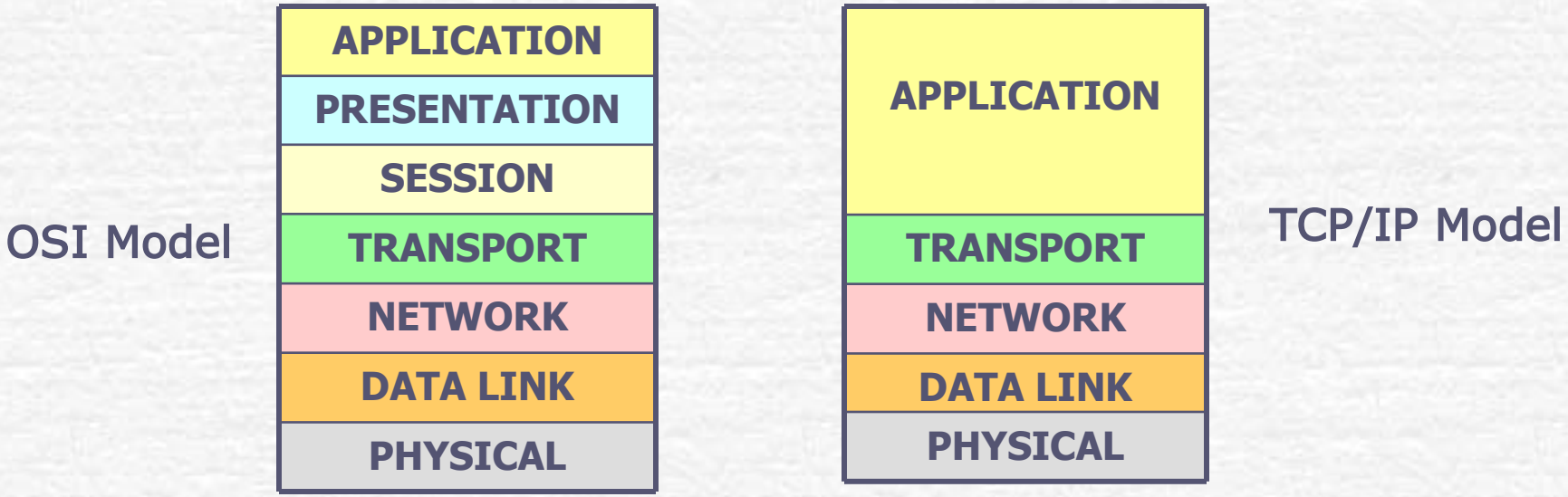
IP Based Network Concepts

IP Protocols

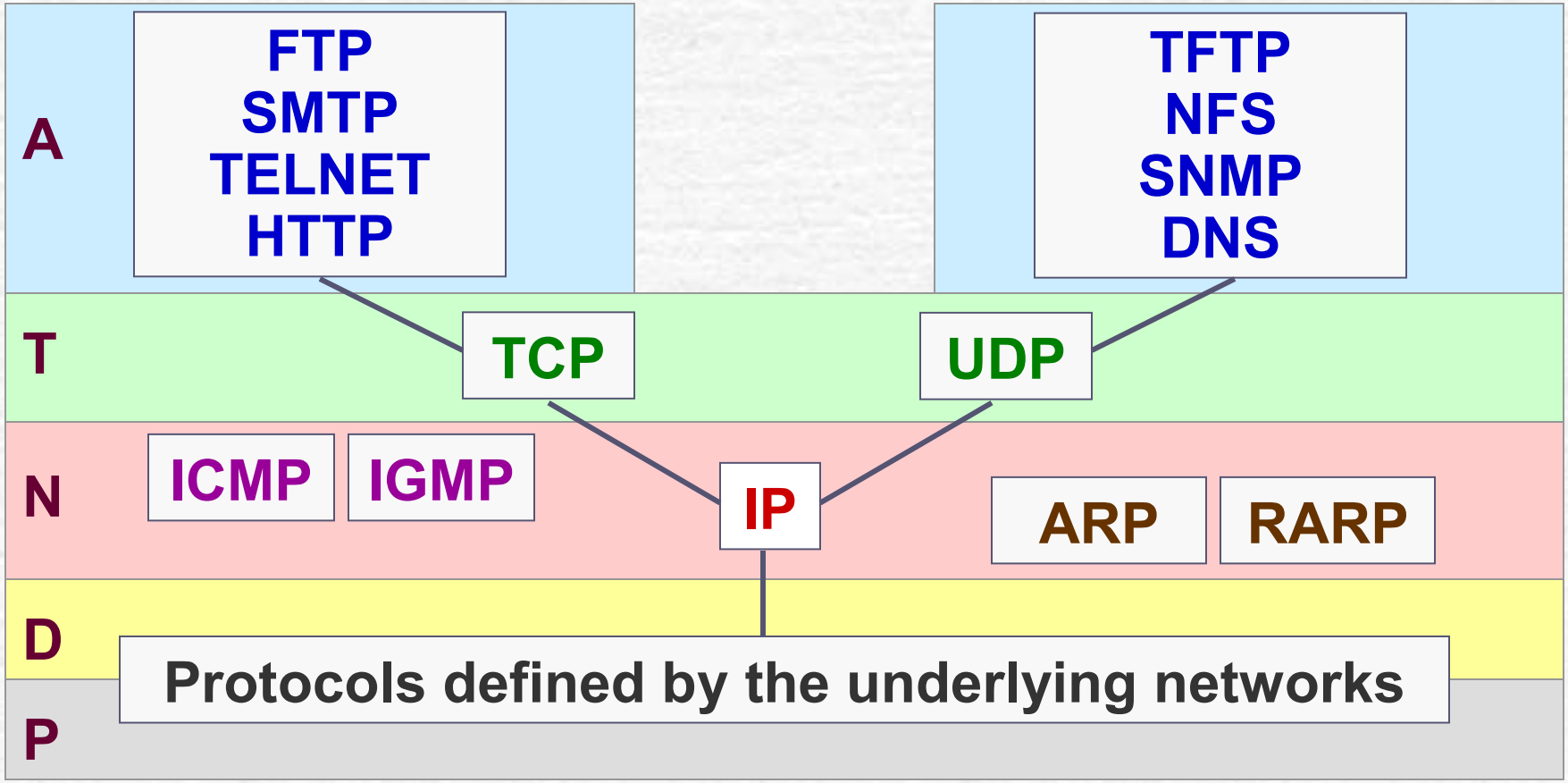
- Internet or IP technology over the years has emerged as the most prominent data communication technology.
- TCP/IP protocol has become de-facto data comm standard throughout the world.
- It can carry even voice/video also over IP protocol and in turn has started challenging the complete monopoly of TDM technology in voice communication.

TCP/IP and OSI

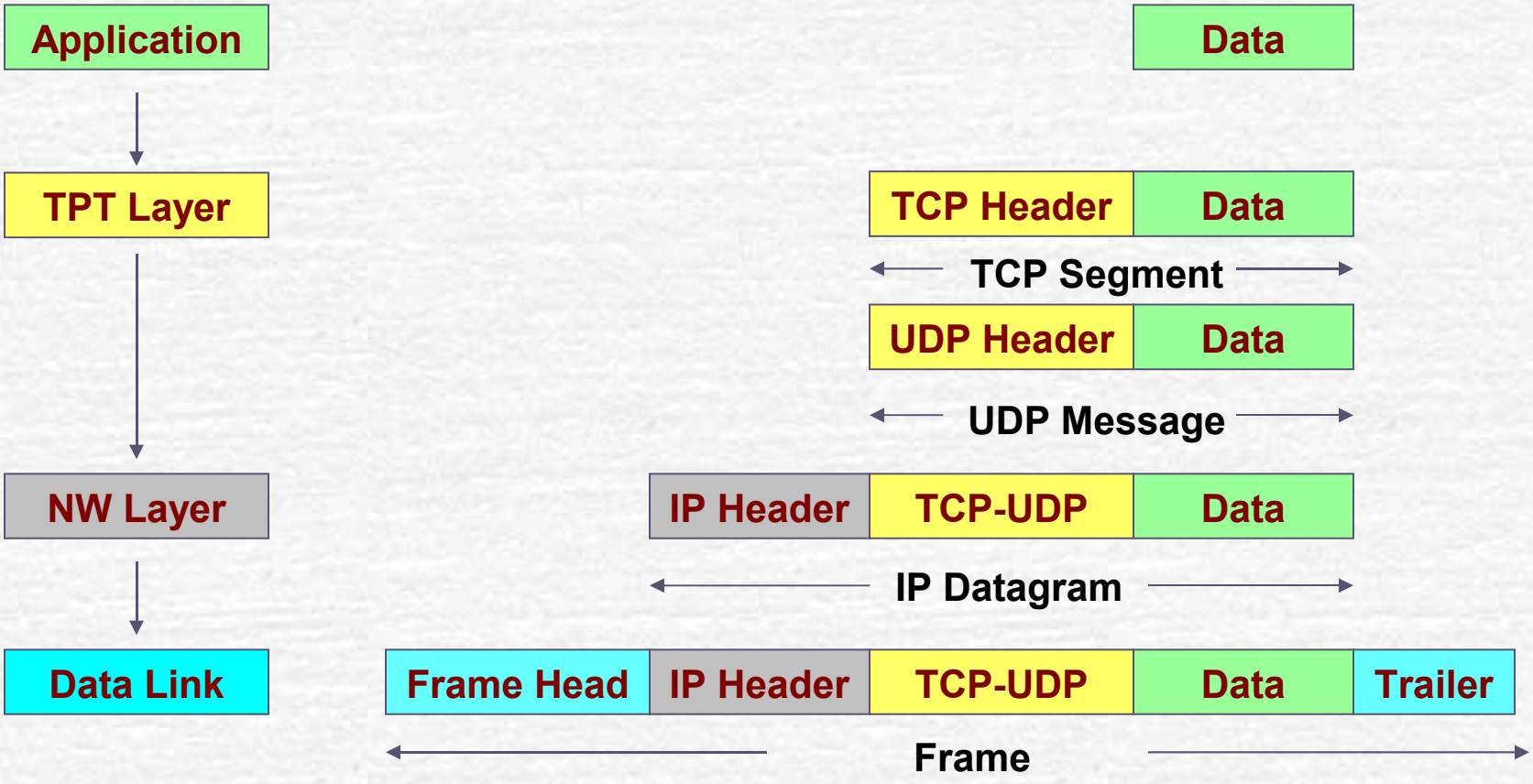
- OSI is made of seven layers.
- TCP/IP protocol is made of five layers.



