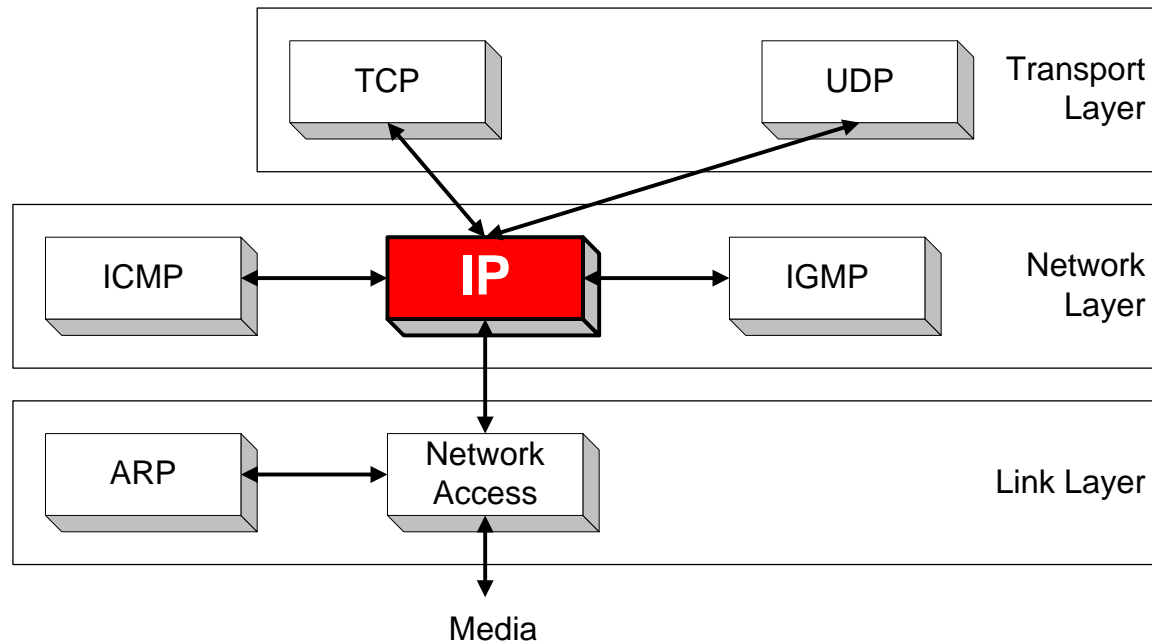


IP – The Internet Protocol



Orientation

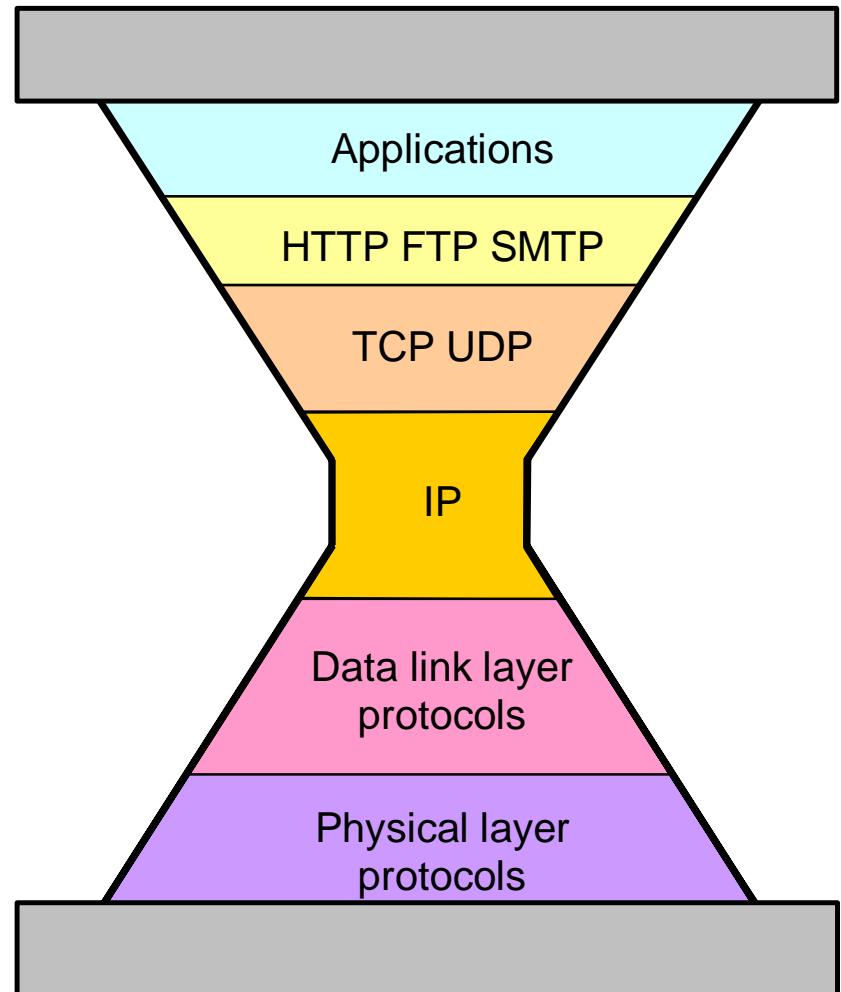
- ▣ IP (Internet Protocol) is a Network Layer Protocol



