Networking and Interworking

Network issues

- Performance
  - Latency
  - Data transfer rate
    - Data transfer rate = amount of Data / time
    - Message transfer rate time = latency + massage length / data transfer rate
  - Total system bandwidth of network
    - Throughput (吞吐量) in the end systems
    - Total volume of traffic can be transferred across network in a time
- Scalability No designable to cope with size and load about network growing
- Reliability Recoverable from communication failures
- Security Protecting network and computers
- Mobility
  - Portability of computer and handled digital devices using wireless network
  - Location and identification are depicted with each other
  - No designable to cope with size and load about network growing
- QoS (Quality of Service)

  Guarantee for requirements of computer and network to meet deadline, bandwidth, bounded latency
- Multicasting One-to-many communication

Types of Networks

- LANs (Local Area Networks) Technology suitable for small area, wire/fiber
  - High bandwidth
  - Low latency
  - ATM, better QoS, but more expensive
- WANs (Wide Area Networks) Large distances, inter-city/country/continental
  - Low bandwidth, high latency
  - Satellite/wire/cable
  - Routers introduce delays
- MANs (Metropolitan Area Networks) Intra-city, cable based, multimedia
- Wireless networks WLANs, WPANs (wireless personal area network)
  - WLANs: Wireless Local Area Networks to replace wired LANs

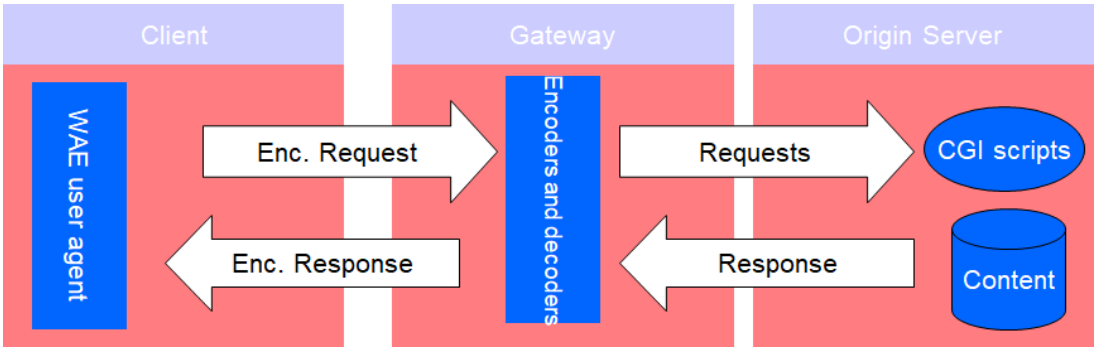
        - WaveLAN technology

          WIFI: Wireless Internet Platform for Interoperability

          IEEE 802.11
        - WMAN: Wireless Metropolitan Area Networks

          WiMAX: Worldwide Interoperability for Microwave Access

          IEEE 802.16
    - WPANs: Wireless Personal Area Networks
        - Infrared (infra-red) links
        - Bluetooth: IEEE 802.15.1 (standard no longer maintained)
        - Mobile phone network (Wireless WAN)
            - European GSM: Global system for Mobile communication
            - US: analogue AMPS: Advanced Mobile Phone System Cellular radio network, Cellular digital packet data Replaced by GSM
        - WAP: Wireless Applications Protocol For use on wireless potable devices



Network Principles

Mode of Transmission

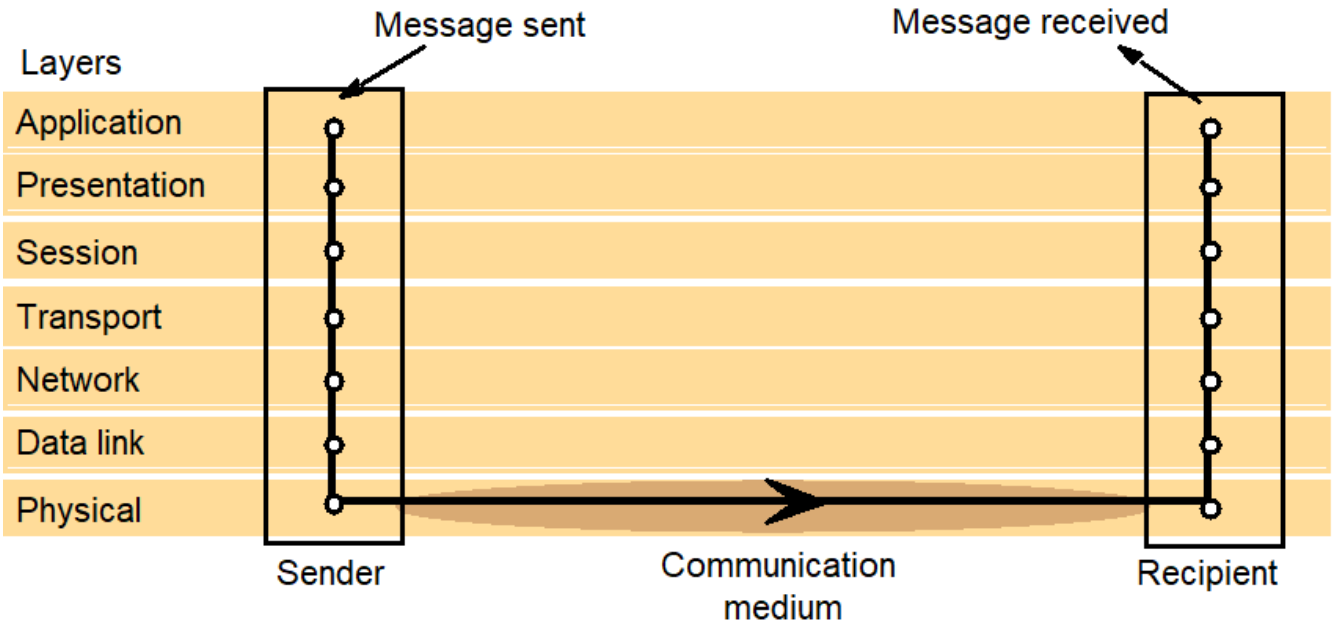
- Packets
    1. Messages divided into packets (on Transport Layer)
    2. Packets **queued in buffers** before sent onto link
    - QoS not guaranteed
- Data streaming
    - Links **guarantee QoS** (rate of delivery)
    - For multimedia traffic
    - Need higher bandwidth