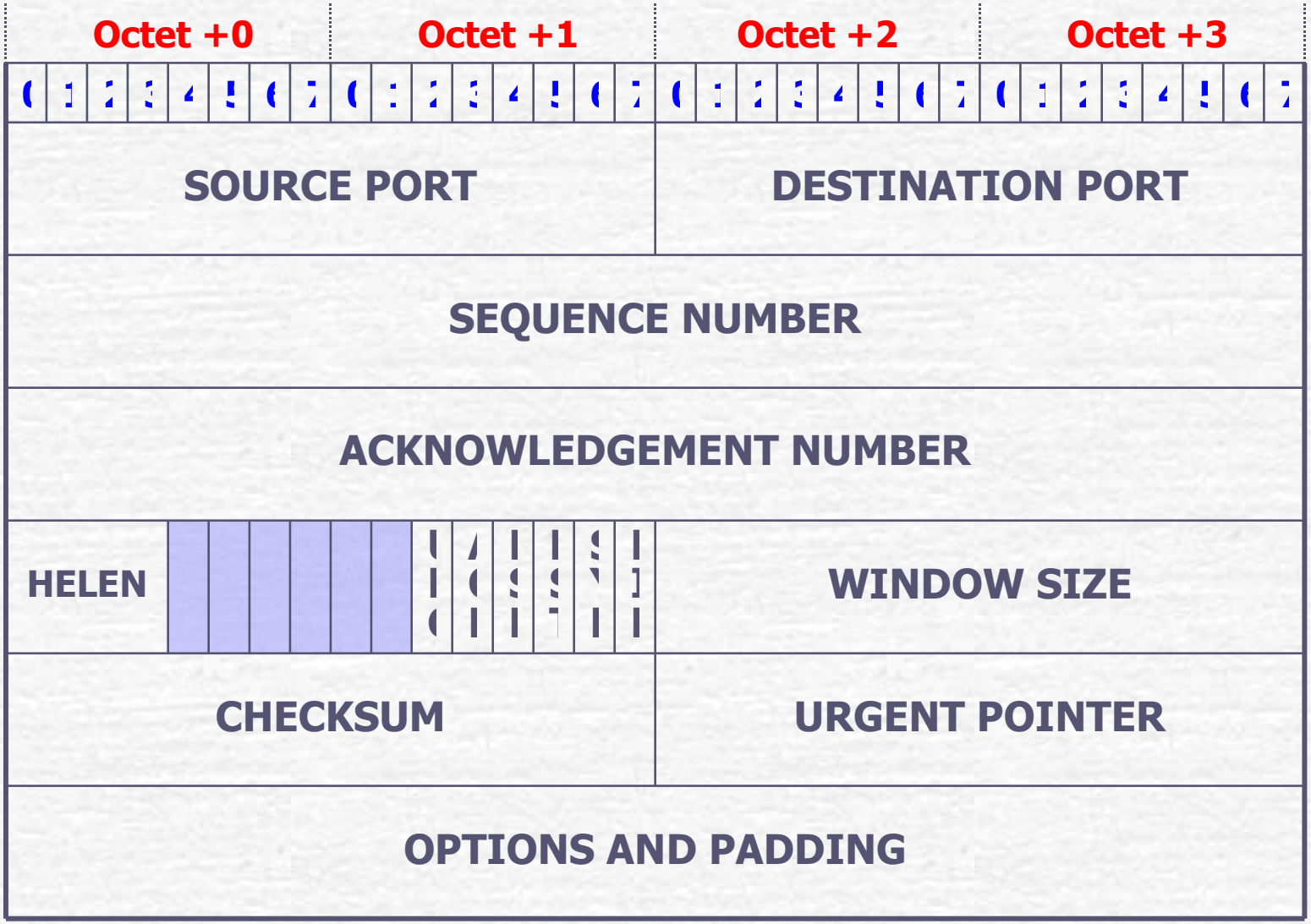
TCP/IP Protocol Suite



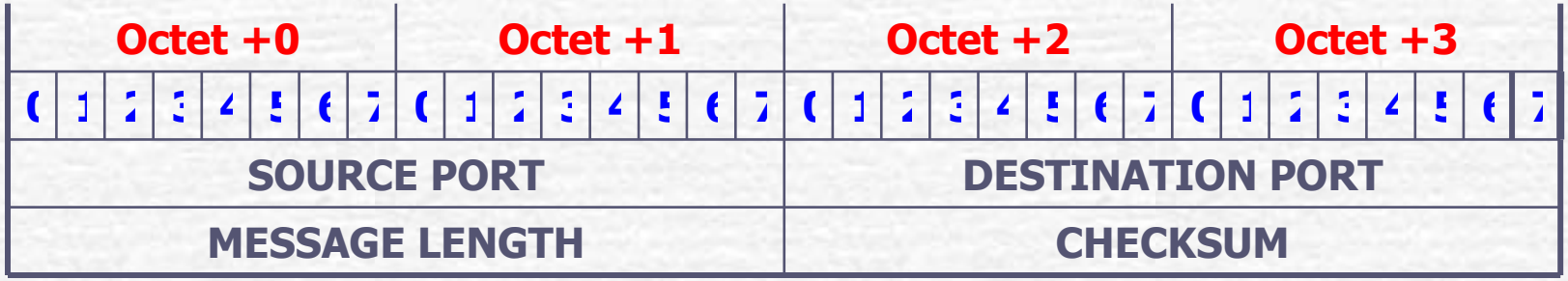
Data Encapsulation



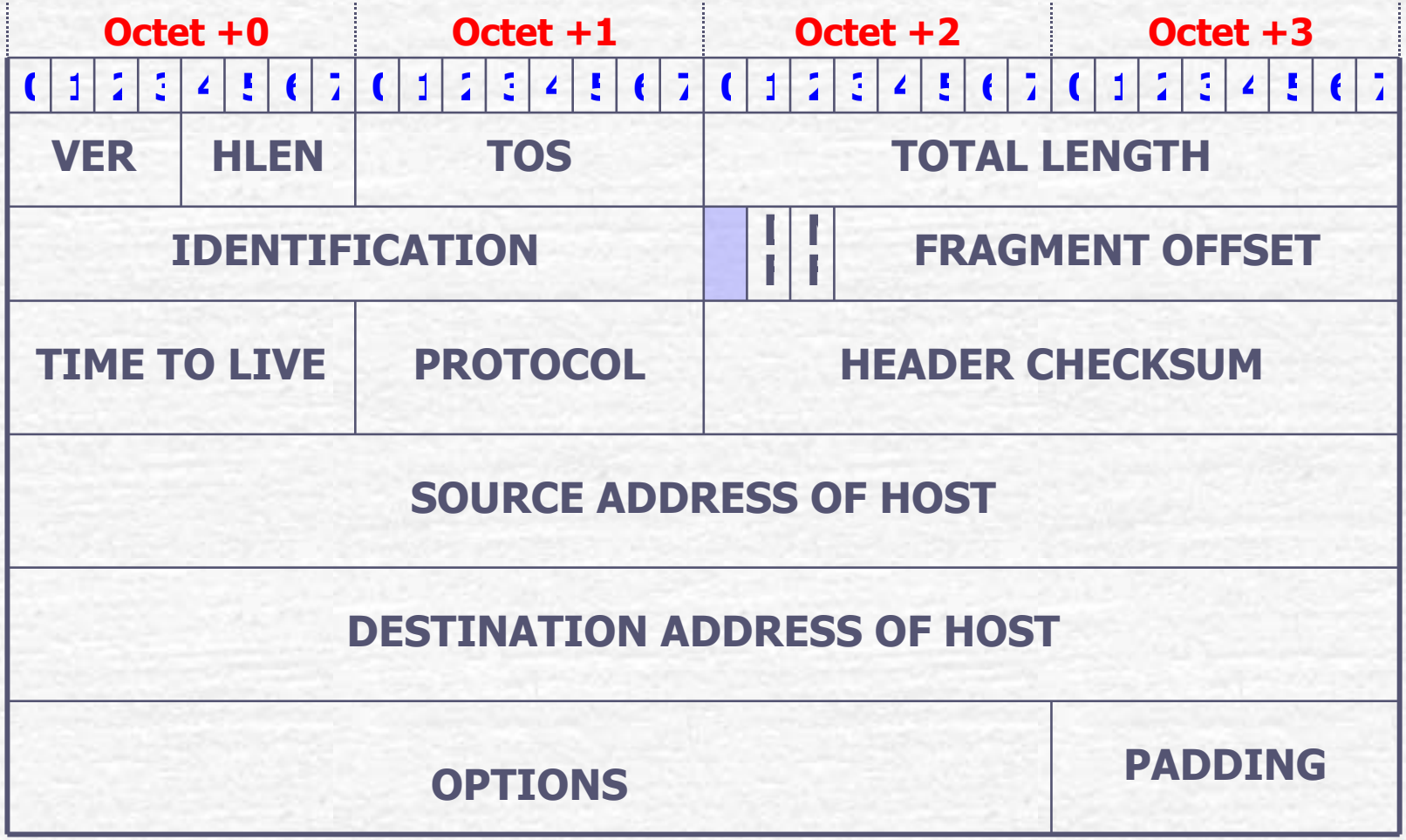
TCP Header


Octet +0
Octet +1
Octet +2
Octet +3
SOURCE PORT
DESTINATION PORT
SEQUENCE NUMBER
ACKNOWLEDGEMENT NUMBER
HELEN
WINDOW SIZE
CHECKSUM
URGENT POINTER
OPTIONS AND PADDING

UDP Header


Octet +0
Octet +1
Octet +2
Octet +3
SOURCE PORT
DESTINATION PORT
MESSAGE LENGTH
CHECKSUM

IP Header


Octet +0
Octet +1
Octet +2
Octet +3
VER
HLEN
TOS
TOTAL LENGTH
IDENTIFICATION
FRAGMENT OFFSET
TIME TO LIVE
PROTOCOL
HEADER CHECKSUM
SOURCE ADDRESS OF HOST
DESTINATION ADDRESS OF HOST
OPTIONS
PADDING

Internet Control Message Protocol

- Internet Control Message Protocol is a mechanism used by hosts and routers to send notification of datagram problems back to the sender.
- Sends error messages only to the source and not to intermediate routers.
- Sole function is to report problems, not to correct them.
- ICMP uses echo/reply to test whether a destination is reachable and responding.

