Internet Protocol Suite

Srinidhi Varadarajan
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

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<td>Pad (variable)</td>
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<tr>
<td>Data</td>
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</table>
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