

Internet Protocol Suite

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Internet Protocol Suite: Transport

- **TCP: Transmission Control Protocol**
 - Byte stream transfer
 - Reliable, connection-oriented service
 - Point-to-point (one-to-one) service only
- **UDP: User Datagram Protocol**
 - Unreliable (“best effort”) datagram service
 - Point-to-point, multicast (one-to-many), and
 - broadcast (one-to-all)

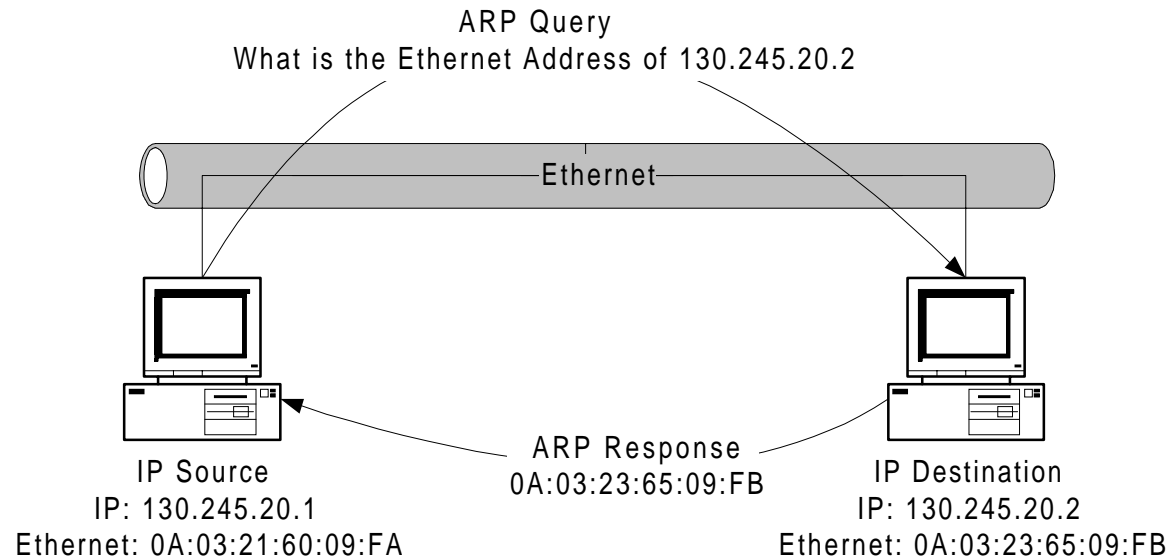
Internet Protocol Suite: Network

- **IP: Internet Protocol**
 - Unreliable service
 - Performs routing
 - Supported by routing protocols,
 - e.g. RIP, IS-IS,
 - OSPF, IGP, and BGP
- **ICMP: Internet Control Message Protocol**
 - Used by IP (primarily) to exchange error and control messages with other nodes
- **IGMP: Internet Group Management Protocol**
 - Used for controlling multicast (one-to-many transmission) for UDP datagrams

Internet Protocol Suite: Data Link

- **ARP: Address Resolution Protocol**
 - Translates from an IP (network) address to a network interface (hardware) address, e.g. IP address-to-Ethernet address or IP address-to-FDDI address
- **RARP: Reverse Address Resolution Protocol**
 - Translates from a network interface (hardware) address to an IP (network) address

Address Resolution Protocol (ARP)



- **Maps IP addresses to Ethernet Addresses**
- **ARP responses are cached**

Internetworking

- **Motivation**
 - Heterogeneity
 - Scale
- **IP is the glue that connects heterogeneous networks giving the illusion of a homogenous one.**
- **Salient Features**
 - Best Effort Service Model
 - Global Addressing Scheme

Internet Protocol: IP

- **The Internet Protocol (IP) delivers datagrams across networks through routers**
- **IP provides unreliable datagram service**
 - **Datagrams (packets) may or may not be delivered**
 - **Datagrams may arrive at destination out of order**
 - **Datagrams may be arbitrarily delayed**
- **Datagram service is not demanding on the underlying network, thus allowing just about any network to join the Internet**