ICMP..

- Echo request/reply (PING; Packet INternet Gropher)
  - Destination unreachable
    - 0-Network unreachable
    - 1-Host unreachable
    - 2-Protocol unreachable
    - 3-Port unreachable
    - 4-Fragment needed but DF bit is set
    - 5-Source route failed
    - 6-Destination network unknown

ICMP…

- 7-Destination host unknown
- 8-Source host isolated
- 9-Communication with destination network administratively prohibited
- 10-Communication with destination host administratively prohibited
- 11-Network unreachable for type of service
- 12-Host unreachable for type of service

- Time exceeded message format
  - 0-TTL exceeded
  - 1-Fragment reassembly time exceeded

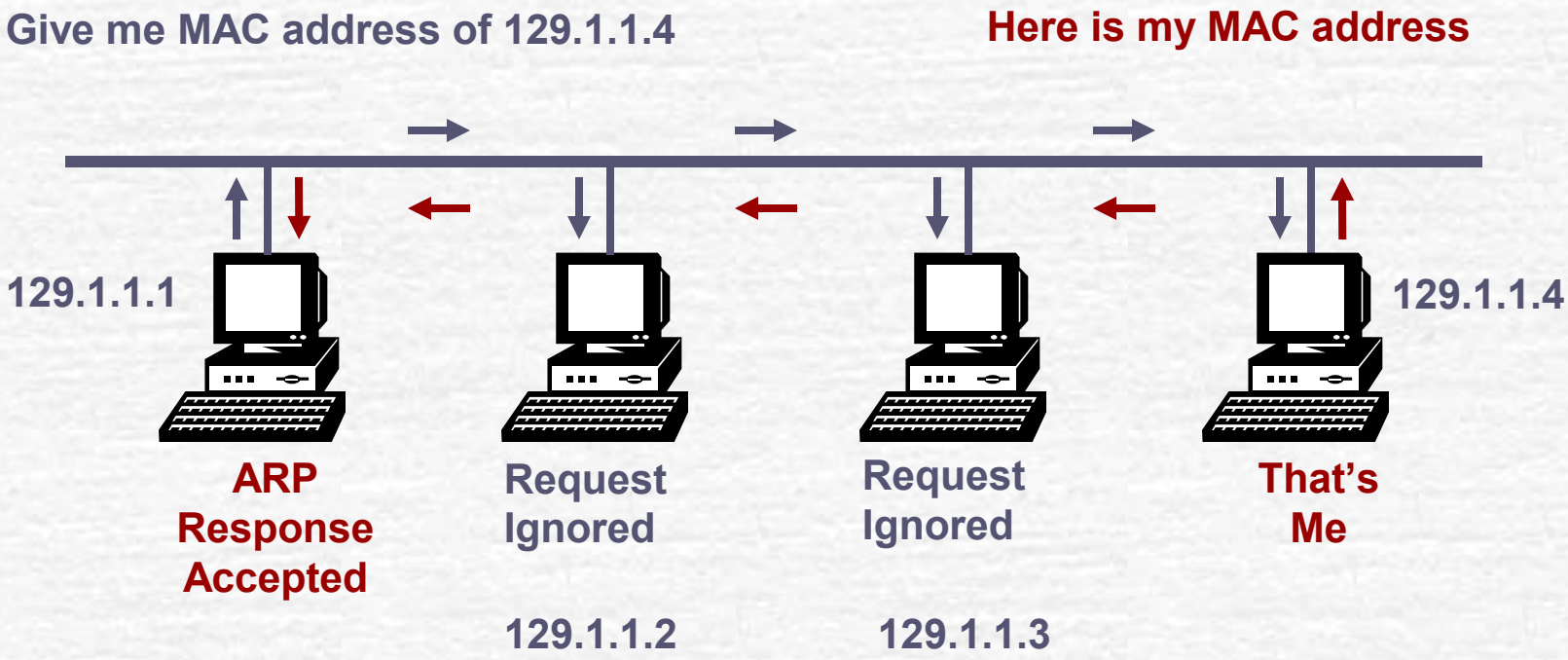
Internet Group Message Protocol

- Internet Group Message Protocol provides allows for multicast to operate on an internetwork.
  - Multicast is one-to-many communication.
  - A message sent can be simultaneously received by a group of hosts.
- Special type of Class-D IP addresses, starting with 1110, are reserved as multicast addresses.

Address Resolution Protocol

- Address Resolution Protocol is used to translate 32 bits IP addresses to 48 bits Ethernet addresses.
- A host's physical address is determined by broadcasting its IP address to all machines.
- The machine with matching IP address, in broadcast message, sends its hardware address to the machine originating broadcast.

