Δίκτυα Υπολογιστών

Πρόγραμμα Μεταπτυχιακών Σπουδών:
Τεχνο – Οικονομικά Συστήματα

Καθηγητής Συμεών Παπαβασιλείου

Εθνικό Μετσόβιο Πολυτεχνείο
Τμήμα Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών
Τομέας Επικοινωνιών, Ηλεκτρονικής & Συστημάτων Πληροφορικής

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Βιβλίο Αναφοράς: TCP/IP Illustrated, Vol. I, by W.R. Stevens (Addison Wesley)

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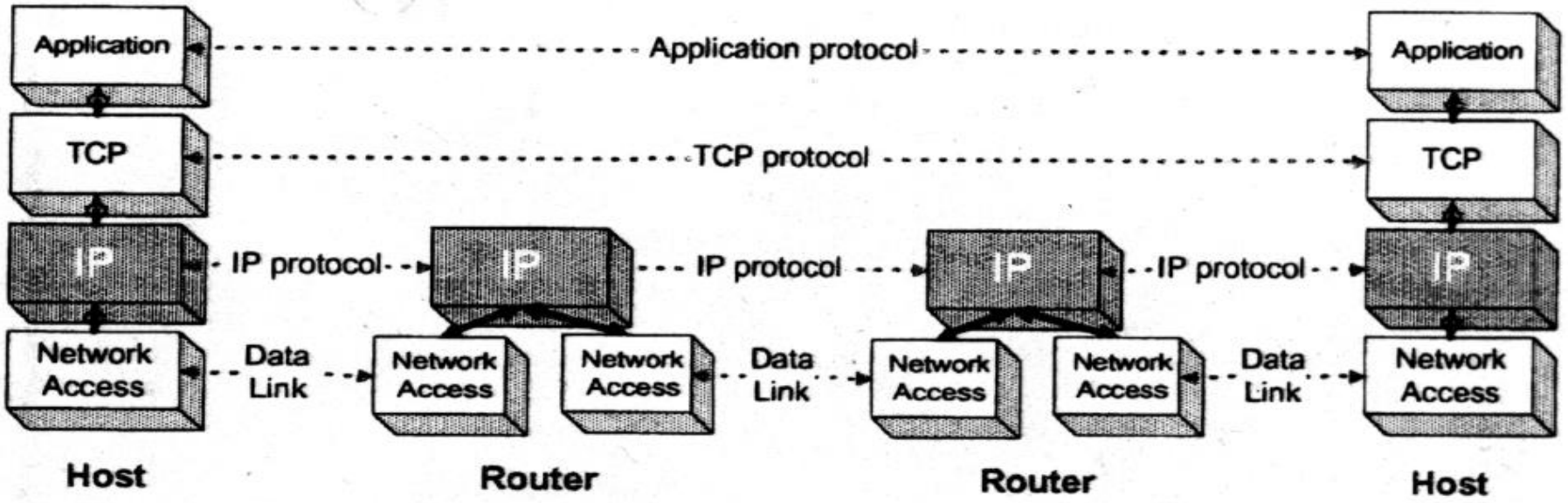
Επίπεδο Δικτύου

Introduction of IP Protocol

IP is the highest layer protocol that is implemented at both routers and hosts:

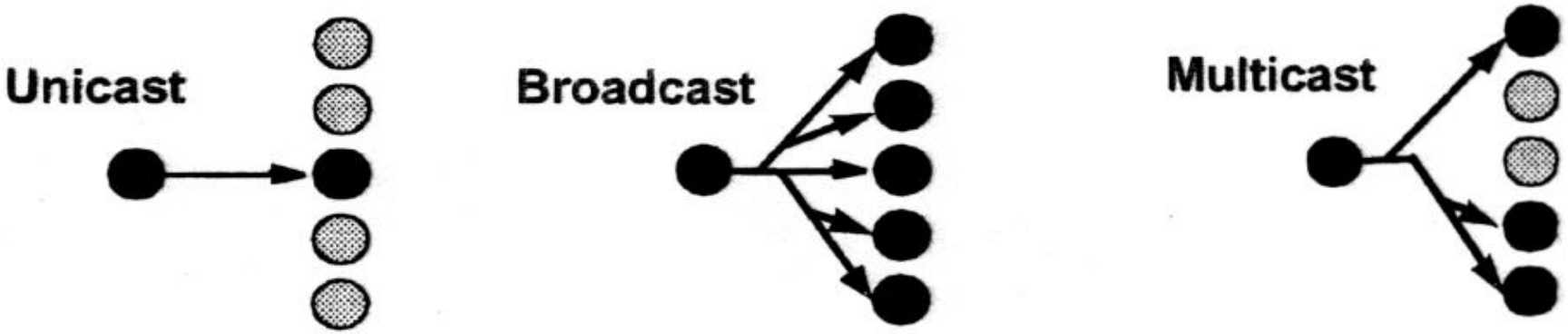


IP:Internet Protocol

- IP is the Network Protocol for the TCP/IP protocol suite
- It is unreliable, connectionless (datagram) delivery service. Does not guarantee that a transmitted packet will be delivered.
- IP does not maintain any state info about the successive datagrams. Each datagram is handled independently.
- Consequences of unreliable and connectionless service: Lost packets, packets delivered out of sequence, duplicated packets
- IP offers best effort service (no performance guarantees on time, packet loss rate, throughput)
- IP provides very limited QoS support (by use of Type of Service field)