Internet Protocol: IP

- **Two transport services are commonly built on top of IP**
 - Transmission Control Protocol (TCP)
 - User Datagram Protocol (UDP)
 - Other transport protocols may also use IP, e.g. the Real Time Transport Protocol (RTP, RTSP)
- **IP functions:**
 - Route datagrams through the Internet
 - Provide Internet-wide addressing
 - Fragment datagrams, as needed for underlying network
- **Currently version: IPv4. IPv6 is “next generation” IP**

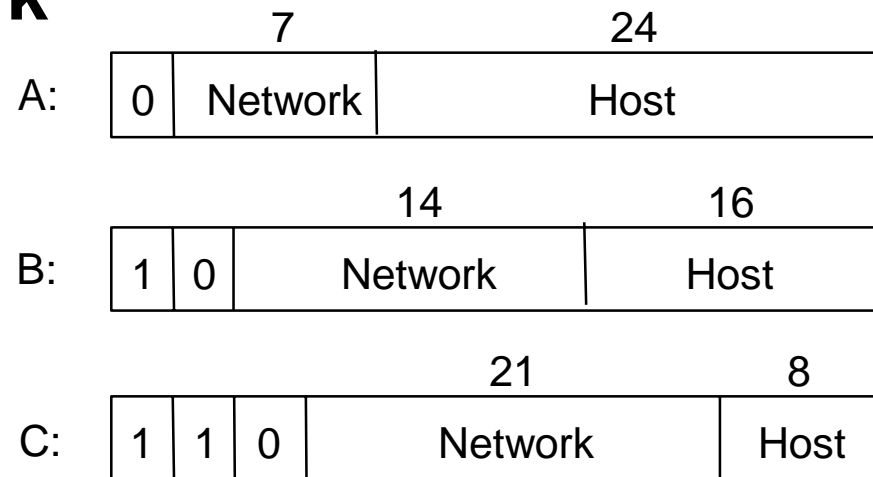
Global IP Addresses

- **Properties**

- globally unique
- hierarchical: network + host

- **Dot Notation**

- 10.3.2.4
- 128.96.33.81
- 192.12.69.77



Internet Addressing

- **Example: IP address for abc.xyz.net**
 - **10000000 10101101 01011100 01100000**
 - **128.173.92.96**
 - **netmask: 255.255.0.0**
 - **network: 128.173.0.0**
 - **hostid: 92.96**

