Internet protocols, TCP/IP suite

S-72.353

Layered structure of TCP/IP

Layer		Servi	ces		
5...7	SMTP	DNS	http	FTP	TELNET
4	T	CP	U	DP	NVP
3	IP	IC	MP	IP	
				ARP	RARP
2	CSMA/CD	Token ring	PSDN	Oth	ers

The vital protocols are IP, ICMP, TCP, and UDP. They serve numerous application protocols.

TCP/IP works on top of either LAN or WAN protocols. Any physical layer can be used.

TCP/IP does not follow the OSI layer model, it preceded it. Its logical structure is “messy”. It has arisen from the needs to solve practical problems.

Other protocols will be described in turn later.

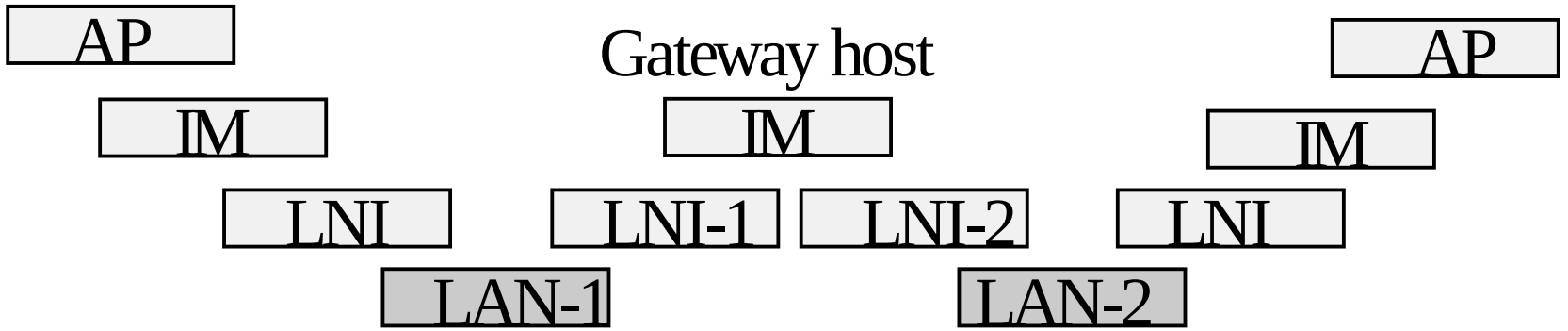
Operation of the Internet

The operation of the internet can be described as follows:

The sending application program (AP) prepares its data and calls on its LAN module (LNI) to send that data as a datagram and passes the destination address and other parameters as arguments of the call.

The internet module (IM) prepares a datagram header and attaches the data to it. The internet module determines a LAN address for this internet address, in this case it is the address of a gateway. It sends this datagram and the local network address to the LAN interface (LNI).

The LAN interface (LNI) creates a local network header, and attaches the datagram to it, then sends the result via the LAN (LAN-1).



Operation of internet continued

The datagram arrives at a gateway host wrapped in the LAN header, the LAN interface (LNI-1) strips off this header, and turns the datagram over to the internet module (IM). The internet module determines from the internet address that the datagram is to be forwarded to another host in a second network. The internet module determines a LAN address for the destination host.

It calls on the LAN interface (LNI-2) for that network to send the datagram. This LAN interface creates a local network header and attaches the datagram sending the result to the destination host.

At this destination host the datagram is stripped of the local net header by the LAN interface (LNI) and handed to the internet module (IM).

The internet module (IM) determines that the datagram is for an application program in this host. It passes the data to the application program in response to a system call, passing the source address and other parameters as results of the call.

Lower layers (2)

The internet is built for the purpose of exploiting Local Area Networks (LAN).

Typically CSMA/CD or Token ring local area networks are exploited.

Hosts and gateways may also have wide area networks (WAN) links.

ATM (Asynchronous Transmission Mode) and Frame Relay links are also used. For ATM IP is usually linked at AAL layer.

