Internet Engineering

241-461

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Network Numbers (2)

- With subnets
  - Generally need just 1 net number / organisation
- But still just 2,000,000 (and a few) net numbers
  - Many more than 2M organisations
- In 1980's early 1990's
  - Many organisations used IP networking
    - So need IP address(es)
  - Few connected to internet
    - Only communicate locally
  - Consuming many of the network addresses
    - Or just "borrowing" someone else's address
    - Copying documentation
- RFC1924
  - Private Use Addresses
    - Addresses not to be connected to Internet
    - Available for anyone to use
      - for their local (disconnected) network

RFC1924 Addresses

- 10.0.0.0/8
  - 1 Class A network (ARPANET)
- 172.16.0.0/12
  - 16 Class B networks
- 192.168.0.0/16
  - 256 Class C networks
- Eventually with even greater address shortage
  - Organisations only able to obtain
    - very small number of addresses
- RFC1924 addresses used by connected organisations
  - Number all their hosts
- Network Address Translation (NAT)
  - Converts private address
    - to an available public address
  - When packet leaves organisation's network
    - and the reverse for incoming packets

CIDR

- Still running out of addresses
  - Clearly need new protocol
    - Eventually IPv6 developed
  - Interim
    - Need to extend lifetime of IPv4
- Classless Inter-Domain Routing
  - Remove Class concept from IP address
    - No more class A B or C
  - Until now remote networks identified by class
    - Automatically know which bits are network number
  - Now must explicitly send netmask with every network address
    - As mask or as mask length count
    - so network bits can be identified
  - Only not needed with host address
    - Always all 32 bits
- Now able to allocate any sized network block to organisation

IPv6

- Need a protocol with more addresses
  - Otherwise quite like IPv4 which works well
- More addresses means more bits
  - How many bits?
- Want to allocate enough
  - so numbers never run out again
- 64 bits?
  - 2^{64} addresses - 8 bytes for each address
    - 18,446,744,073,709,551,616
    - $2^{32} * 2^{32}$
  - Is that enough?
    - Some addresses always wasted
      - Always allocate powers of 2 blocks
      - Netmask guarantees that
    - How many wasted?
      - Many
  - Maybe 64 bits not enough

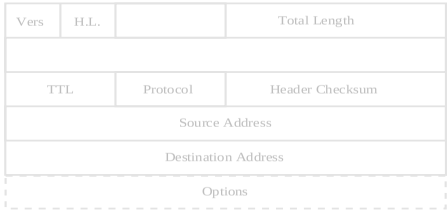
IPv6 (2)

- 80 bits?
  - 2^{80} addresses - 10 bytes for each address
    - 1,208,925,819,614,629,174,706,176
    - $2^{16} * 2^{64}$
  - This should be enough
    - But 80 is not a convenient size for computers
- 128 bits
  - 2^{128} addresses - 16 bytes for each address
    - 340,282,366,920,938,463,463,374,607,431,768,211,456
    - $2^{64} * 2^{64}$
      - 18446744073709551616 ^{2}
- The clever part
  - Use 128 bits
    - 80 bits for network identification
    - 48 bits for local part
      - autoconfiguration (later)
  - Later changed to 64 + 64

Other Network Layer requirements

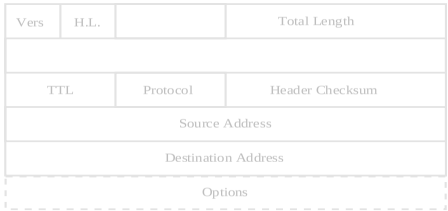
- Error Detection (some)
  - Checksum
    - Header only
    - Ensure packet delivered to correct destination
      - With unaltered source address
    - No verification of packet contents
- Link Layer Interface
  - Deal with link layer restrictions
- Packet Length
  - Header field
- Protocol Identification
  - Header field
- Packet Lifetime
  - Header field
    - Number of seconds packet can live
    - 8 bits - maximum value 255
      - 4¼ minutes

IPv4 header (simplified)



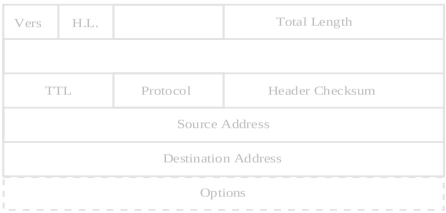
- Vers - IP version (4)
  - 4 bit field, values 0 .. 15
- HL - Header Length
  - 4 bit field, values 0 .. 15 words
    - That is 0 .. 60 bytes
    - Including fixed part of IP header
      - So mimimum value is 5 (20 bytes)
- Total Length - packet size
  - 16 bit field (0 .. 65535)
    - Includes IP header
      - Note limit on UDP datagram size

IPv4 header (simplified) (2)



- TTL - Time To Live
  - 8 bit field, values 0 .. 255
    - Seconds remaining before packet destroyed
- Protocol
  - 8 bit field, values 0 .. 255
    - Protocol that is data in IP packet
    - Heards that follows IP header (and is options)
  - List of numbers and protocols exists
    - 6 --> TCP
    - 17 --> UDP
    - 1 --> ICMP (later...)

IPv4 header (simplified) (3)



- Header Checksum
  - 16 bit field
    - Checksum of the IP header (and nothing else)
    - Verifies addresses & protocol unchanged
      - Must be updated as TTL changes
- Source Address
- Destination Address
  - IP addresses (32 bits) of sender and recipient(s)
- Options
  - Extra stuff needed in header
    - Rarely used today