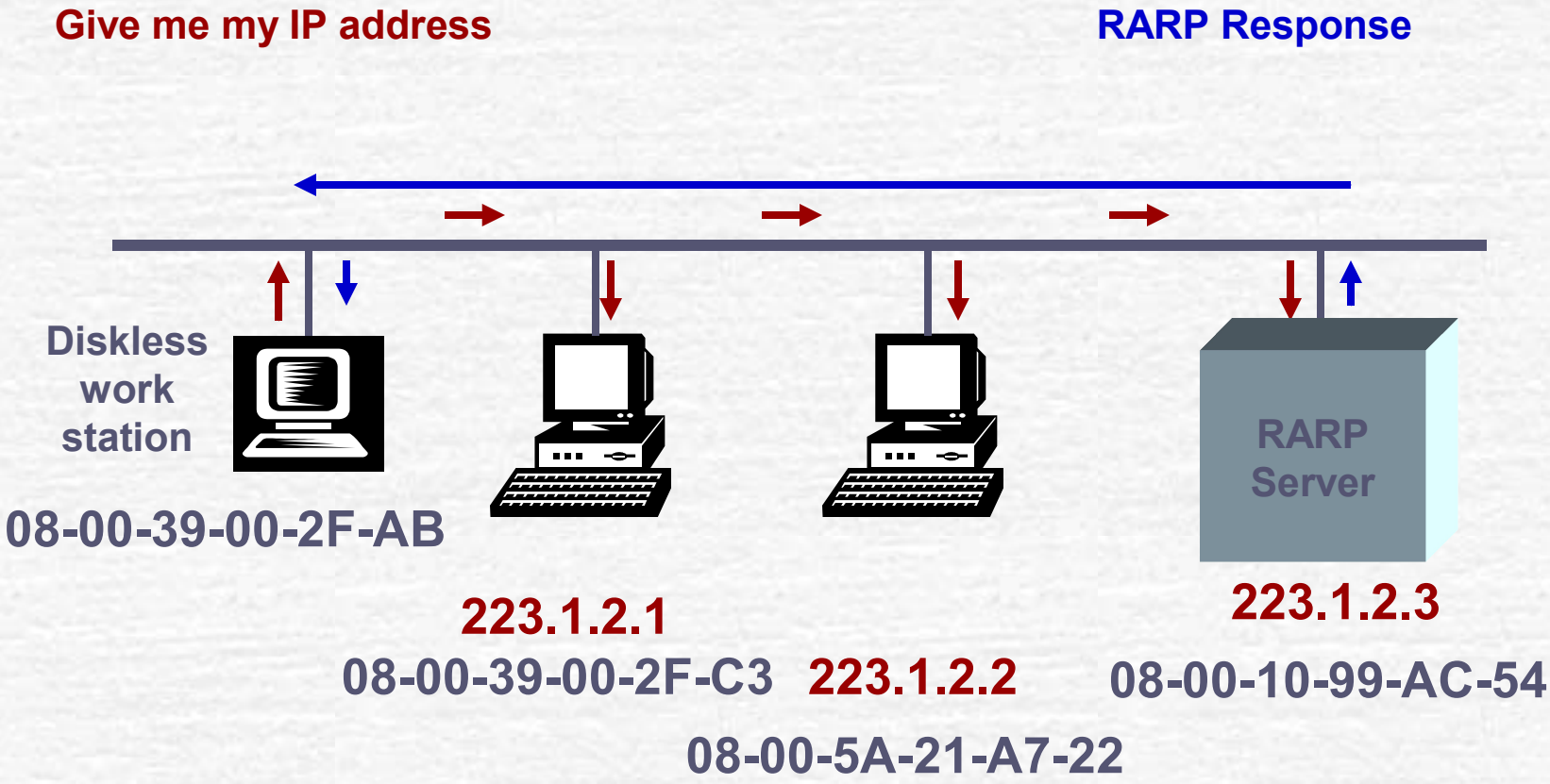
ARP Operation



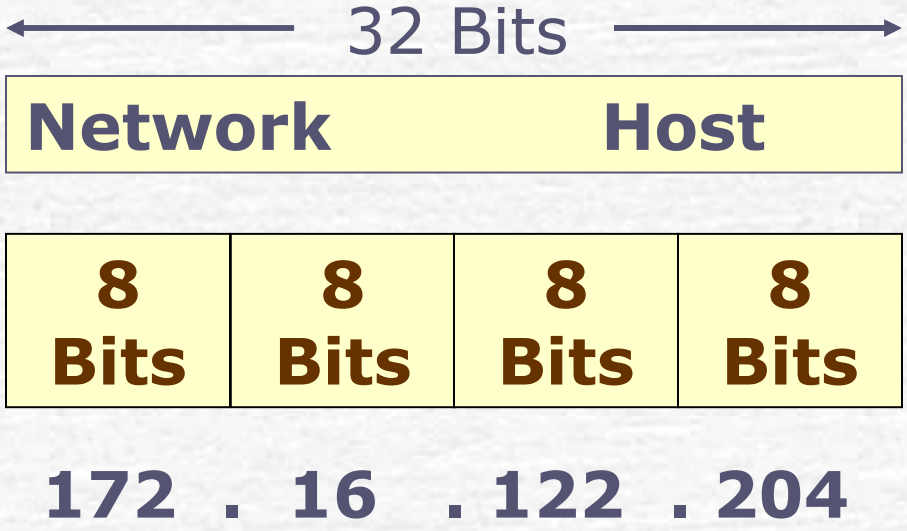
Reverse Address Resolution Protocol

- Reverse Address Resolution Protocol is used to get the 32 bits Source IP address, knowing the 48 bits Hardware address.
- It is reverse of ARP, hence named Reverse Address Resolution Protocol.
- A diskless workstation broadcasts RARP-Request to find its IP Address at the time of boot up.

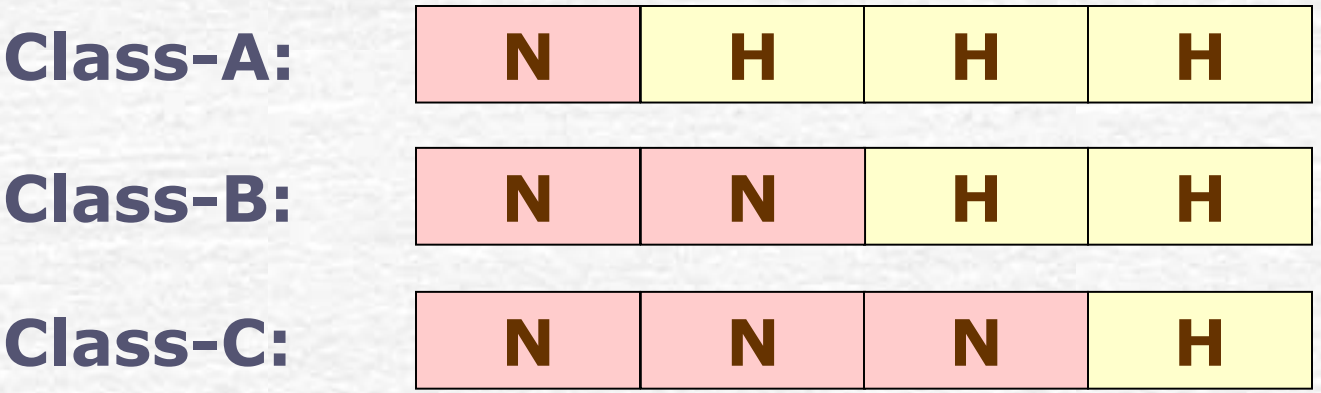
RARP Operation



IPv4 Address

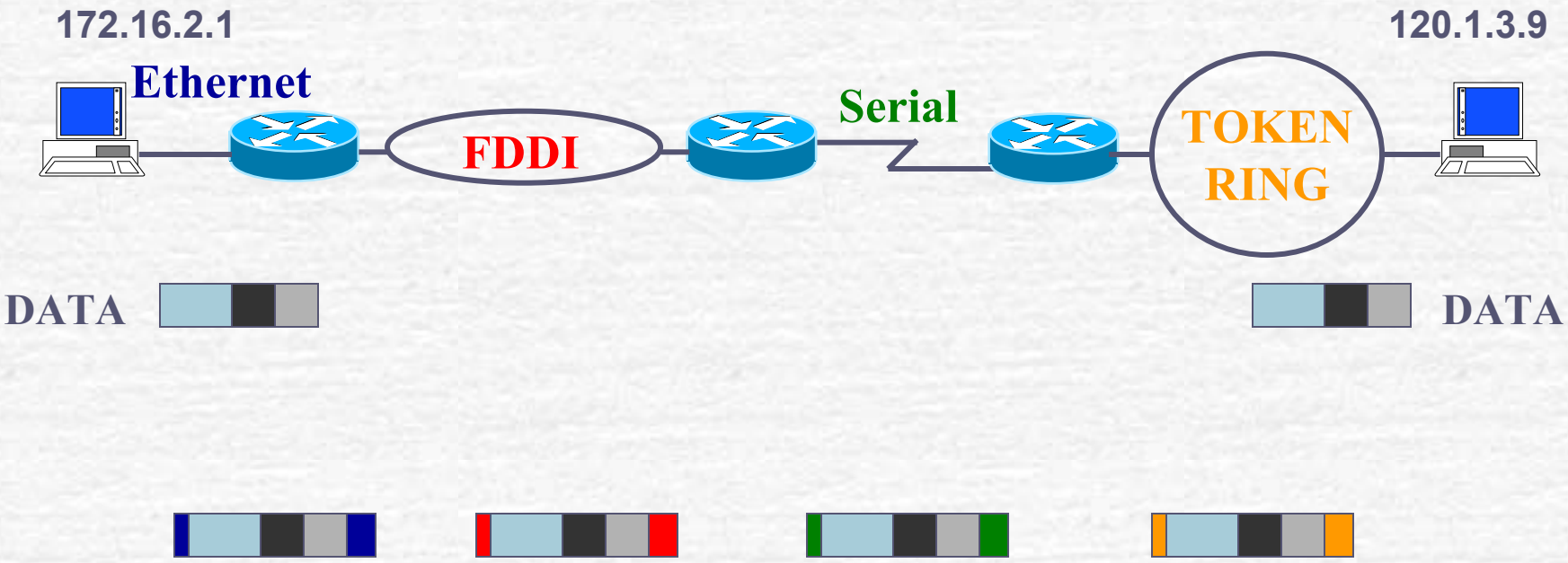


IPv4 Address Classes



Present day Internet does not use Class full addressing, Instead Classless addressing is used.

Routing



Router Basics

- For routing the router will do a route table look up.
- At a minimum, each route entry must contain two items.
  - a destination address i.e. the address of the network the router can reach.
  - a pointer to the destination.
  - the pointer will indicate the destination network directly connected to the router or

Router Basics

- the address of another router on a directly connected network.
- a router one hop closer to the destination is called a next hop router.

Router Lookup

- The router will match the most specific address it can in the descending order of specificity as below:
  - A host address
  - A subnet
  - A group of subnets
  - A major network number
  - A group of major network numbers
  - A default number

Route Table Updation

- Route table aquires information in two ways:
  - Information may be added manually, by means of static route entries or
  - Automatically by one of several systems of automatic information discovery and sharing known as dynamic routing protocols.

Static - Dynamic Routing

- Static/Non Adaptive
  - Choice of route is computed in advance, off line, and downloaded to the router when network is booted.
- Dynamic/Adaptive
  - Routing decisions change to reflect the changes in topology and/or traffic.

Static Routing

- Routes to destinations are set up manually.
- Network reachability is not dependent on the existence and state of the network.
- Route may be up or down but static routes will remain in the routing tables and traffic would still be sent towards the route.
- Not suitable for large networks.

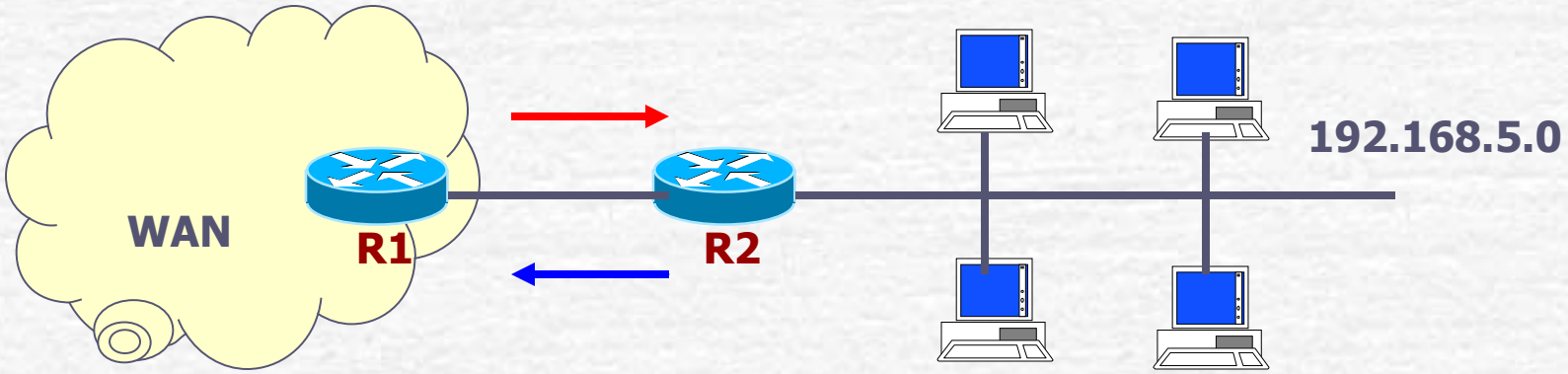
Default Routing

- When a router receives a packet and its table does not contain the network number indicated in the packet, it is forwarded to default router.
- The default router, too, may have a default router.
- If there is no route or default route at any stage, the router will send a control message (through ICMP) to the originating station.