Network layer (3)

IP (**I**nternet **P**rotocol) offers services interconnecting networks for layer 4 clients. The protocol uses data-grams that are sent between hosts.

ICMP (**I**nternet **C**ontrol **M**essage **P**rotocol) is used by internet hosts and gateways to probe the status of internet services.

ARP (**A**ddress **R**esolution **P**rotocol) is needed to find the LAN address related to the host IP address.

RARP:tä (**R**everse **ARP**) is needed to find the IP address related to a host LAN address.

Transport layer (4)

TCP (**T**ransmission **C**ontrol **P**rotocol) takes care of reliable transmission of the byte stream within a logical connection.

UDP (**U**ser **D**atagram **P**rotocol) is a connection-less protocol which is used to perform transact-ions without acknowledgements.

NVP (**N**etwork **V**oice **P**rotocol) is an option for voice transmission.

Higher layer services (5-7)

Typical higher layer services are

TelNet (**Tel**ecommunications **Net**work) offers virtual terminal services which allow the terminal users access to hosts.

FTP (**F**ile **T**ransfer **P**rotocol) is used for file transportation between hosts.

SMTP (**S**imple **M**ail **T**ransfer **P**rotocol) offers electronic mail service between hosts.

DNS (**D**omain **N**ame **S**ervice) is used to convert host names to internet addresses.

Http (**H**yper**T**ext **T**ransfer **P**rotocol) is used within www-service (**W**orld **W**ide **W**eb) to convey pages with different elements.

IP

The task of IP is to connect two or more packet networks to an internet.

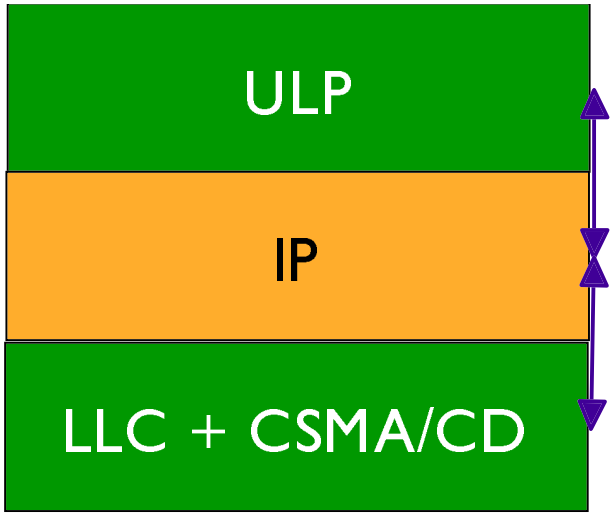
IP is a relatively simple connectionless protocol with only one state.

The internet architecture consists of two levels:

(1) a collection of networks and
(2) networks, which may contain subnetworks.

Hosts are connected either to networks or subnetworks.

IP layer



The task of the IP is to send datagrams to the internet.

IP gives services to Upper Layer Protocols (ULP) and it uses the services of the link level.

The IP service is **not reliable**. The receiving host may discard packets if its buffers overflow.
The IP does not notice if the link layer has lost or discarded any packets.
The IP isolates upper layers from LAN addresses.

Phases of communication (IP)

1. The ULP submits data to be transmitted by IP.
2. The IP packs data in an internet datagram and transmits it to the link layer protocols (LLC + CSMA/CD in a LAN).
3. If the destination host is located in the same LAN, IP sends it directly to this host.
4. If the destination host is in some other LAN, the IP sends the datagram to the nearest gateway.
5. The gateway addresses the datagram to the destination host in another network if the host is there, otherwise to the next gateway.
6. By repeating this procedure the datagram will be either eventually forwarded to the destination host or it will be lost in the collection of networks.
7. The receiving host will dismantle its datagram and will submit it to the ULP program to be processed.

IP Gateway

The IP gateway contains the internet module on two LAN interface modules.

The chain of internet modules forms the gateway route. This does not refer to the internal routing of any of participating networks.

Gateways need information on the structure of gateway network.