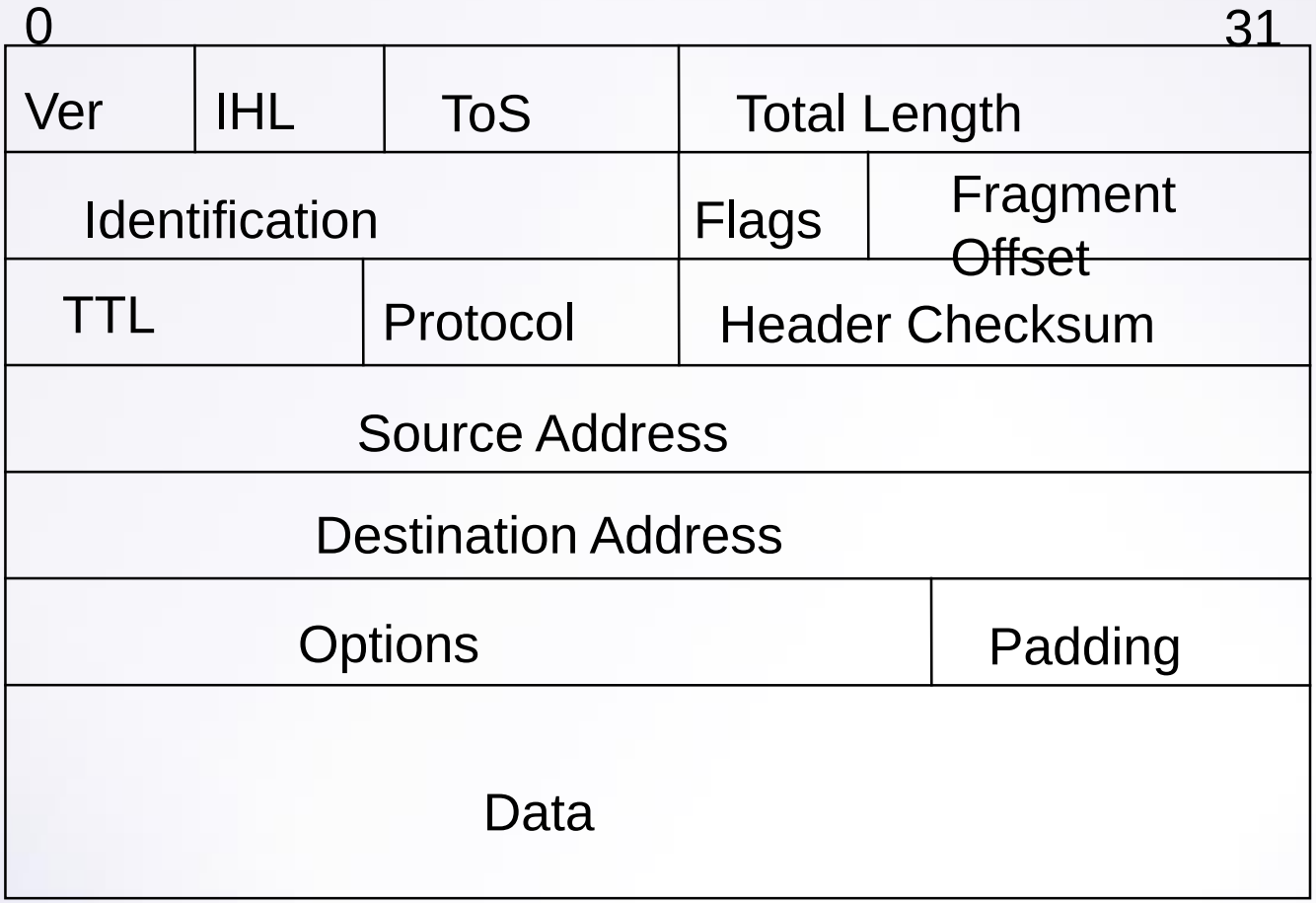
IP Service

- IP supports the following services:
  - one-to-one (unicast)
  - one-to-many (multicast)
  - one-to-all (broadcast)



- IP multicast actually supports a many-to-many service.
- IP multicast requires support of other protocols (IGMP, multicast routing).

IP Header Format



IP Header Description

- Version (4 bits): The IP Version Number
- Internet Header Length (IHL) (4bits): The length of the header in 32 bit words
- Type of Service (ToS) (8 bits): 3-bit precedence field (implement priority in routers), 4 ToS bits, 1 unused bit (future use). The 4 ToS bits (flags) mean (only one such flags can be set):
  - minimize delay (interactive applications i.e. Telnet)
  - maximize throughput (file transfer i.e. FTP)
  - maximize reliability (network management)
  - minimize cost (i.e. news)

IP Header Description (cont.)

- Total Length (16 bits): Total length of IP datagram in octets (including header)
- Identification (16 bits): Unique identifier for the datagram
- Flags (3 bits): Options that indicate if fragmentation is permitted and/or used

IP Header Description (cont.)

- Fragment Offset (13 bits): Indicates where in the datagram the offset belongs (measured in 8-octet units)
- Time To Live (TTL) (8bits): Measured in hops and/or seconds. To prevent packets from getting into loop.
- Protocol (8 bits):Identifies the next protocol that follows the IP header(i.e. TCP, UDP, ICMP)
- Header Checksum (16 bits): computed on the IP header only

IP Header Description (cont.)

- Source Address (32bits): The IP address of the originating host
- Destination Address (32 bits): The IP address of the destination host
- Options (variable): (i.e. route specifications)
- Padding: Provided so that the IP header ends on a 32 bit boundary
- Data (variable): A multiple of 8 bits not to exceed 65,535 octets for IP header plus higher layer data