Default Routing

- Refers to "last resort" outlet.
- Easiest form of routing for a domain connected to a single exit point.
- Default router is indicated as 0.0.0.0 with no subnet mask.

Static and Default Routing



- Traffic to network 192.168.5.0 (Static Route).
- All outgoing traffic from network 192.168.5.0 (Default Route).

Dynamic Routing

- Routes are learnt via an internal or external routing protocols.
- Network reachability is dependent on the existence and state of the network.
- If a router is down, its entry will be deleted from the routing table and traffic to that will not be forwarded.
- Used to enable routers to build their own routing tables and make appropriate decisions.

Dynamic Routing

- Each router uses the update information to calculate its own "shortest path" (distance in hops) to a network.
- Tables are updated only:
  - If the received information indicates a shortest path to the destination network.
  - If the received information indicates a network that is no longer reachable.
  - If a new network is found

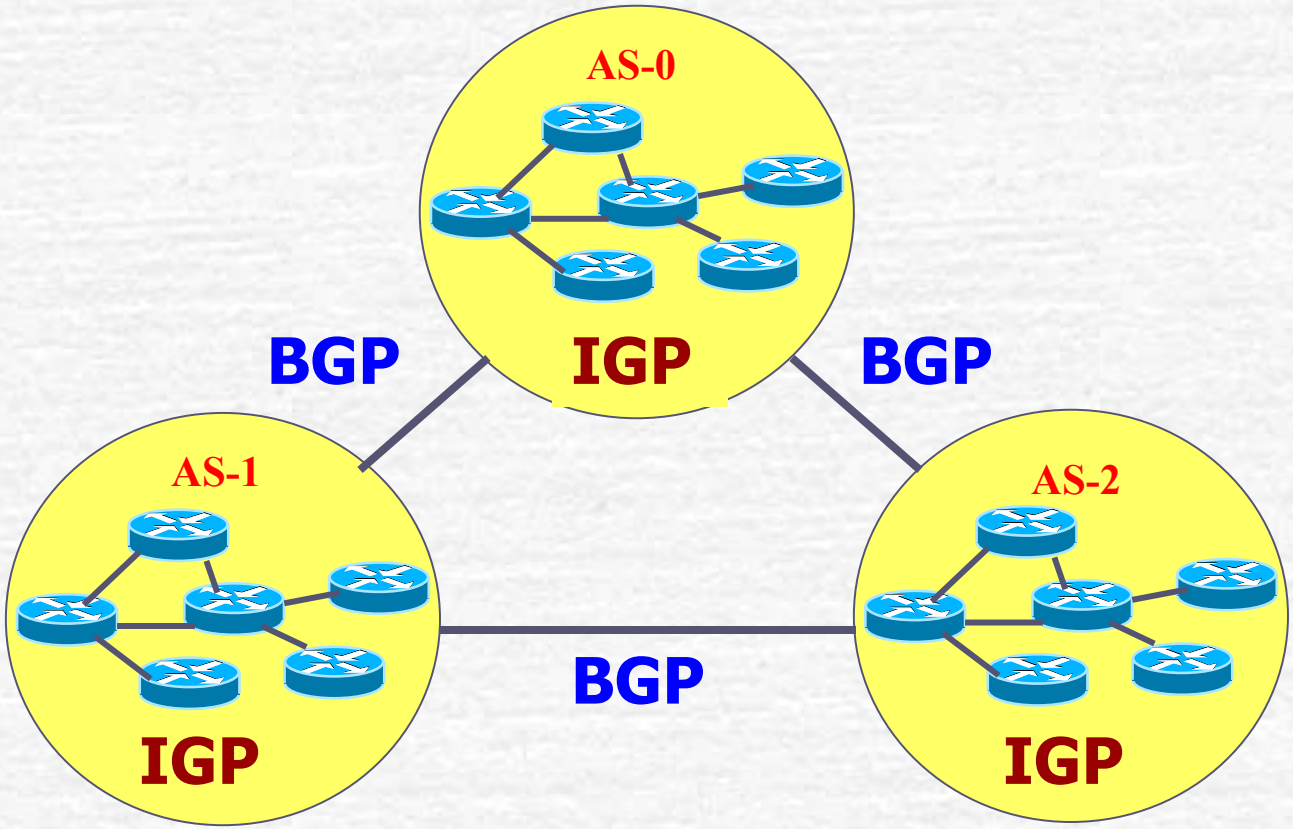
Routing Protocol

- It is a language a router speaks with other routers to share information about the reachability and status of the network.
- Provides mechanisms for sharing routing information.
- Allows the routers to communicate with other routers to update and maintain routing tables.

Routing Protocol

- Routing Protocol messages do not carry end user traffic from network to network.
- Routing Protocol uses the routed protocol to pass information between routers.
- RIP & OSPF are routing protocols.