- Local gateways may use any appropriate program.
- Public networks use the Exterior Gateway Protocol (RFC904)

IP header

IP header structure:

[VER,IHL,TOS,TL,ID,F, FO, TTL, PROT, CRC, SOURCE, DEST, OPT, PADD]

- VER version (4 bits) ;
- IHL Internet Header Length in units of 32 bits (8 bits);
- TOS Type of Service (8 bits);
- TL Length of the datagram (Total Length) (16 bits);

IP packet fragmentation

In various subnetworks or WAN sections the packet size may be smaller than the original packet size (X25 128 bytes) which requires fragmentation of IP packets.

In fragmented packets special fields are needed:

ID (Identification) indicates the identity of the datagram to which a fragment belongs (16 bits);

F (Flag) indicates if the datagram can be fragmented and whether more fragments are coming. (3 bits);

FO position of the fragment in the datagram (Fragment Offset). In an unfragmented datagram or its first fragment FO=0 (13 bits).

More field definitions for the IP header

TTL Lifetime of the datagram (Time to Live), at most 255 s. TTL is reduced by one at every router. If TTL=0, the datagram is deleted. (8 bits). The default initial value is usually 64.

PROT Protocol refers to that higher level protocol that sent the datagram (16 bits).

CRC Header Checksum is computed by summing one's complement values of the 16 bit words in the header and by taking one's complement value of the sum.

SOURCE The Source Address (internet address) of the sending host (32 bits).

DEST Destination Address (32 bits).

More field definitions for the IP header (2)

OPT Options). Contains three subfields, copy, class and number. Class may be control or debugging.

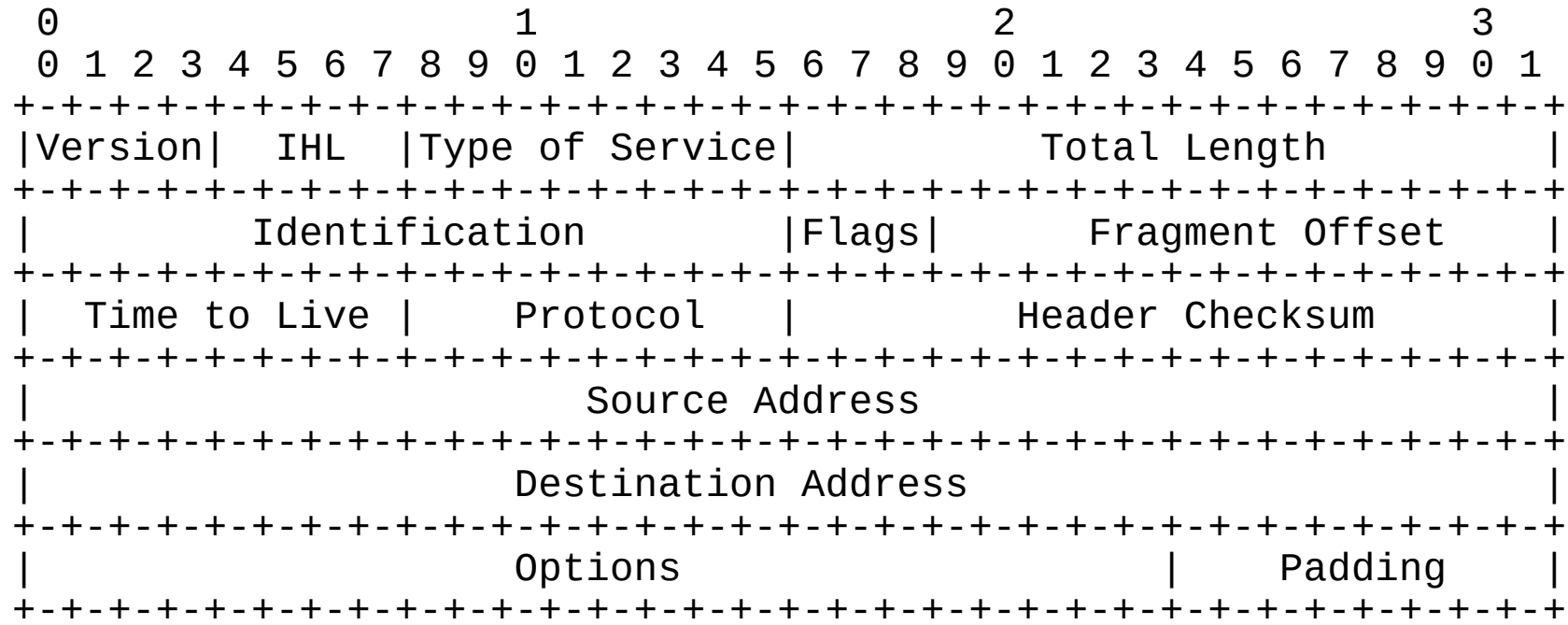
Possible additions to IP (number indicated, V if variable length): (may have security problems)