- ▣ IP's current version is Version 4 (IPv4). It is specified in RFC 891.

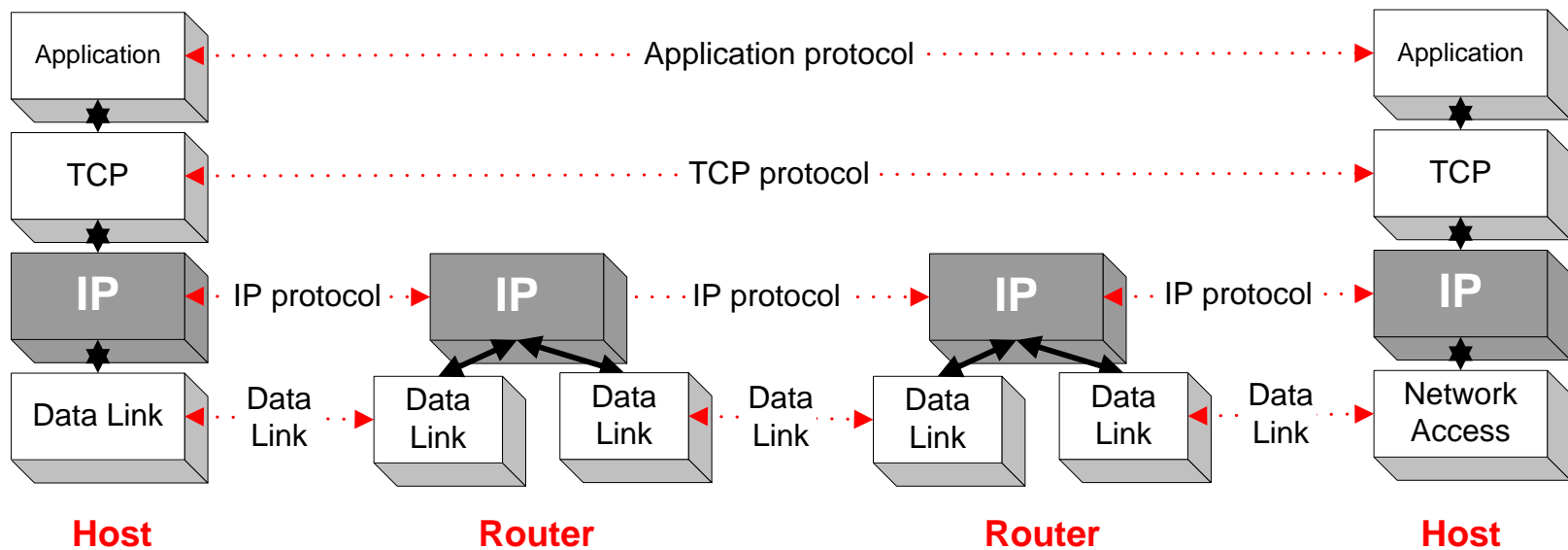
IP: The waist of the hourglass

- IP is the waist of the hourglass of the Internet protocol architecture
- Multiple higher-layer protocols
- Multiple lower-layer protocols
- Only one protocol at the network layer.