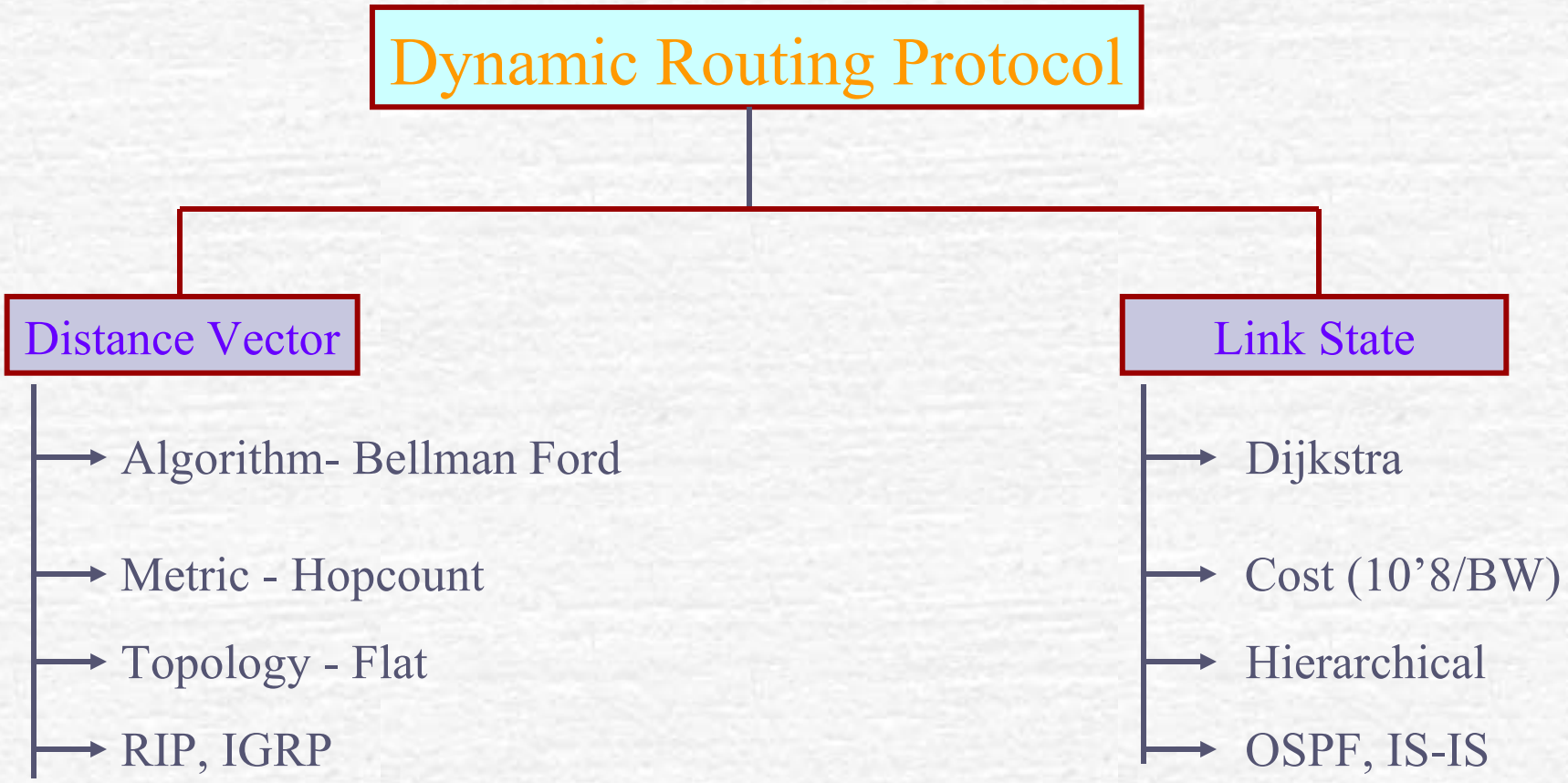
Routing Protocols



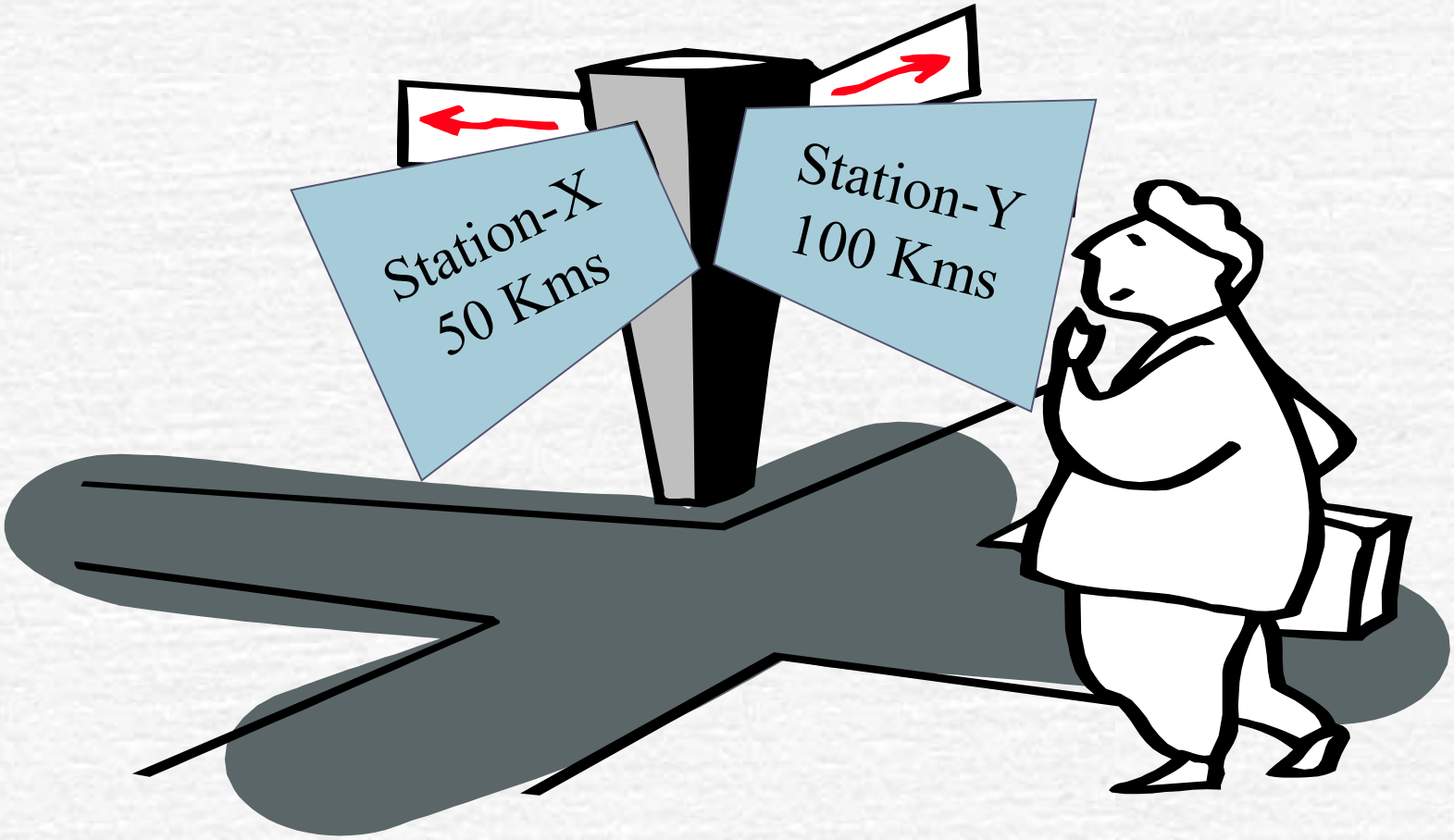
Interior-Exterior Protocols

- Interior Gateway Protocols
  - Routing Protocols which run within an Autonomous System are IGPs.
  - Distance Vector and Link State protocols are IGPs.
- Exterior Gateway Protocols
  - Routing Protocols that route between Autonomous System are EGPs.
- IGPs discover paths between networks.
- EGPs discover paths between autonomous systems.

Dynamic Routing Protocol



Distance Vector



Distance Vector

- Distance Vector means <Vector,Distance>
- Vector means the network number.
- Distance means what costs it go there.
- The distance is sometimes called metric.

Metrics

- Hop Count
- Bandwidth
- Load
- Delay
- Reliability
- Cost

Distance Vector Protocols

- Routing Information Protocol (RIP) for IP.
- Xerox Networking System's XNS RIP.
- Novell's IPX RIP.
- Cisco's Internet Gateway Routing Protocol (IGRP).
- DEC's DNA Phase IV.
- Apple Talk's Routing Maintenance Protocol (RTMP).

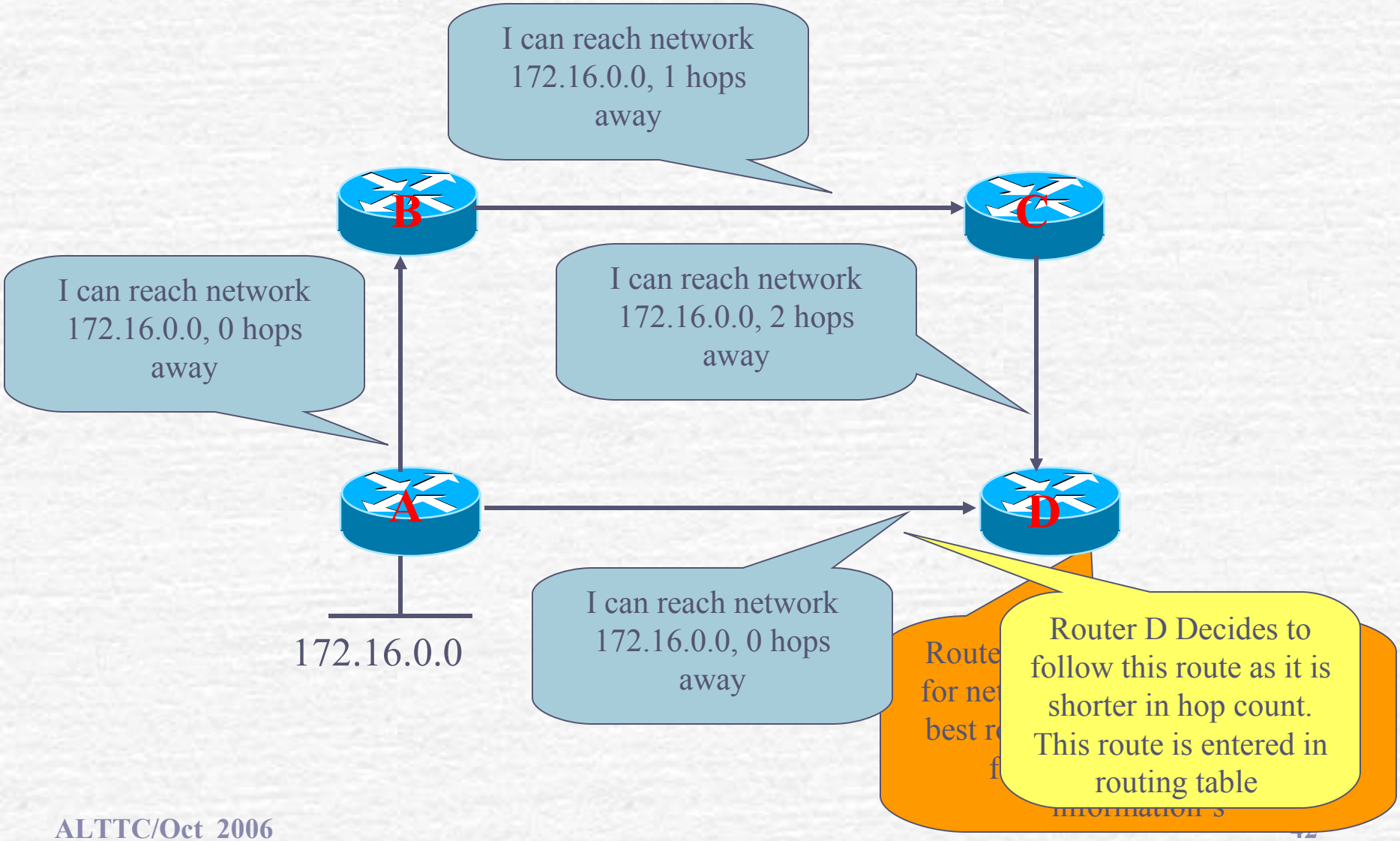
Routing Information Protocol (RIP)

- RIP is a distance vector protocol designed to serve as an IGP for the exchange of routing information within an autonomous system.
- RIP is a simple protocol suitable for use in networks of relatively small size not requiring complex metrics.
- Hop count is used as the metric for path selection
- RIP supports point-to-point links and broadcast networks
- Max. allowable hop count is 15

Routing Information Protocol

- RIP packets are carried over UDP and for routing purposes use port 520.
- Unless triggered by a configuration change RIP packets are sent every 30 seconds.
- If no update packets received within 180 seconds the distance for that route is set to infinity and will subsequently be removed from the routing table.
- The address 0.0.0.0 represents the default route to external network

Routing Information Protocol



Link State Routing

- Each router passes this information around, making a copy of it, but never changing it.
- Every router will have identical information about the internetwork.
- Every router will independently calculate its own best paths.
- Link State Routing protocols are sometimes called Shortest Path First or Distributive Database Protocols.

Link State Routing

- Link State Routing protocols are built around well known algorithm from graph theory E.W.Dijkstra shortest path algorithm.
- Examples of LSR are:
  - Open Shortest Path First (OSPF)
  - The ISO's Intermediate System to Intermediate System (IS-IS) for IP
  - DEC's DNA Phase V
  - Novell's Netware Link State Protocol (NLSP)