Switching Schemes

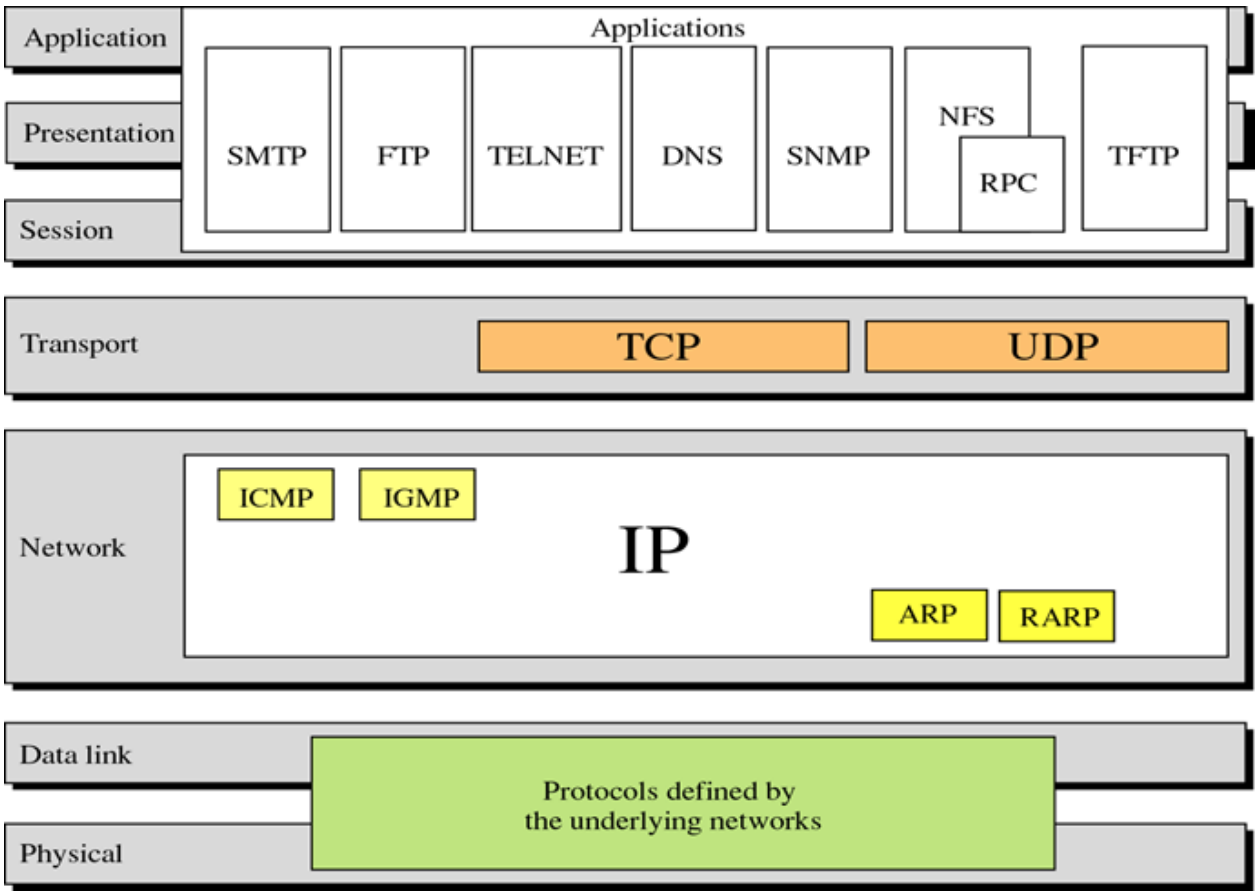
- Broadcasts (Ethernet, wireless)
    - Send messages to all nodes
    - Nodes listen for own messages (carrier sensing)
- Circuit switching (phone networks)

- Packet switching (TCP/IP)
    - Store-and-forward
    - Unpredictable delays
- Frame/Cell relay (ATM)
    - Bandwidth & latency guaranteed (virtual path)
    - Small, fixed size packets (padded if necessary) 53 bytes= header 5 + body 48
    - Avoids error checking at nodes (use reliable links)

