Introduction To Data Comm & Networking
Module 6
Chapter 9 – IPv4

http://intronetworks.cs.luc.edu/current2/html/index.html

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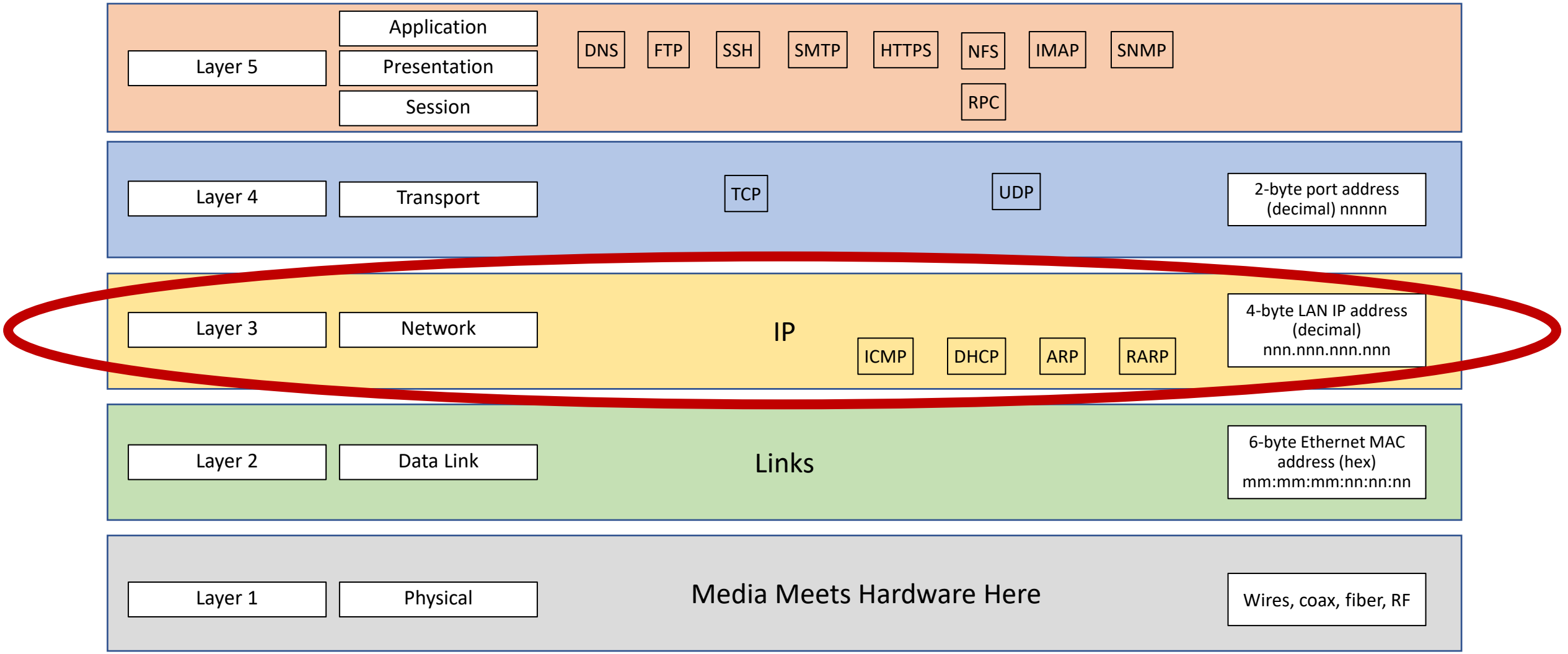
TCP/IP 5-Layer Network Stack



Internet Protocol (IPv4)

- IP is a fundamental underlying protocol that sits by itself and encapsulates Transport protocols for above layers.
- IP lives at the Network layer.
- Routing occurs at the Network (IP) layer.
- IP is generally associated with IPv4 addresses which are 4 bytes in dotted decimal notation: nnn.nnn.nnn.nnn.
- IP has some crucial helper protocols: ARP, RARP, ICMP, and IGMP without which Ethernet/TCP-IP networking would not work.
- Unlike the Data Link layer and Transport layer, there are no other kinds of protocols that can replace IP at the Network layer.
- IPv6 improved addressing capabilities due to 16-byte addresses providing an astronomically huge address space (see chapter 11).

IPv4 Header

IPv4 header format

Offsets	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Version				IHL				DSCP						ECN		Total Length															
4	32	Identification																Flags			Fragment Offset											
8	64	Time To Live								Protocol								Header Checksum															
12	96	Source IP Address																															
16	128	Destination IP Address																															
20	160	Options (if IHL > 5)																															
⋮	⋮																																
56	448																																

https://en.wikipedia.org/wiki/IPv4

IPv4 – header fields

Version: Indicates IP version 4 or 6.

