Internet

1) Internet basic technology (overview)

2) Mobility aspects

3) Quality of Service (QoS) aspects

Relevant information: these slides (overview) course textbook (Part H) www.ietf.org (details)
IP network architecture
Server-client concept

- Transactions are always started by client.
- Network does not have to know IP address of client before transaction.
- Clients can be behind dial-up modem connections.
- Concept used in WWW applications.
IP protocol suite

- FTP
- SMPT
- HTTP
- DNS
- SNMP

- TCP
- UDP

- IP
- OSPF
- ICMP

- ARP
- PPP

- LAN-protocols, ATM, PSTN/ISDN, PLMN …
ARP (Address Resolution Protocol) manages mapping between logical IP addresses and physical MAC addresses in LAN’s

PPP (Point-to-Point Protocol) may be used for transport of IP datagrams over circuit switched connections (PSTN, ISDN, PLMN)
OSPF (Open Shortest Path First) is the most famous of possible protocols used for dynamic routing of IP datagrams.

ICMP (Internet Control Message Protocol) is a mandatory protocol used for informing hosts about problems in the network.
TCP (Transmission Control Protocol) takes care of end-to-end flow & error control + segmentation & reassembly of datagrams

UDP (User Datagram Protocol) is used in the connectionless case
Addressing

Host A

Port Y

TCP / UDP

IP

IP address N

Port – points to application

IP address – points to host

Host B

Port Z

TCP / UDP

IP

IP address M

IP datagram contains:
(in IP header)
source IP address N
destination IP address M

(in TCP / UDP header)
source port Y
destination port Z
Applications (1)

FTP (File Transfer Protocol)

SMTP (Simple Mail Transfer Protocol) for outgoing e-mail

POP (Post Office Protocol) for fetching e-mail from mailbox

SNMP (Simple Network Management Protocol)
HTTP (HyperText Transfer Protocol) is used for client-server type of communication, and is the most popular protocol for transport of WWW content.

http://www.ietf.org/overview.html

- Uniform Resource Locator (URL)
- protocol
- host computer
- content page written in HTML
DNS (Domain Name System) performs transformation between IP addresses and domain names.

122.233.121.123 <-> thisnetwork.thishost.com

IP address must be used for routing through IP networks; however, domain names are more user friendly.
IPv4 address structure

Hierarchical structure:

Class A
- $2^7 = 128$
- $2^{24} = 16.8 \times 10^6$
- Flat structure would provide $2^{32} = 4.3 \times 10^9$ IP addresses
- IPv6 is needed!

Class B
- $2^{14} = 16384$
- $2^{16} = 65536$
- Running out of addresses $\Rightarrow$ IPv6 is needed!

Class C
- $2^{21} = 2.1 \times 10^6$
- $2^8 = 256$

IPv6 provides $2^{128} = 3.4 \times 10^{38}$ IP addresses!
### IP header structure (IPv4)

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version</strong></td>
<td>IP version</td>
</tr>
<tr>
<td><strong>IHL</strong></td>
<td>IP header length</td>
</tr>
<tr>
<td><strong>Type of Service</strong></td>
<td>IP datagram length 576 ... 65535 octets</td>
</tr>
<tr>
<td><strong>Total length</strong></td>
<td>can be used for QoS management</td>
</tr>
<tr>
<td><strong>Identification</strong></td>
<td>old IP datagrams will be discarded</td>
</tr>
<tr>
<td><strong>Flags</strong></td>
<td>TCP, UDP or ICMP</td>
</tr>
<tr>
<td><strong>Fragment offset</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Time-to-live</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Protocol</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Header checksum</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Source IP address</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Destination IP address</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Options</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Padding</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Payload</strong></td>
<td></td>
</tr>
</tbody>
</table>
IP data unit structure

user/application data

TCP/UDP datagram

IP datagram

bearer protocol frame/packet/cell
Mobility in IP networks

Mobility is not "traditionally" supported in the Internet, but can (will) be implemented in the following ways:

**PLMN -based solutions:**
- GPRS (WAP or "real" HTML-based IP)
- 3G packet transport (solutions evolving)

**IETF solutions (wireless WAN etc.):**
- Mobile IP (described in IETF RFC 2002)

Potential problems:
- System inter-working
- Security
IP transport in GPRS

MT (Mobile Terminated) applications may not be supported (MS = server, client is on network side).