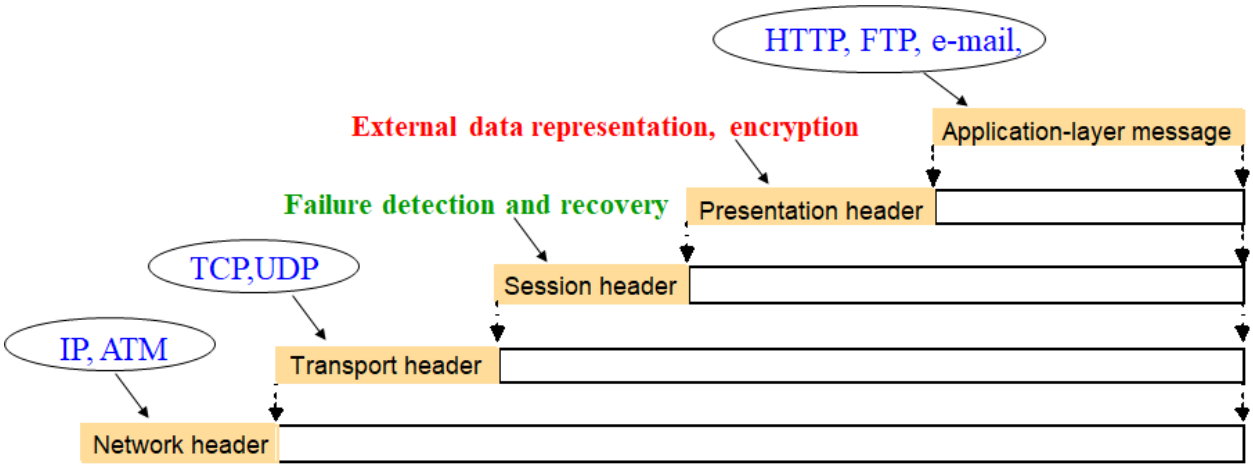
Protocols



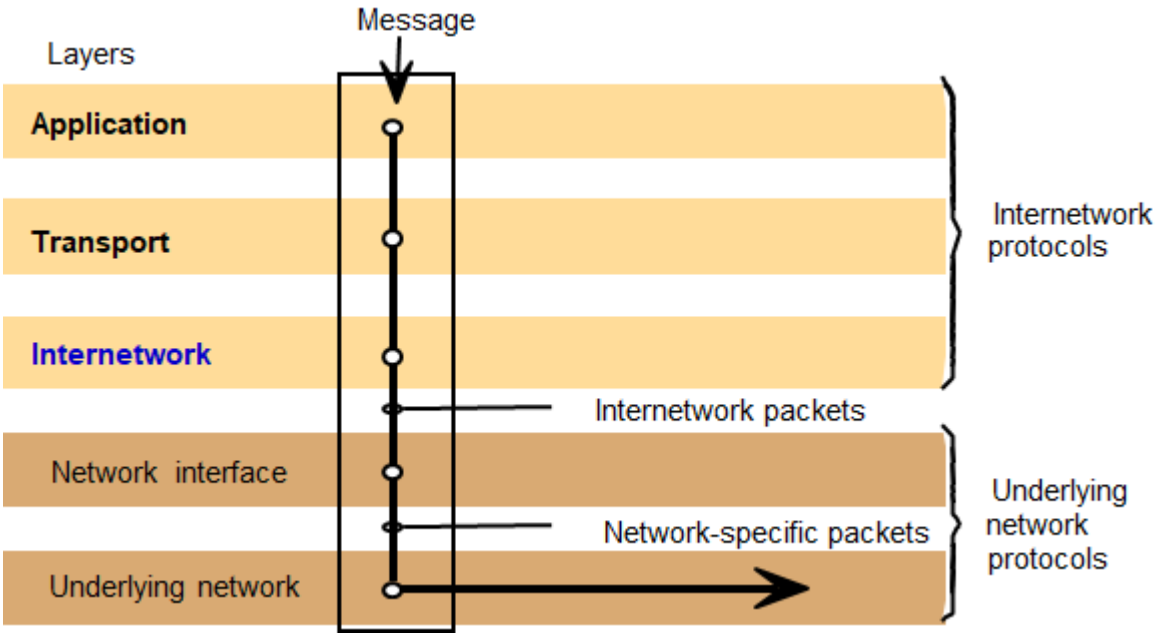
- OSI Model



- Message encapsulation



- Internetwork protocol
  - Internetwork layer(=Virtual network layer) internet packet → destination (by datagram protocol)
  - Network interfaces layer internetwork packets → suitable packets → underlying layer
  - Underlying network layer

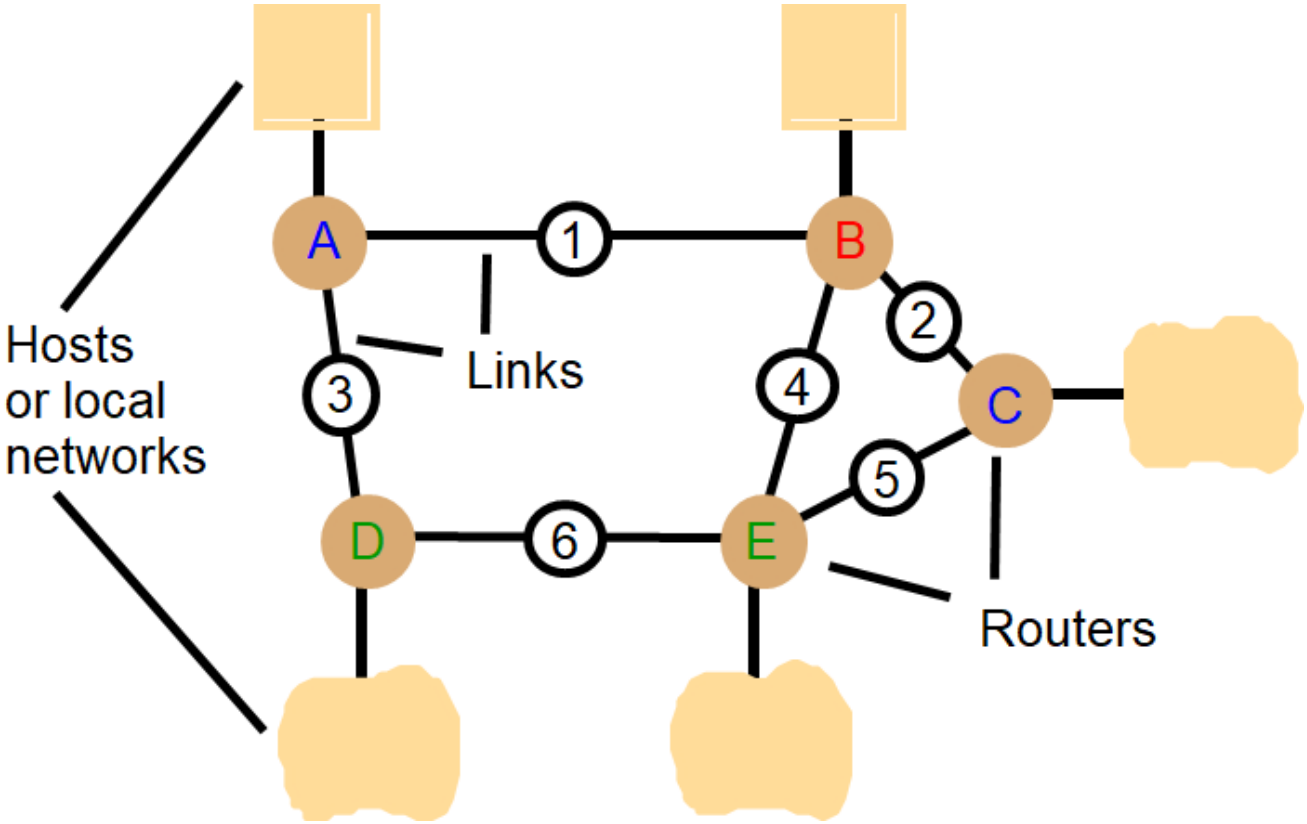


- Port & Addressing
  - Port
    - Network-independent message transport service between networks ports
    - Software-definable destination points for communications
  - Addressing
    - Delivering messages to destination with transport addresses
    - Transport address Network address + port number
- Packet delivery
  - In network layer
    - Datagram packet delivery (IP in Ethernet, most wired and wireless LAN technologies)
    - Virtual circuit packet delivery (ATM)
  - In transport layer
    - Connection-oriented transmission(TCP) Reliable communication with static routing table (ISO, X.25) Ex) remote login(Telnet), FTP, HTTP(big-sized file), stream data
    - Connectionless transmission (UDP) Unreliable communication with pre-defined routing table Ex) rcp, rwho, RPC, HTTP(small-sized file), FTP(non-error bulk file)