- (0) end of option list
- (1) no operation, indicates padding.
- (2) basic security option V
- (3) loose source routing V
- (4) internet timestamps V
- (5) extended security optionV
- (6) record route V
- (7) stream identifier 4
- (8) strict source routing V

PADD Padding.

IP header geometrically

RCF0791



Example Internet Datagram Header

Classes of IP networks

Hosts → / networks ↓	Very many	Interme-diate	Few
Few	A		
Intermediate		B	
Many			C

This is the initial classification of internet addresses in classes A, B and C.

The intention is to provide possibilities for different size networks using dotted quad notation 139.130.204.8.

More on IP classes

Class	Bits 1-3	Network bits	Host bits	Network mask
A	0	7	24	FF000000H
B	10	14	16	FFFF0000H
C	110	21	8	FFFFFF00H

The classes are indicated by bits 1-3.

The second field in address is reserved for networks.

The third field is for host bits.

The network mask is used to address hosts within own network.

IP-classes and types of addresses

Class	Network I	Host ID	Adress range
A	8	24	0.0.0.0 - 127.255.255.255
B	16	16	128.0.0.0 - 191.255.255.255
C	24	8	192.0.0.0 - 223.255.255.255
D			224.0.0.0 - 239.255.255.255

The class A is intended for really large networks, at most 255.

Class C is for small networks which have at most 255 hosts.

A class B network may have at most 65536 hosts

Altogether this arrangement is inflexible, most networks would be class B and its size is too large.

Symbolic notation of hosts and networks

The addresses are usually given in a symbolic form.

- The symbolic address of the host consists of three words separated by dots.
- The last word is known as domain, often a country, in Finland “fi”. Common domains are com, org, net.
- The middle word is a symbol for the network, which is common to some organization, e.g. Helsinki University of Technology uses “hut”.
- The first symbol is the symbolic name of the host.

DNS

Domain Name System (DNS).

Allows use of symbolic addresses, DNS names

When a DNS name is used the client has to have access to a DNS server to have access to the IP address, which is then passed to the IP protocol.

Examples of host names??

One should realize that in fast moving technology hosts are short-lived and so are their names.

128.214.248.6. nic.funet.fi Data store of the Funet network.

130.233.224.20. vipunen.hut.fi: IBM Risc-type computer dedicated to communications.

130.233.161.140. tiltu.hut.fi: Unix-server of Communications Laboratory

130.233.160.33 clara.hut.fi: Server of XX

130.233.160.57 tiltux.hut.fi: Work station HP 9000/710 at Communications Laboratory.

130.233.161.169 tlt-nt3.hut.fi: www-server of Communications Laboratory, also known as by its alias name www.comlab.hut.fi.

130.233.161.159. tlt-pc19: A PC at Communications laboratory

Classless Inter-Domain Routing (CIDR)

CIDR (”cider“)

RFC 1519, 1517, 1338

In this system the network part of the address may have any value.

The network address would now have the format a.b.c.d/x, where x indicates the number of leading bits that constitutes the network portion of the address.

The remaining 32-x bits are used to identify the hosts within the organization.