# 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)**

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# 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**

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# 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**

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# Address Resolution Protocol (ARP)
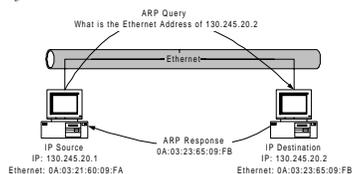


- **Maps IP addresses to Ethernet Addresses**
- **ARP responses are cached**

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# 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

| | | 7 | 24 | |
|---|---|---|---|---|
| A: | 0 | Network | Host | |

| | | | 14 | 16 |
|---|---|---|---|---|
| B: | 1 0 | Network | Host | |

| | | | 21 | 8 |
|---|---|---|---|---|
| C: | 1 1 0 | Network | Host | |

- **Dot Notation**
  - 10.3.2.4
  - 128.96.33.81
  - 192.12.69.77
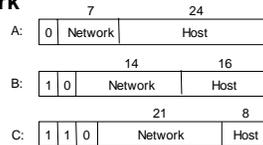
## Internet Addressing

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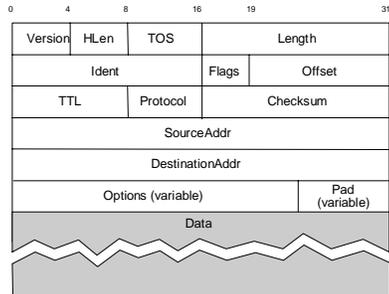  - network: 128.173.0.0
  - hostid: 92.96

## 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

| 0 | 4 | 8 | 16 | 19 | 31 |
|---|---|---|---|---|---|

| Version | HLen | TOS | Length | | |
| Ident | | | Flags | Offset | |
| TTL | | Protocol | Checksum | | |
| SourceAddr | | | | | |
| DestinationAddr | | | | | |
| Options (variable) | | | | Pad (variable) | |
| Data | | | | | |

## 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**
  - **Decremented 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**