Routing

- Necessary in non-broadcast networks (cf Internet) : Hop by Hop
- Distance-vector algorithm for each node
  - Stores table of state & cost information of links, cost infinity for faulty links
  - Determines route taken by packet (the next hop)
  - Periodically updates the table and sends to neighbors
  - May converge slowly [Bellman-Ford]
- RIP-1 (Router Information Protocol) for Internet

- Local router table changes
- Use default routes, plus multicast and authentication
- Better convergence (routes better route to an existing destination)



- RIP routing algorithm

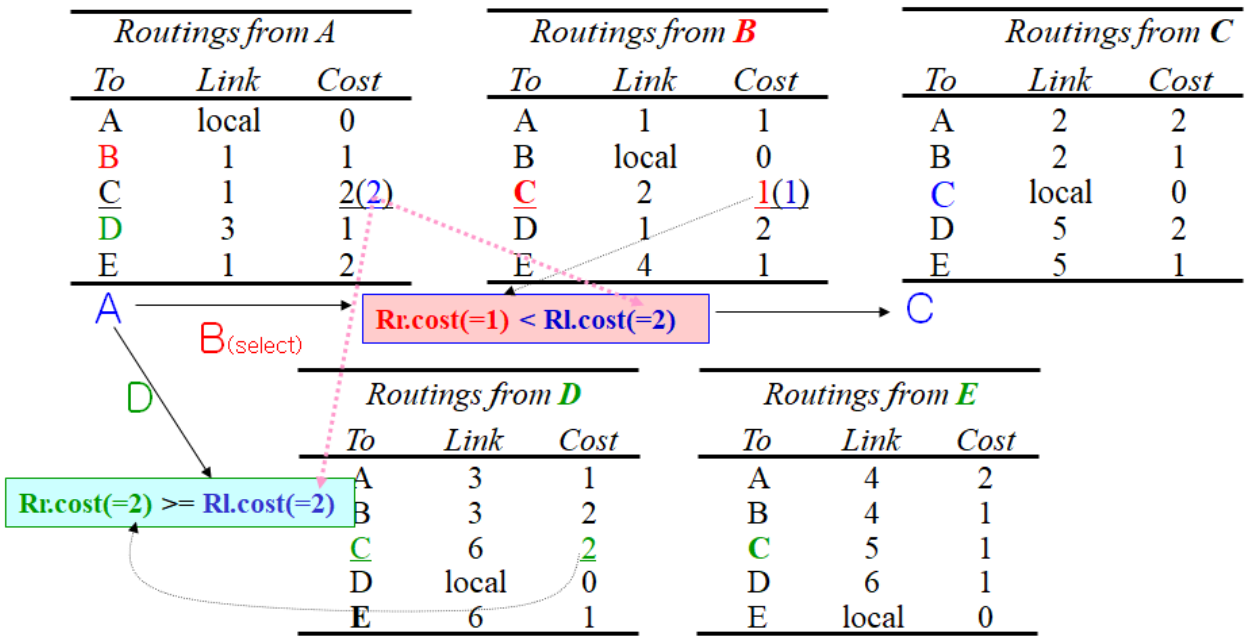
  Variables: `Tl` local table, `Tr` remote table received.

  - `Rr`: remote, `Rl` : local

  Send: Each `t` seconds or when `Tl` changes, send `Tl` on each non-faulty outgoing link.
  Receive: Whenever a routing table `Tr` is received on link `n`:

```
for all rows Rr in Tr {
    if (Rr.link != n) {
        Rr.cost = Rr.cost + 1; // hop
        Rr.link = n;
        if (Rr.destination is not in Tl) add Rr to Tl;
        // add new destination to Tl
        else for all rows Rl in Tl {
            if (Rr.destination = Rl.destination and (Rr.cost < Rl.cost or
Rl.link = n))
                Rl = Rr;
            // Rr.cost < Rl.cost : remote node has better route
            // Rl.link = n : remote node is more authoritative
        }
    }
}
```