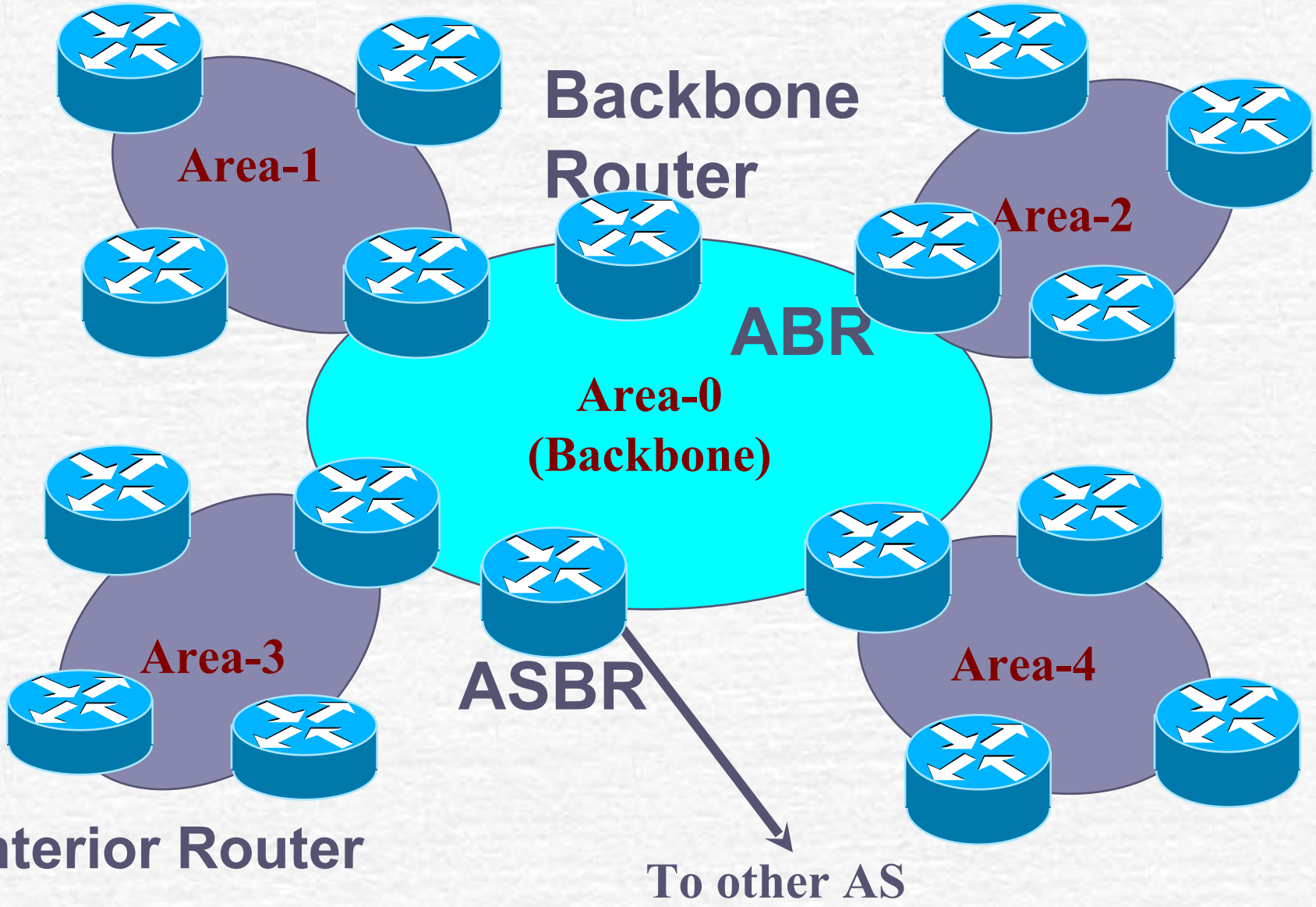
Open Shortest Path First (OSPF)

- Link State Protocol
- Supports VLSM, IP Classless(CIDR)
- Open (non-proprietary)
- Interior Gateway Protocol (IGP)
- Current Version is 2 (defined in RFC 1247)
- Latest RFC 2328 deletes TOS routing which is not widely used
- Uses SPF algorithm to calculate Shortest path tree (Dijkstra's Algorithm)

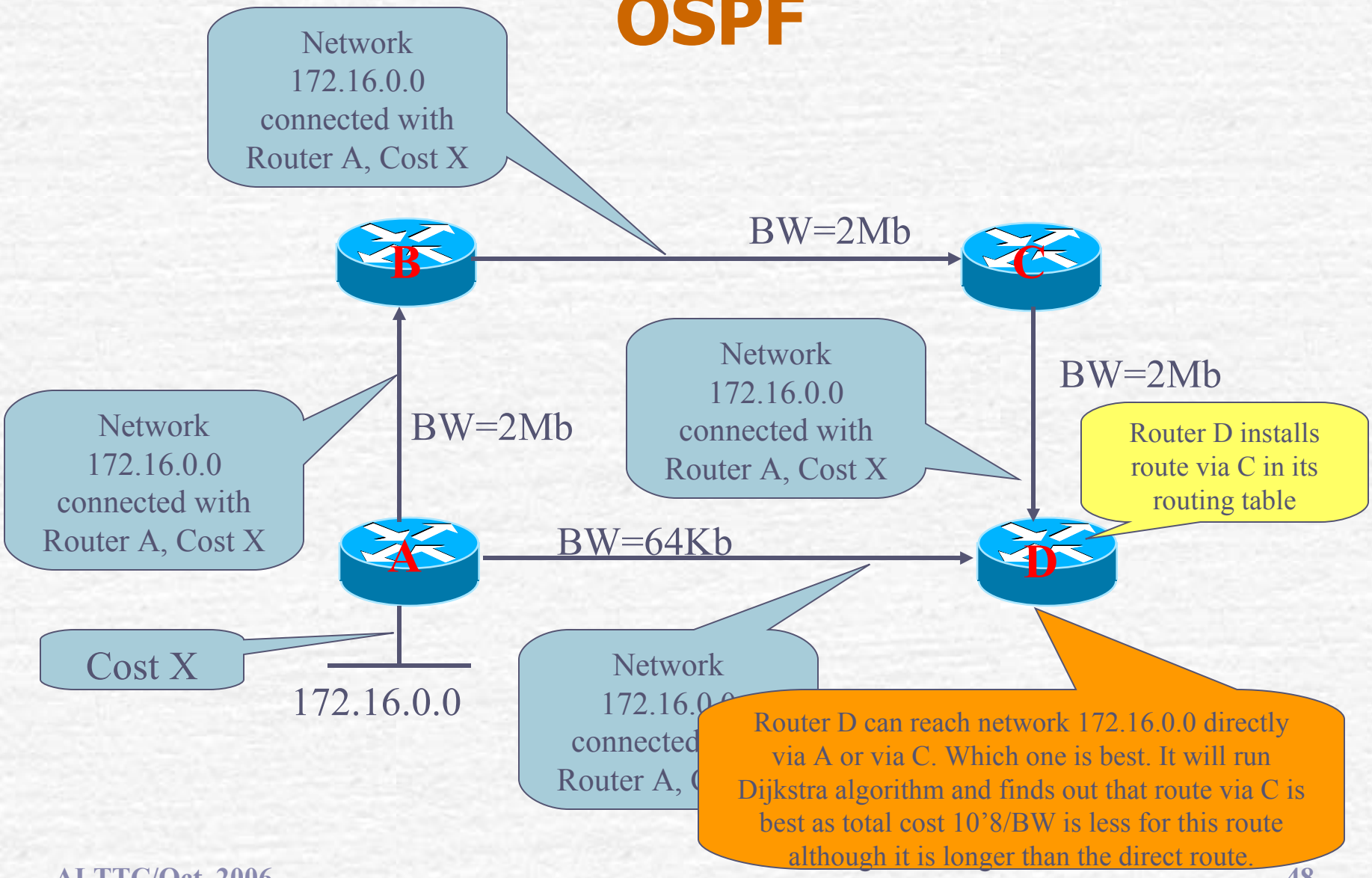
OSPF Features

- Hierarchical routing topology
- Uses Multiple Areas within an Autonomous System (AS)
- Area 0 is backbone area
- All other Areas are connected to Area 0 directly
- Less CPU / Memory and less protocol data traffic
- Supports VLSM, CIDR
- Supports Authentification for secure routing

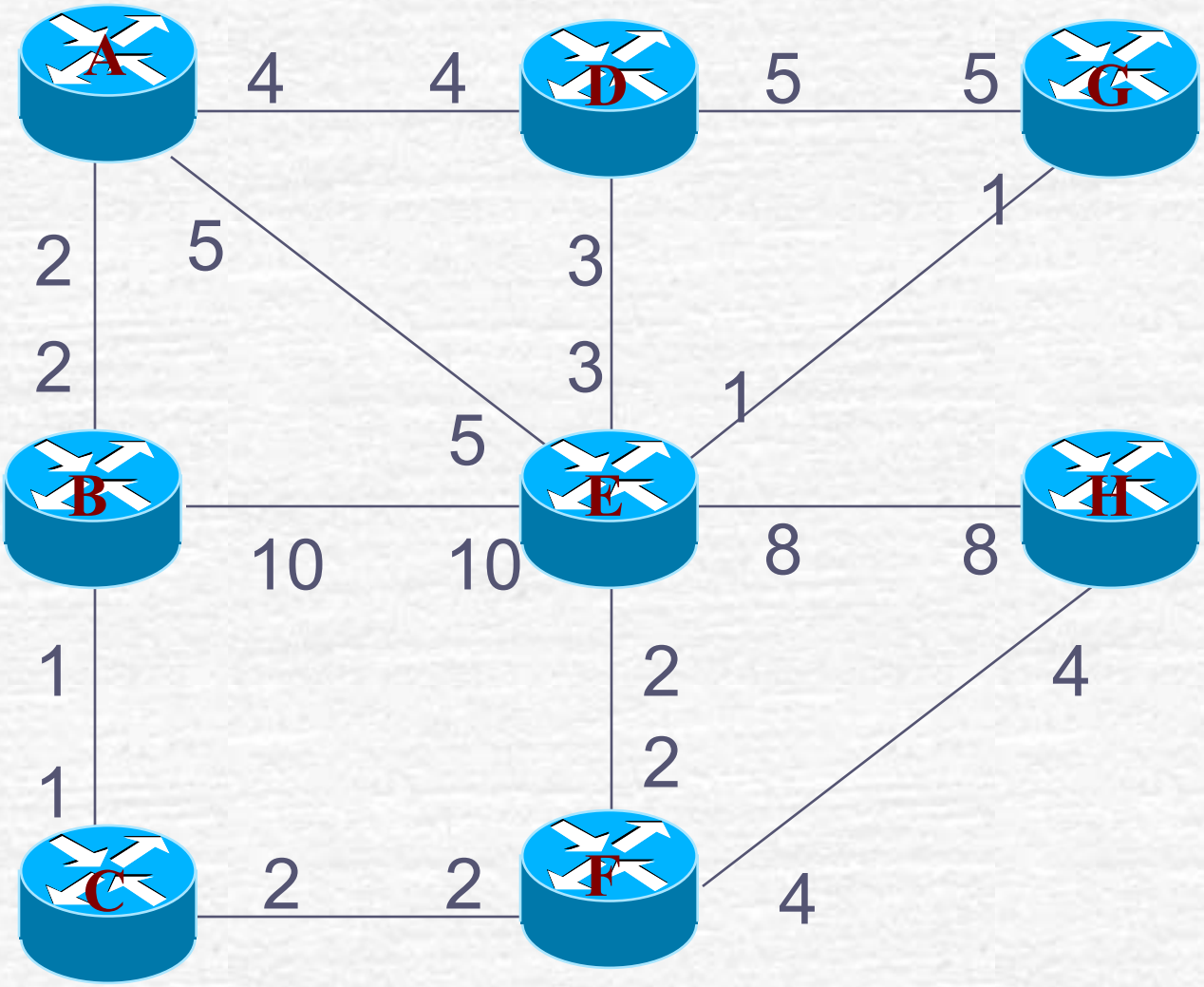
OSPF Areas


Area-1
Backbone Router
Area-2
ABR
Area-0 (Backbone)
Area-3
ASBR
Area-4
Interior Router
To other AS