Application protocol

- ▶ IP is the highest layer protocol which is implemented at both routers and hosts

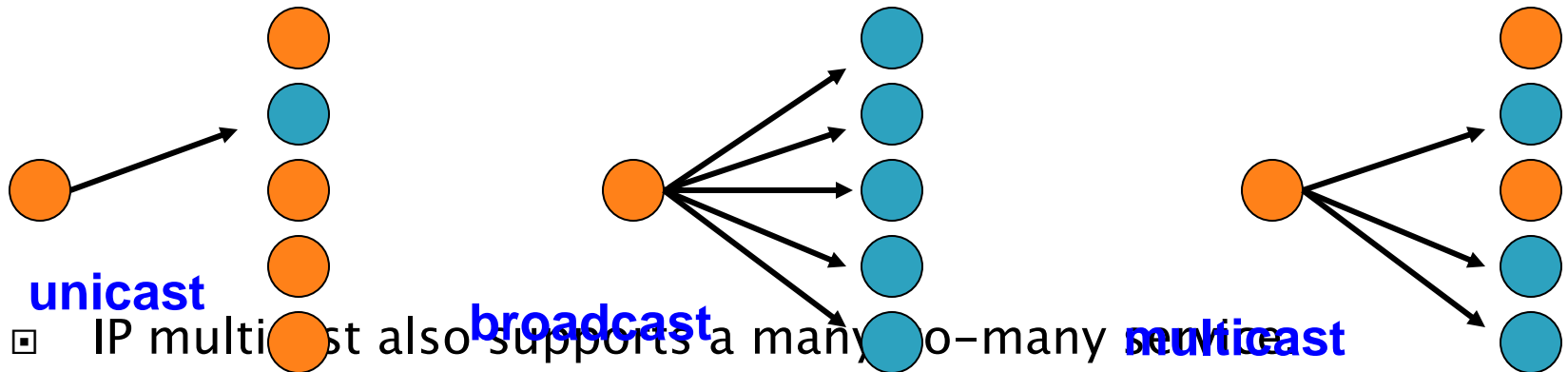


IP Service

- ▶ Delivery service of IP is minimal
- ▶ IP provide provides an **unreliable connectionless** best effort service (also called: “datagram service”).
 - **Unreliable:** IP does not make an attempt to recover lost packets
 - **Connectionless:** Each packet (“datagram”) is handled independently. IP is not aware that packets between hosts may be sent in a logical sequence
 - **Best effort:** IP does not make guarantees on the service (no throughput guarantee, no delay guarantee,...)
- ▶ Consequences:
 - Higher layer protocols have to deal with losses or with duplicate packets
 - Packets may be delivered out-of-sequence

IP Service

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



- IP multibroadcast also supports a many-to-many **multicast**
- IP multicast requires support of other protocols (IGMP, multicast routing)

IP Datagram Format

- ▶ **Question:** In which order are the bytes of an IP datagram transmitted?
- ▶ **Answer:**
 - Transmission is row by row
 - For each row:
 1. First transmit bits 0–7
 2. Then transmit bits 8–15
 3. Then transmit bits 16–23
 4. Then transmit bits 24–31
- ▶ This is called **network byte** order or **big endian** byte ordering.
- ▶ **Note:** Many computers (incl. Intel processors) store 32-bit words in little endian format. Others (incl. Motorola processors) use big endian.

Big endian vs. small endian

- Conventions to store a multibyte work

- Example: a 4 byte Long Integer **Byte3** **Byte2** **Byte1** **Byte0**

Little Endian

- ▶ Stores the low-order byte at the lowest address and the highest order byte in the highest address.

```
Base Address+0  Byte0  
Base Address+1  Byte1  
Base Address+2  Byte2  
Base Address+3  Byte3
```

- ▶ Intel processors use this order

Big Endian

- ▶ Stores the high-order byte at the lowest address, and the low-order byte at the highest address.

```
Base Address+0  Byte3  
Base Address+1  Byte2  
Base Address+2  Byte1  
Base Address+3  Byte0
```

- ▶ Motorola processors use big endian.

Fields of the IP Header

- ▶ **Version (4 bits):** current version is 4, next version will be 6.
- ▶ **Header length (4 bits):** length of IP header, in multiples of 4 bytes
- ▶ **DS/ECN field (1 byte)**
 - This field was previously called as Type-of-Service (TOS) field. The role of this field has been re-defined, but is “backwards compatible” to TOS interpretation
 - **Differentiated Service (DS) (6 bits):**
 - Used to specify service level (currently not supported in the Internet)
 - **Explicit Congestion Notification (ECN) (2 bits):**
 - New feedback mechanism used by TCP

Fields of the IP Header

- ▶ **Identification (16 bits):** Unique identification of a datagram from a host. Incremented whenever a datagram is transmitted
- ▶ **Flags (3 bits):**
 - First bit always set to 0
 - DF bit (Do not fragment)
 - MF bit (More fragments)Will be explained later → Fragmentation