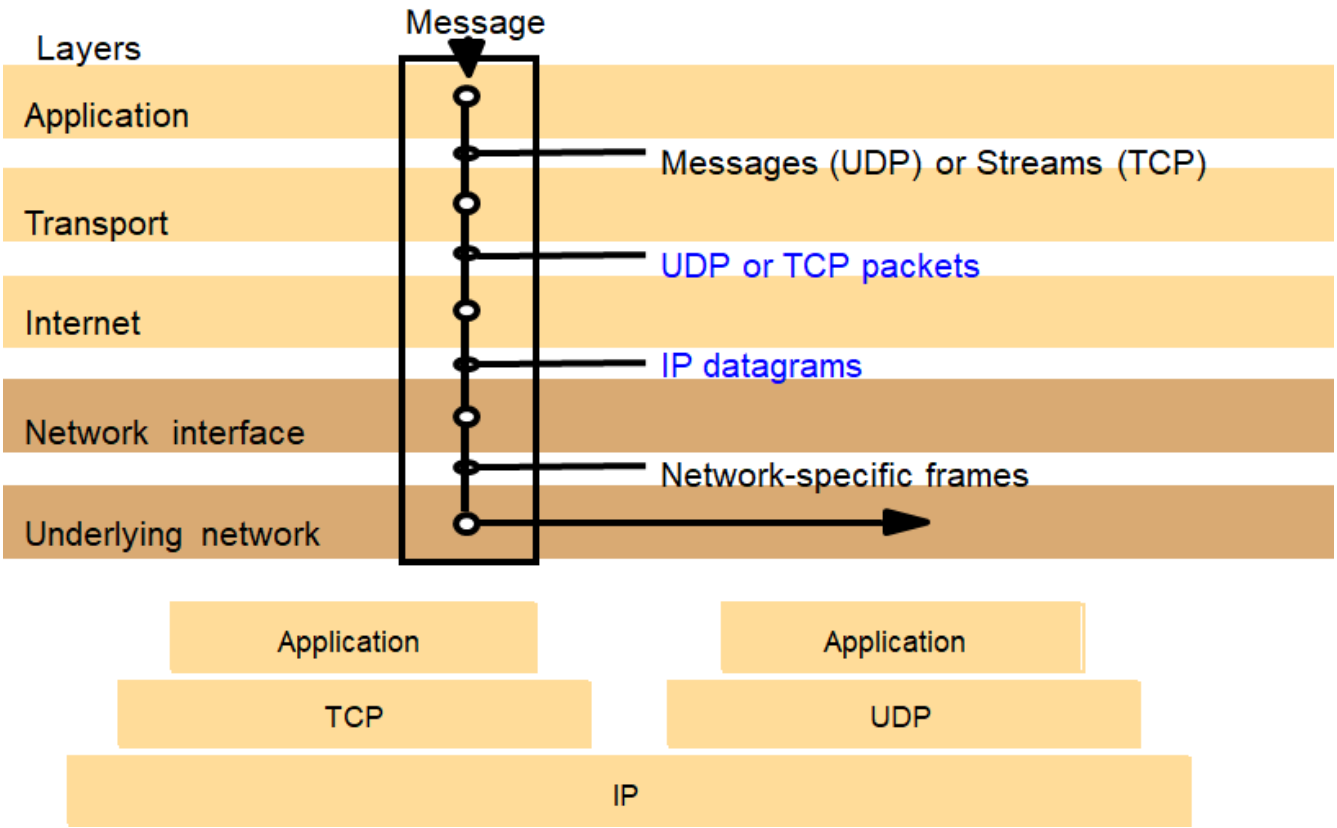
- Routing tables (A -> C)



Congestion Control

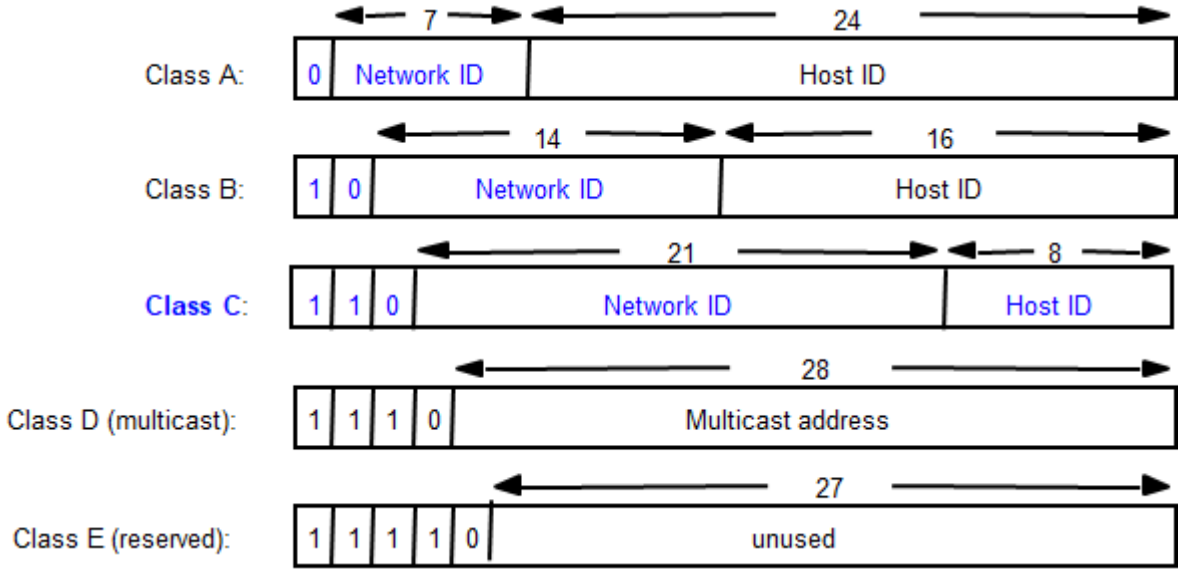
- When load on network exceeds 80% of its capacity packet queues long, links blocked
- Solutions (in datagram-based network layers)
  - packet dropping reliable of delivery at higher levels
  - reduce rate of transmission
    - nodes send choke packets (Ethernet) special message requesting a reduction in transmission rate
    - transmission control (TCP)
  - transmit congestion information to each node QoS guarantees (ATM)