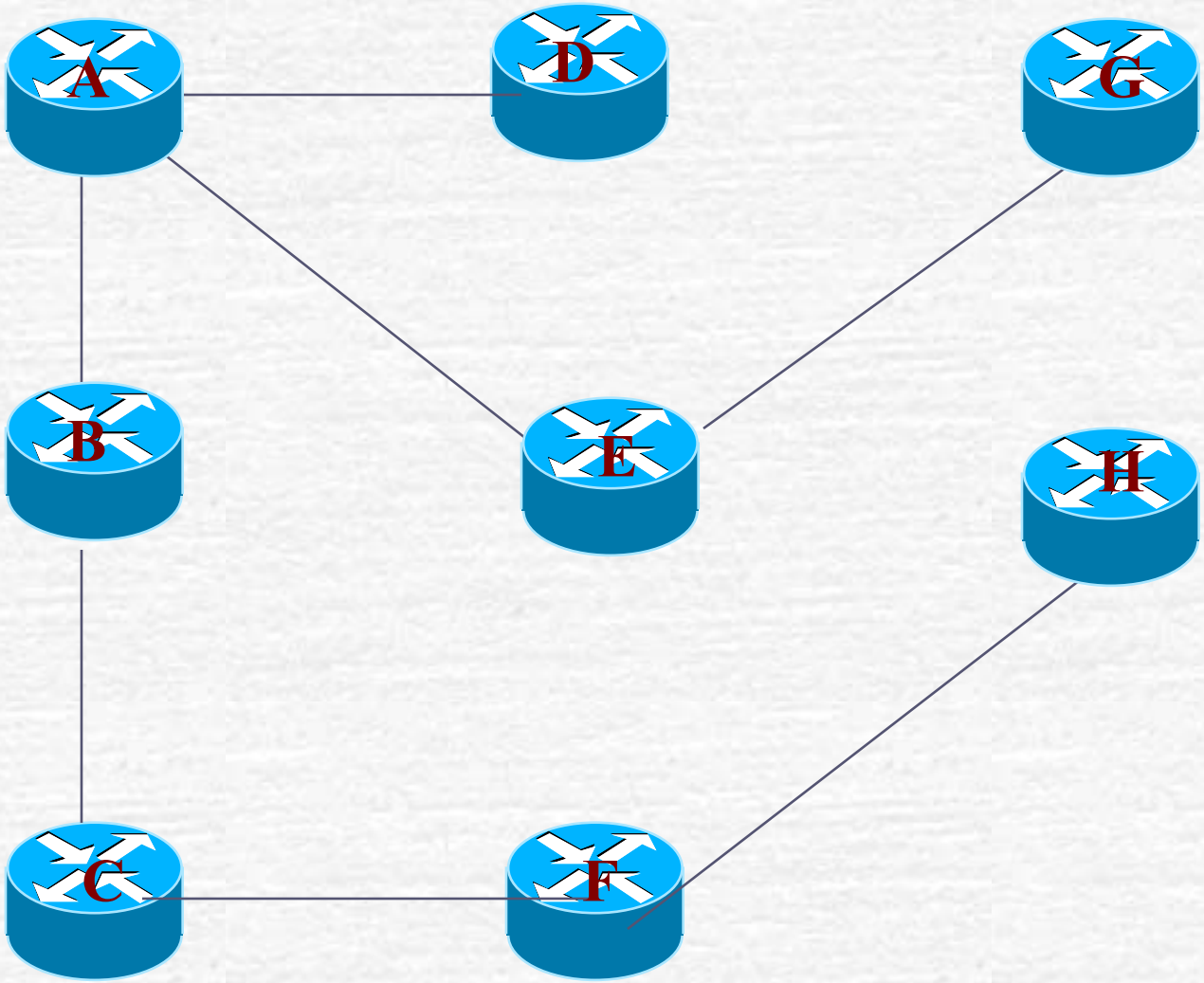
OSPF


Network 172.16.0.0 connected with Router A, Cost X
BW=2Mb
B
C
Network 172.16.0.0 connected with Router A, Cost X
BW=2Mb
Network 172.16.0.0 connected with Router A, Cost X
BW=2Mb
Router D installs route via C in its routing table
A
BW=64Kb
D
Cost X
172.16.0.0
Network 172.16.0.0 connected Router A,
Router D can reach network 172.16.0.0 directly via A or via C. Which one is best. It will run Dijkstra algorithm and finds out that route via C is best as total cost 10'8/BW is less for this route although it is longer than the direct route.

SPF Algorithm



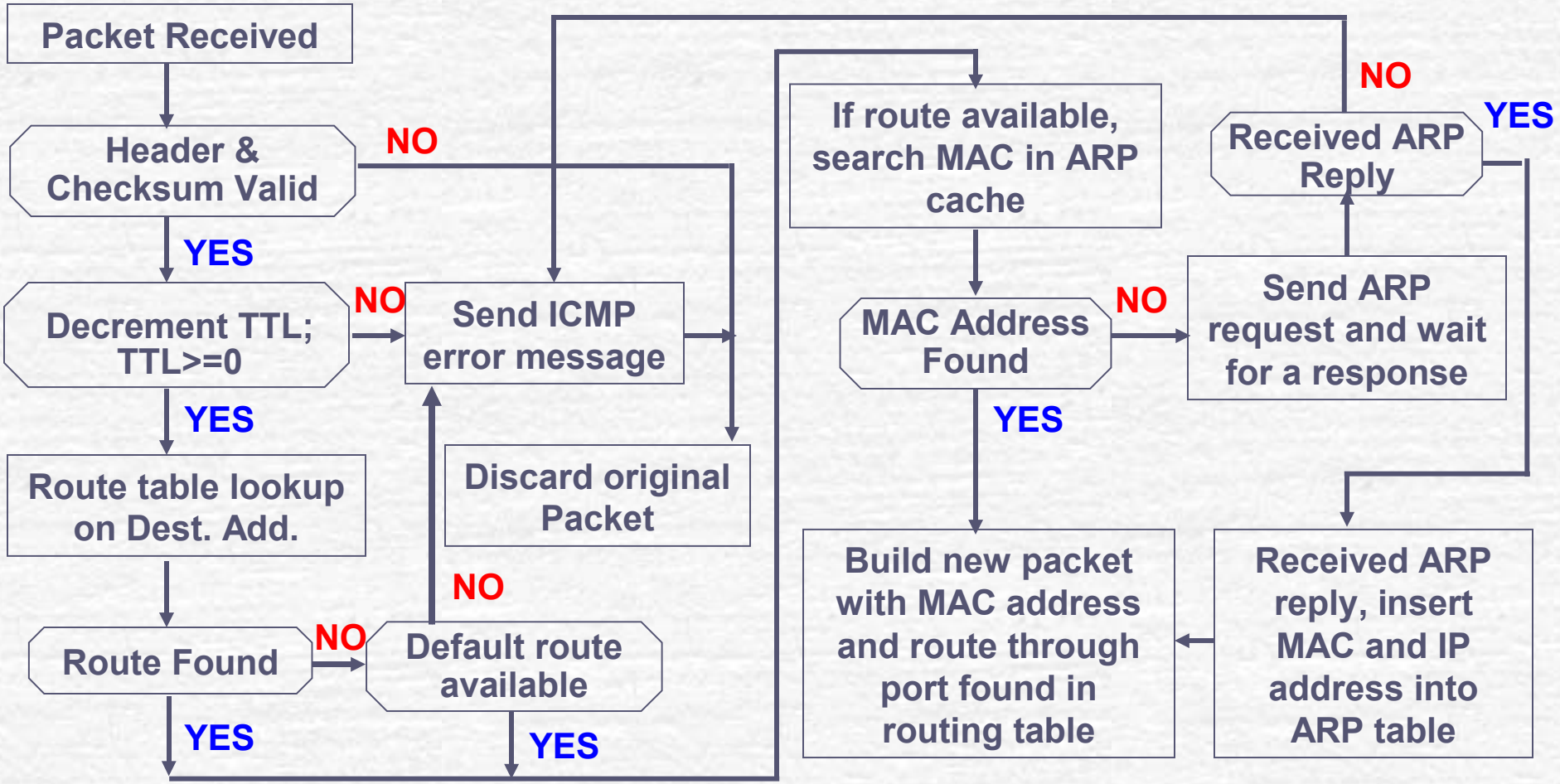
Shortest Path Tree



OSPF Packet Types

Type Code	Description
1	Hello
2	Database Description
3	Link State Request
4	Link State Update
5	Link State Acknowledgement

Flow Chart of a Packet



Thank You !