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.

**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

**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

**Internet Protocol: IP**

- Currently version: IPv4. IPv6 is “next generation” IP
IP Datagram Format

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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
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**IP Header Fields**

- **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

- **Protocol**: identifies higher level protocol that provided data
- **Version**: IP version identifier (currently 4)
- **Type Of Service**: 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