Transport level protocols

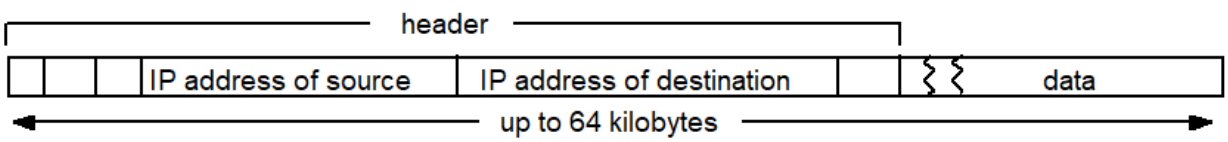


IP(TCP/IP) Addressing

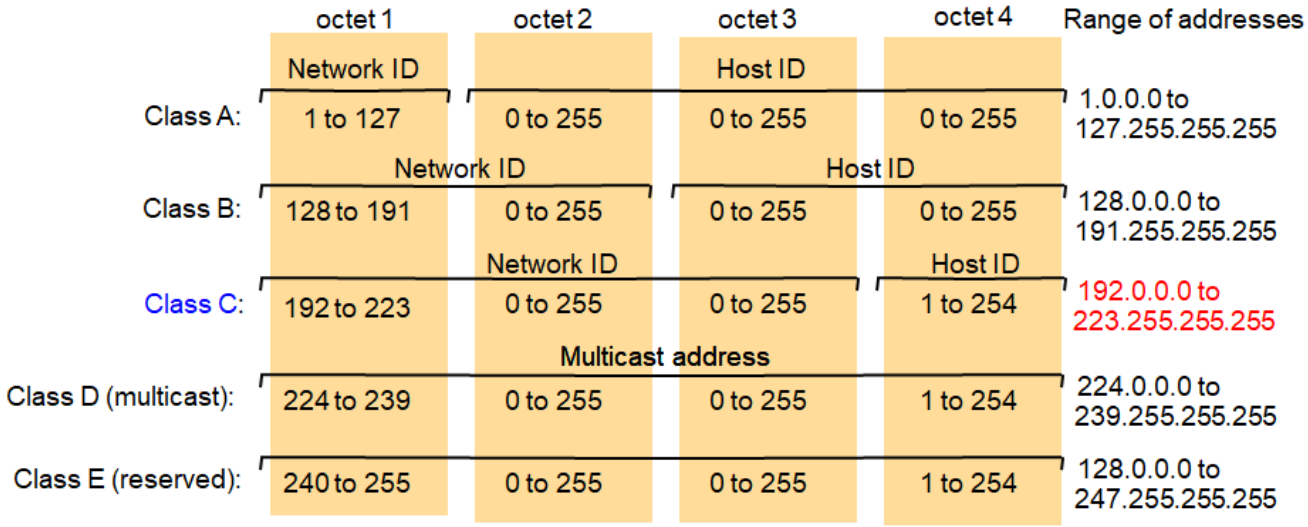
- IP Structure(Universal)(IPv4 : 4bytes = 32bits)



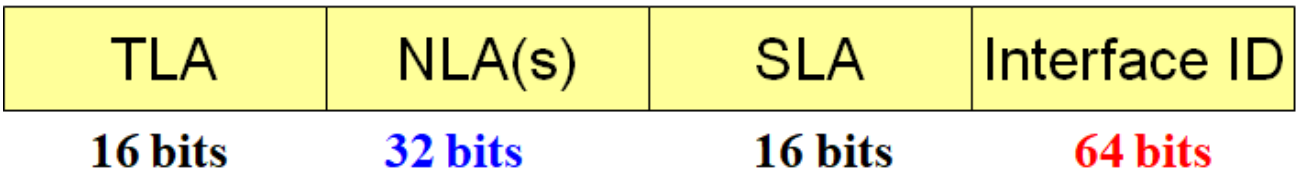
- IP Packet layout



IPv6

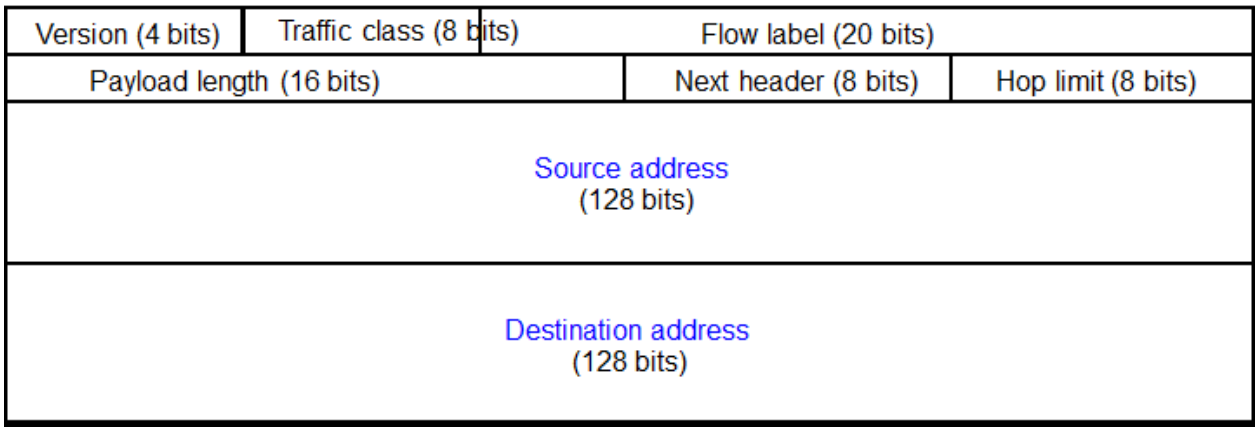


- Large Address Space - 128 bit addresses Every toaster can have its own IP address
- Aggregation-based address hierarchy Efficient backbone routing
- Efficient and Extensible IP datagram
  - No fragmentation by routers
  - 64 bits field alignment
  - Simpler basic header
- Auto-configuration
- Security
- IP Renumbering part of the protocol



- TLA – top level aggregator Primary providers
- NLA: Next Level Aggregator Can have multiple NLA as sub-NLA
- SLA: Site Level Aggregator Your site (16 bits)
- Addresses are allocated from your provider If you change provider, your prefix changes But renumbering (of hosts, routers and sites) has been included in the IPv6 protocol

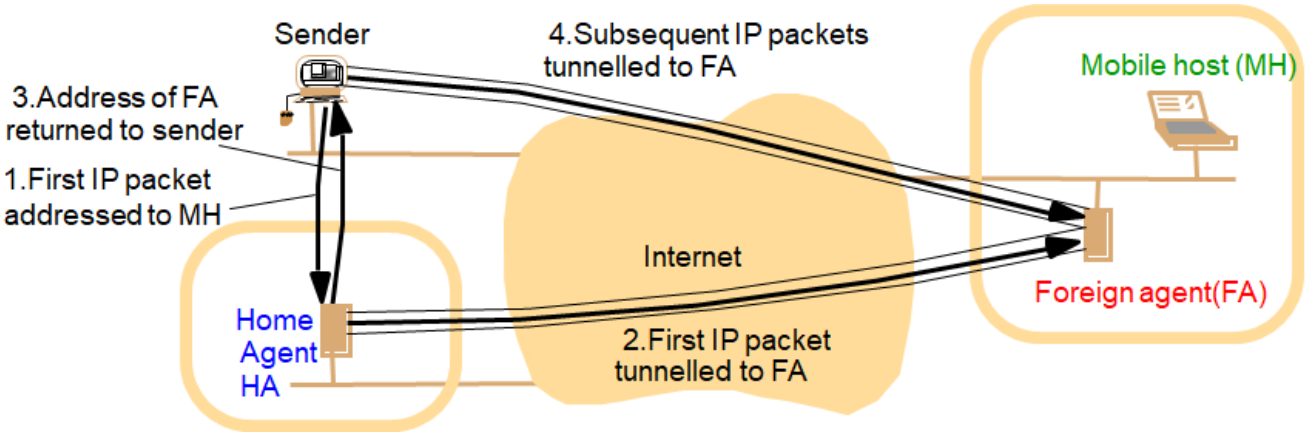
- IPv6 Header layout (16bytes: 128bits)