IP Routing

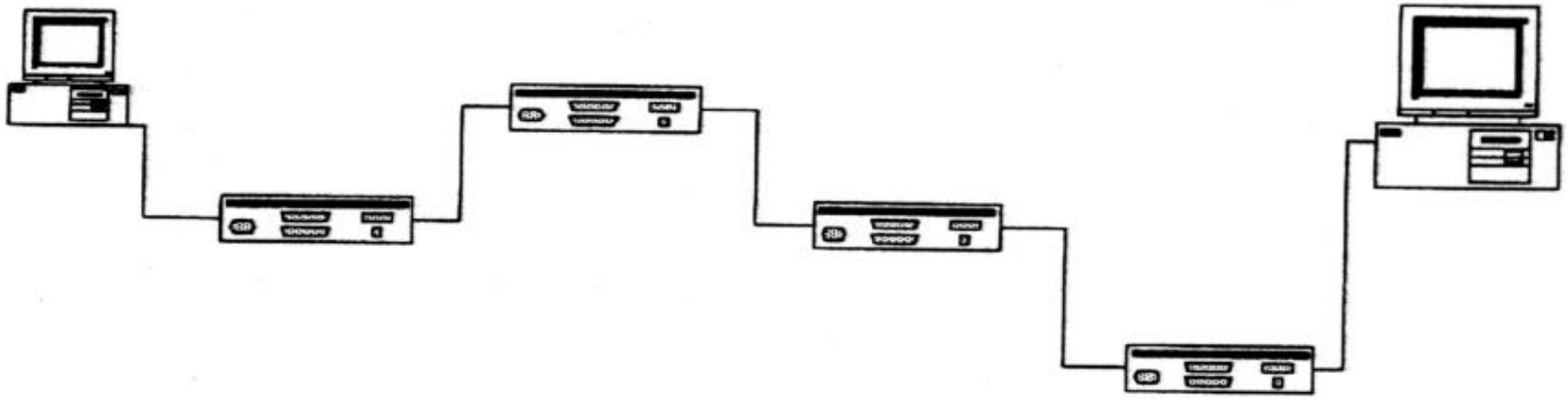
- IP Routing is done on hop-by-hop basis
- If the destination is directly connected to the host or on a shared network the IP datagram is sent directly to the destination otherwise is sent to a router
- The IP layer at each router has a routing table containing the following:
  - Destination IP address (either complete host address or network address)
  - IP address of next hop router or IP address of directly connected network
  - Flags specifying whether the destination IP address is of a host or a network address

IP Routing (cont.)

- Routing Mechanism: procedure to search the routing table
- Routing Policy: procedure to determine which routes go into the routing table (Routing Protocols)

IP Forwarding

- A packet is typically forwarded to a large number of routers before reaching the destination host.



- IP forwarding is done on a hop-by-hop basis, i.e., no one knows the complete route. The goal of forwarding is to bring the IP datagram closer to the destination.

IP Forwarding (cont.)

- IP forwarding is performed by both hosts and routers.
- However, a host never passes a packet from an input interface to an output interface.
- Both routers and hosts have a routing table. Routing table entries look like this and is looked up for each datagram:

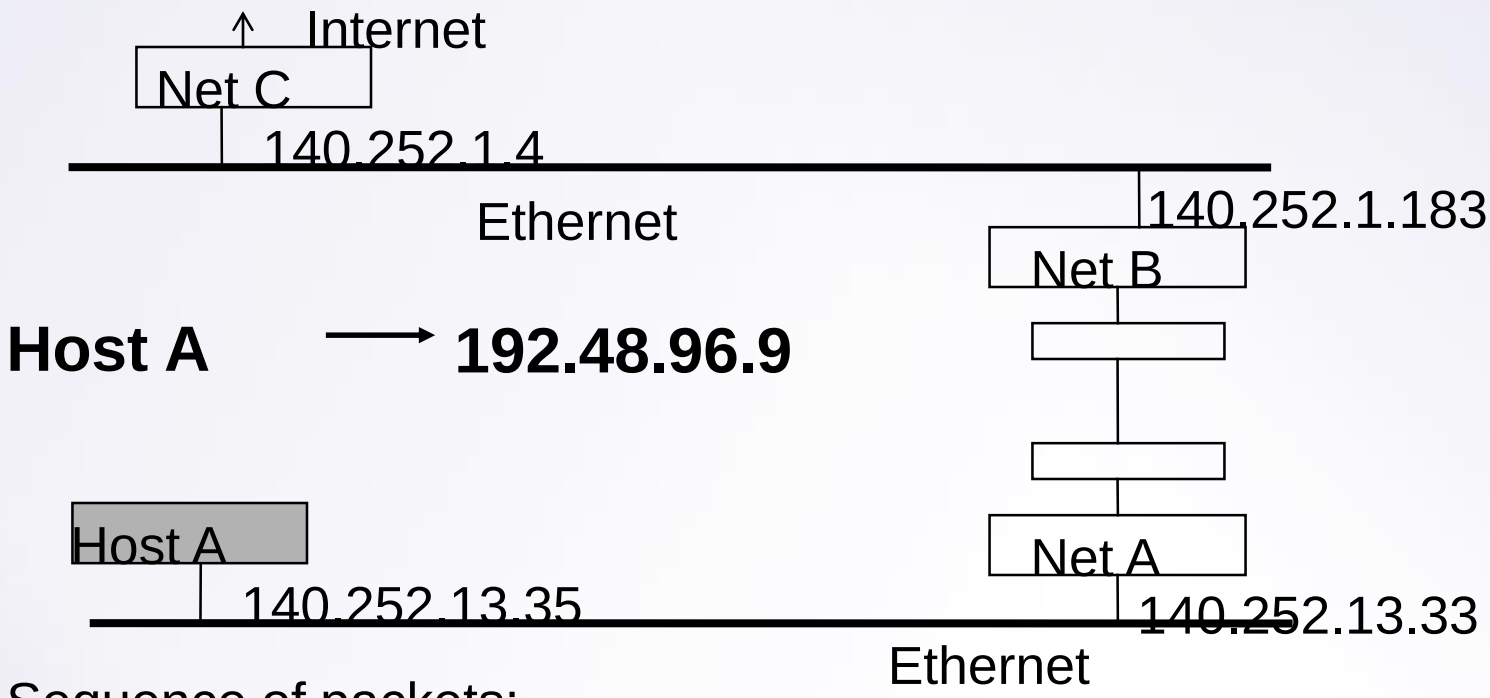
Destination IP address	IP address of Next-Hop-Router	Flags	Specification of an interface
Whole IP address or network ID of IP address	*Address of router interface or directly connected network*		*Interface to which the datagram is passed*