Typical application is MO (Mobile Originated), where MS is client and server is in network.
1. MS requests access (GPRS Attach)
2. GGSN creates an IP session (called “PDP context” in GPRS) defining temporary IP address of MS, address of used GGSN, tunneling IDs ...
3. IP datagrams are tunneled between GGSN and SGSN (GTP = GPRS Tunneling Protocol)
4. IP datagrams from Internet server are always first routed to GGSN
Mobile IP

- IETF solution for wireless LAN –type applications
- breakthrough in conjunction with IPv6?

Basic architecture:
Mobile IP (cont.)

Mobile node terminated IP transport:

1. Correspondent node sends IP datagram to permanent home address
2. Home agent tunnels IP datagram to care-of address
Mobile IP (cont.)

Tunneling in Mobile IP means encapsulation:

- **Mobile Node**
- **Foreign Agent**
- **Home Agent**

*Care-of address (IP address 2)*

*Home address (IP address 1)*

*Original IP datagram*

*IP header* ➔ *IP payload* ➔ *IP header* ➔ *IP payload*
Mobile IP (cont.)

Mobile node originated IP transport:

Mobile Node

Foreign Agent

Home Agent

Care-of address (IP address 2)

Note: source address in IP datagram is home address, not care-of address

Correspondent Node (IP address 3)

Mobile node sends IP datagram directly to correspondent node (no tunneling required)
Mobile IP (cont.)

Mobility requires: (1) agent advertisements

1. Mobile node has no valid care-of address
2. Foreign agents continuously broadcast (at ≈ 1 s intervals) lists of free care-of addresses
3. Mobile node selects a care-of address and informs the foreign agent.
Mobility requires: (2) registration

1. Mobile node informs home agent about new care-of address
2. Home agent replies with "ok"-message (or resolves the problem if situation is not ok)
3. From now on home agent can tunnel IP datagrams to mobile node.
QoS support mechanisms in IP networks

- Problems with “Best Effort” IP transport (the old way)

Existing and suggested alternatives for introducing QoS in IP backbone applications (situation year 2001):

Alternative 1: RSVP (Resource ReSerVation Protocol)
Alternative 2: DiffServ (Differentiated Services)
Alternative 3: MPLS (Multi-Protocol Label Switching)
Alternative 4: IP tunneling over ATM
QoS support mechanisms (2)

Problems with “Best Effort” IP transport service:

"Best effort" service is sufficient for traditional Internet applications like web browsing, e-mail, and file transfer.

"Best effort" service is not sufficient for:

- Speech (Voice)
- Interactive Video
- Video / Audio Streaming

- Low delay
- High throughput
- Low delay variation
- Consistent throughput
- Low round-trip delay
QoS support mechanisms (3)

RSVP (Resource ReSerVation Protocol)  (IETF RFC 2205)

Resources are reserved beforehand (or at certain intervals)

RSVP can be considered an example of the *integrated services* concept
(compare with *differentiated services*)
**QoS support mechanisms (4)**

**DiffServ (Differentiated Services)** (IETF RFC 2475)

Service "tagging" in ToS byte at ingress point

- **IPv4 Header**
  - ToS byte = 8 bits
  - $2^8 = 256$ priority levels could be used

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**QoS support mechanisms (5)**

**MPLS (Multi-Protocol Label Switching)** (IETF RFC 2702)

Label switching in all routers along the path

1. Virtual connection must be established first (using e.g. RSVP)
2. IP datagrams are encapsulated in MPLS frames and relayed through routers (i.e. only label, not IP header is used for routing)
QoS support mechanisms (6)

**IP tunneling over ATM**

IP datagrams are encapsulated in ATM cells and transported over ATM virtual connections.

See lecture slides on ATM for protocol stacks involved.