- IPv6's main advances (Adapted by IETF in 1994)
  - Address space (2128 = 3×1038 IPs), routing speed up
  - Real-time and other special services
  - Future evolution
  - Multicating & anycasting
  - Security

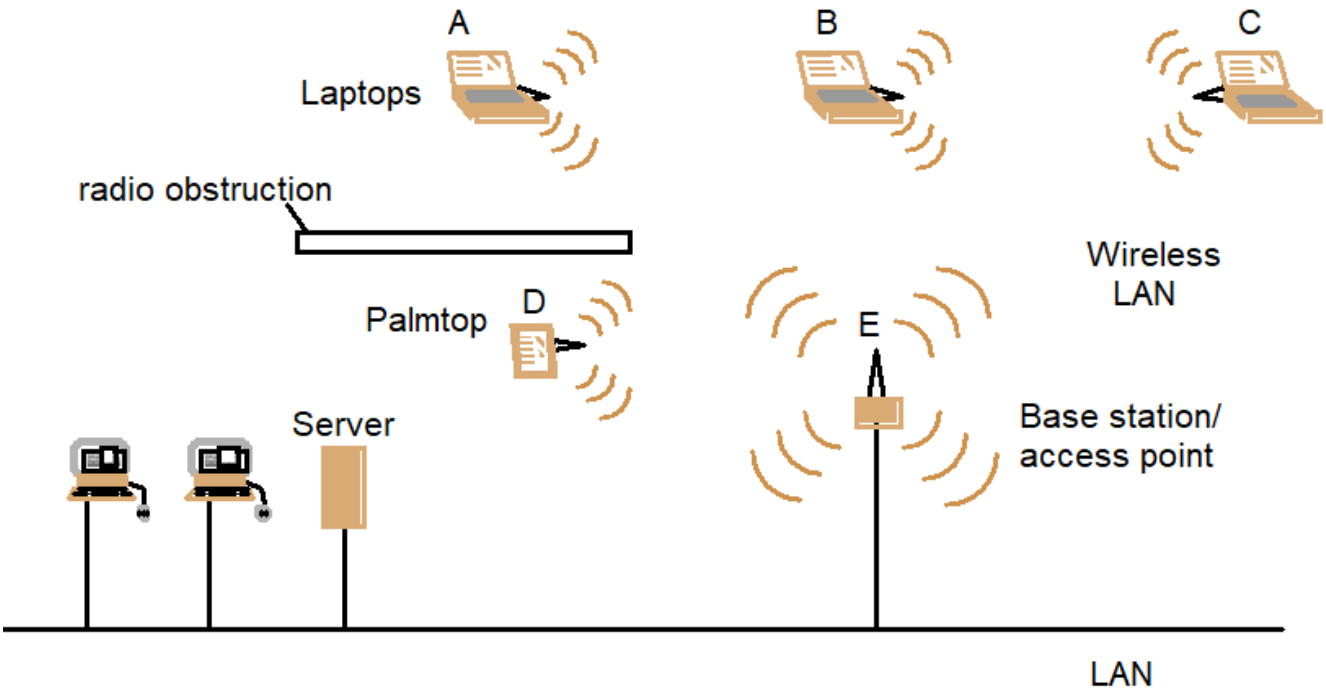
MobileIP

- At home normal, when elsewhere mobile host: notifies HA(Home Agent) before leaving informs FA(Foreign Agent), who allocates temporary care-of IP address & tells HA
- Packets for mobile host (MH): first packet routed to HA, encapsulated in MobileIP packet and sent to FA (tunneling) FA unpacks MobileIP packet and sends to mobile host sender notified of the care-of address for future communications which can be direct via FA
- Problems efficiency low, need to notify HA



Wireless LAN: IEEE 802.11

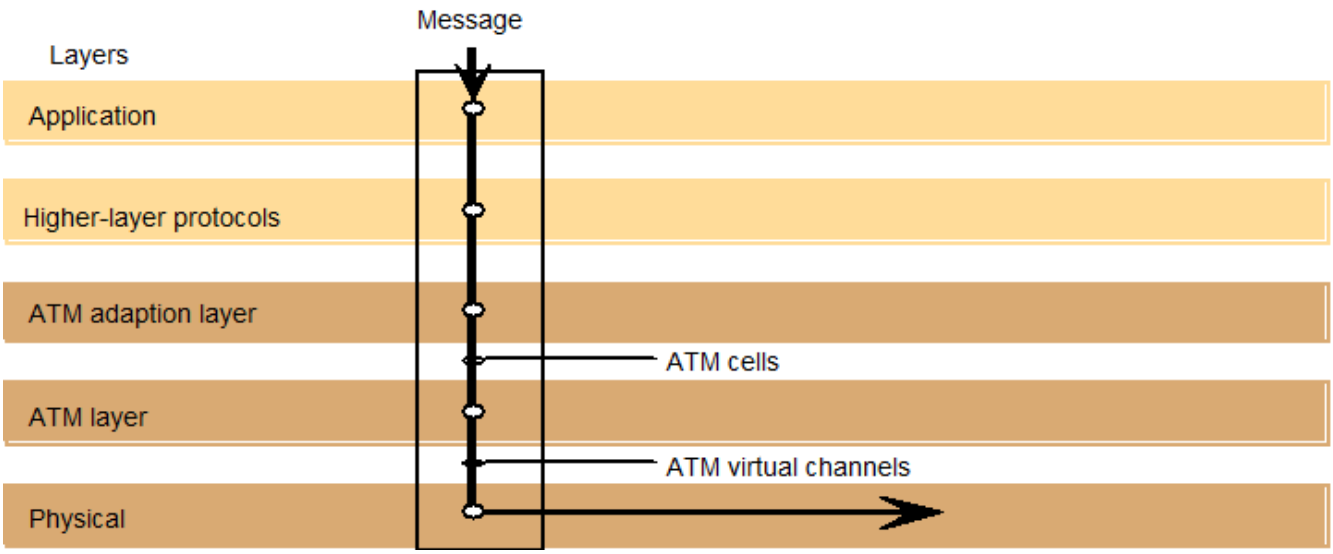
- Radio broadcast (fading strength, obstruction)
- Collision avoidance by Slot reservation mechanism by Request to Send (RTS) and Clear to Send (CTS) Stations in range pick up RTS/CTS and avoid transmission at the reserved times Collisions less likely than Ethernet, since RTS/CTS short Random back off period
- Problems Security (eaves dropping), use shared-key authentication