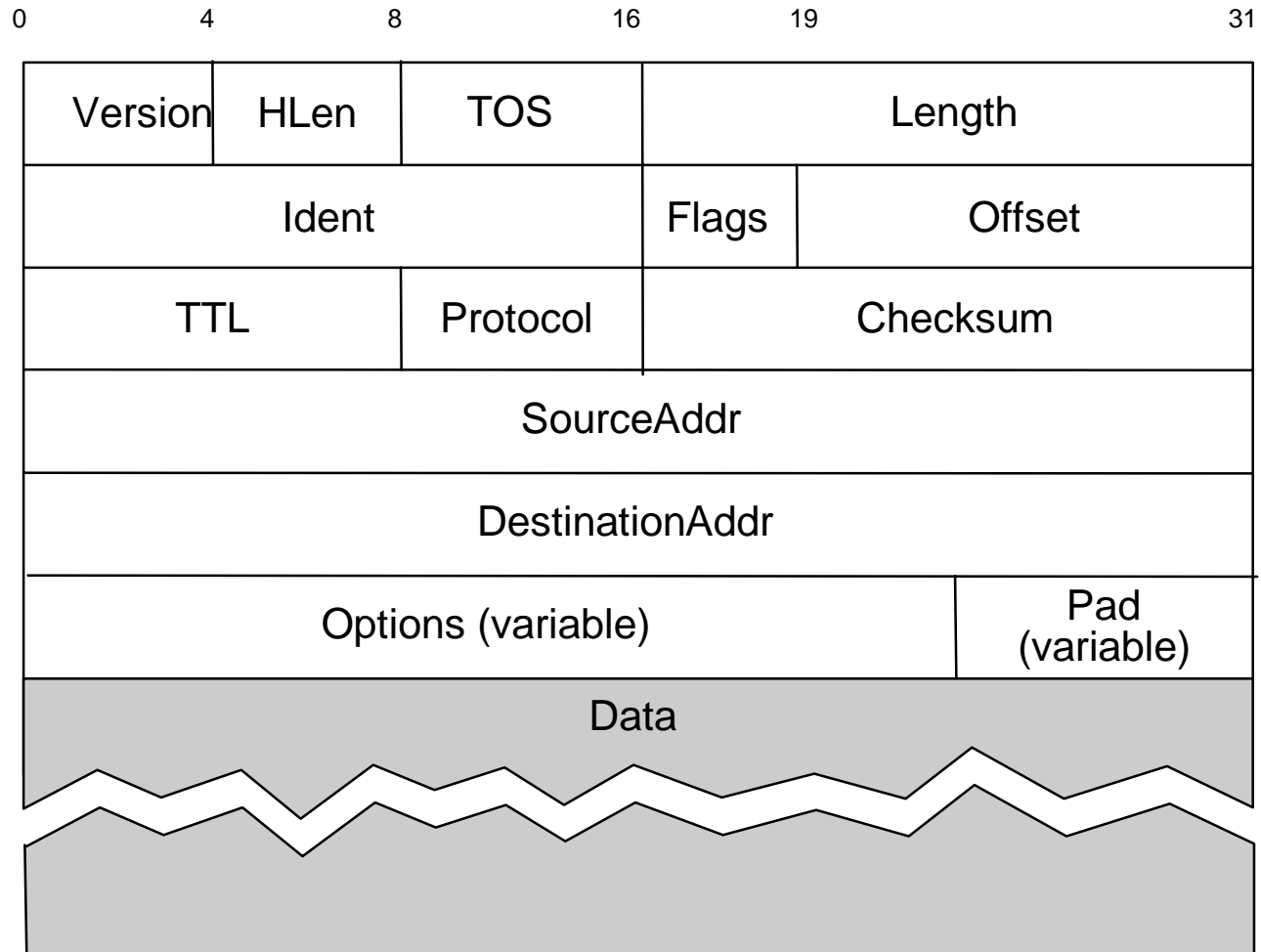
Internet Addressing

- **Special addresses used for broadcasting**
 - Directed broadcast: network (or subnet) plus hostid that is all 1's
 - Limited broadcast: all 1's (network and hostid)
- **Example: broadcasting for abc.xyz.net**
 - Directed broadcast (using subnet):
128.173.255.255
 - Limited broadcast: 255.255.255.255
- **The Address Resolution Protocol (ARP) provides a translation between an IP address and an appropriate local network address (e.g. Ethernet physical address)**

IP Datagrams

- **IP datagrams include**
 - Header, minimum size of 20 bytes
 - Data
- **Data size**
 - Less than or equal to minimum transport unit (MTU) of the underlying network
- **Fragmentation**
 - Packets may need to be fragmented at intermediate nodes if packet is too big for an intermediate network
 - Path MTU less than link MTU at sender
 - Receiver reassembles fragments to form entire IP packet

IP Datagram Format



IP Header Fields

- **Identification: unique datagram identifier**
- **Total Length: length of this datagram + header, in bytes**
 - Hosts are required to accept datagrams up to 576 bytes
 - Many applications (e.g. NFS) accept up to 8,192 bytes
 - Datagram may be fragmented
- **Internet Header Length: length of header in 32-bit words**

IP Header Fields

- **Fragment Offset: offset of fragment in this datagram in 8-byte units**
- **Flags: indicate**
 - If this is last fragment, and
 - If datagram should not be fragmented
- **Time To Live: maximum number of routers through which the datagram may pass**
 - Decrement at each router
 - Used to prevent looping in the network
 - Also used to limit scope of multicast datagrams

IP Header Fields

- **Protocol: identifies higher level protocol that provided data**
- **Version: IP version identifier (currently 4)**
- **Type of Service:**
 - Precedence field (ignored)
 - Type of service (TOS) -- maximize throughput, minimize delay, maximize reliability, minimize cost (no guarantees, though)
- **Header Checksum: checksum over header (protects addresses, lengths, etc.)**
 - 16-bit one's complement sum

IP Header Fields

- **Source IP Address: full address of source node**
- **Destination IP Address: full address of destination node**
- **Options (rarely used, may not be supported by routers):**
 - **Security and handling restrictions**
 - **Record route**
 - **Loose source routing**
 - **Strict source routing**