IP Routing Mechanism

Upon the reception of an IP datagram:

- Search the routing table for an entry that matches the complete destination IP address (network ID + Host ID). If found send the packet to the next hop router
- Otherwise: search for an entry that matches the destination network address. If found send the datagram to the next hop router (all hosts on a single network can be handled by this entry)
- Otherwise: search for an entry labeled Default. If found send the packet to the next hop router
- If none of those steps work then an error message is generated

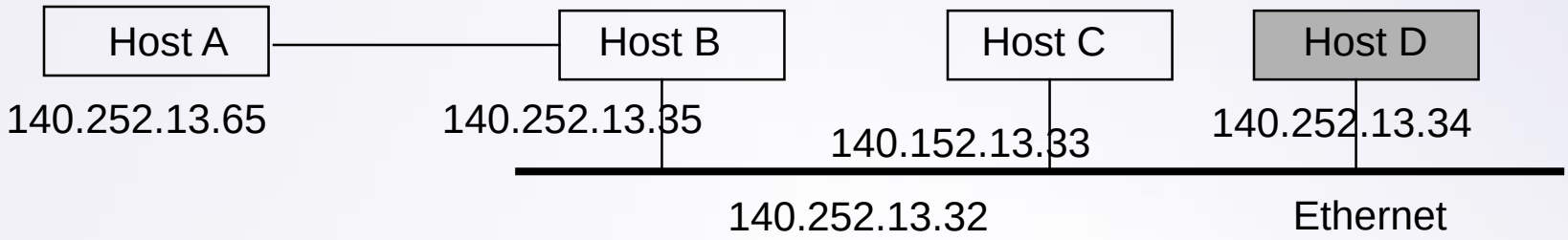
IP Routing Example



Sequence of packets:

HostA ---> NetA	Dest_IP_addr=192.48.96.9 Dest_Eth_addr=Eth_addr(NetA)
NetA ---> NetB	Dest_IP_addr=192.48.96.9
NetB ---> NetC	Dest_IP_addr=192.48.96.9 Dest_Eth_addr=Eth_addr(NetC)

Routing Table



Routing Table of Host D (140.252.13.34):

Destination	**Router**	**Flags**
140.252.13.65	140.252.13.35	UGH
127.0.0.1	127.0.0.1	UH
140.252.13.32	140.252.13.34	U
default	140.252.13.33	UG

U: The route is up

G: The route is to a router (If the flag is not set the route is to a directly connected network)

H: The route is to a Host (the destination is a complete Host address)

D(M): The route was created (modified) by a Redirect Message