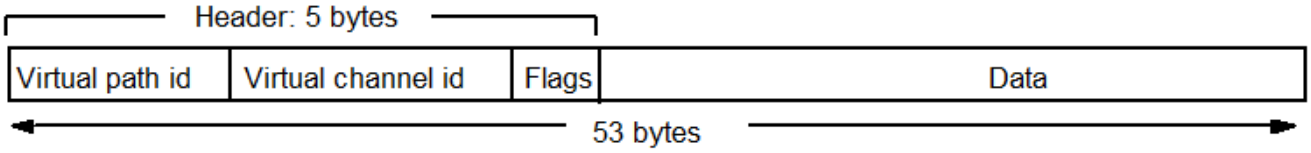
Asynchronous Transfer Mode (ATM)

- Multimedia data(voice and video), distributed system services are available
- Packet switching network based on Cell-relay (a method of packet routing)
- Avoiding flow-control and error checking at the intermediate nodes
- Small and fixed length unit of data transmitted (53bytes= header 5 + body 48) reduction of buffer size, complexity, queuing delay at intermediate nodes
- B-ISDN (CCITT I.150 standard)
- Optical fiber transmission medium (155 - 622 megabits/sec)
- ATM protocol layers (next page)

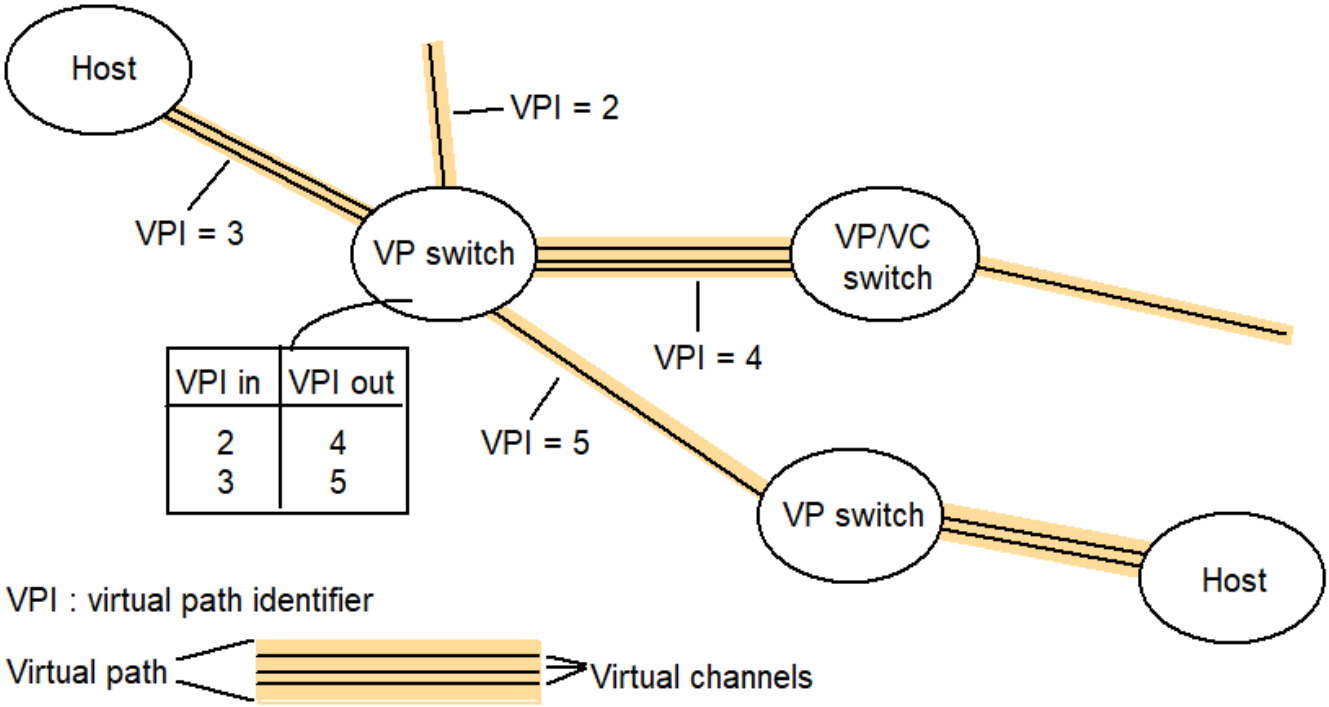
ATM Protocol Layer



ATM Cell Layout



Switching virtual in an ATM network



VPI : virtual path identifier

- From 202.30.11.187 to 202.30.11.44

202.30.11.187	1 1 0 0 1 0 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0 1 1 1 0 1 1 1 0 1 1
	AND
255.255.255.0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
	=
202.30.11.0	1 1 0 0 1 0 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0
202.30.11.44	1 1 0 0 1 0 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0 1 1 0 0 1 0 1 1 0 0
	AND
255.255.255.0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
	=
202.30.11.0	1 1 0 0 1 0 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0