Internet Header Length (IHL): header size (min value [5] × 4 bytes = 20 bytes; max value [15] × 4 bytes = 60 bytes).

Differentiated Service Code Point (DSCP): originally type of service (ToS), specifies differentiated services.

Explicit Congestion Notification (ECN): optional for end-to-end network congestion without dropping packets.

Total Length: packet size in bytes, including header and data. Min 20 (header without data); max 65,535.

Identification: primarily used for uniquely identifying the group of fragments of a single IP datagram.

Flags: bit 0 must be zero; bit 1 Don't Fragment (DF): if set and packet larger than MTU then packet dropped; bit 2 More Fragments (MF): for fragmented packets, all fragments except the last have the MF flag set.

Fragment Offset: This field specifies the offset of a particular fragment relative to the beginning of the original unfragmented IP datagram in units of eight-byte blocks. The first fragment has an offset of zero.

Time To Live (TTL): limits a datagram's lifetime to prevent network failure in the event of a routing loop.

Protocol: defines the protocol used in the data portion of the IP datagram.

Header Checksum: used for error-checking of the header.

Source Address: the sender of the packet (may be changed by NAT).

Destination Address: receiver of the packet (may be changed by NAT).

Options: not often used may be considered as dangerous by some routers and be blocked.

https://en.wikipedia.org/wiki/IPv4

IPv4 – Classful Addressing

- 4 octets in dotted decimal notation: nnn.nnn.nnn.nnn
- 4-byte addresses can provide for a theoretical maximum of about 4 billion addresses which sounds like a lot but is quite limiting.
- Originally, simple classful addressing required a subnet mask for 3 main classes A, B, C.

CLASS	NETWORKS	HOSTS	SUBNET MASK
A	128	16,777,214	255.0.0.0
B	16,384	65,534	255.255.0.0
C	2,097,152	254	255.255.255.0

IPv4 – Classless Addressing

- Classless Inter-Domain Routing (CIDR)
- Classless addressing replaced classful addressing and is used now.
- Subnetting goes hand-in-hand with classless addressing.
- Classless addressing is a more efficient use of IPv4's limited 4-byte address space.
- Subnet mask is indicated by /nn (e.g. /24 is the same as 255.255.255.0)
- It makes more sense in binary.

CIDR (count 1's in subnet mask)	BINARY SUBNET MASK
/23	11111111 11111111 11111110 00000000
/24	11111111 11111111 11111111 00000000
/25	11111111 11111111 11111111 10000000
/26	11111111 11111111 11111111 11000000

IPv4 – CIDR Reference

CIDR	Addresses	Usable Hosts	DECIMAL				BINARY			
/30	4	2	255	255	255	252	11111111	11111111	11111111	11111100
/29	8	6	255	255	255	248	11111111	11111111	11111111	11111000
/28	16	14	255	255	255	240	11111111	11111111	11111111	11110000
/27	32	30	255	255	255	224	11111111	11111111	11111111	11100000
/26	64	62	255	255	255	192	11111111	11111111	11111111	11000000
/25	128	126	255	255	255	128	11111111	11111111	11111111	10000000
/24	256	254	255	255	255	0	11111111	11111111	11111111	00000000
/23	512	510	255	255	254	0	11111111	11111111	11111110	00000000
/22	1024	1022	255	255	252	0	11111111	11111111	11111100	00000000
/21	2048	2046	255	255	248	0	11111111	11111111	11111000	00000000
/20	4096	4094	255	255	240	0	11111111	11111111	11110000	00000000
/19	8192	8190	255	255	224	0	11111111	11111111	11100000	00000000
/18	16384	16382	255	255	192	0	11111111	11111111	11000000	00000000
/17	32768	32766	255	255	128	0	11111111	11111111	10000000	00000000
/16	65536	65534	255	255	0	0	11111111	11111111	00000000	00000000
/15	131072	131070	255	254	0	0	11111111	11111110	00000000	00000000
/14	262144	262142	255	252	0	0	11111111	11111100	00000000	00000000
/13	524288	524286	255	248	0	0	11111111	11111000	00000000	00000000
/12	1048576	1048574	255	240	0	0	11111111	11110000	00000000	00000000
/11	2097152	2097150	255	224	0	0	11111111	11100000	00000000	00000000
/10	4194304	4194302	255	192	0	0	11111111	11000000	00000000	00000000
/9	8388608	8388606	255	128	0	0	11111111	10000000	00000000	00000000
/8	16777216	16777214	255	0	0	0	11111111	00000000	00000000	00000000

IPv4 - Interface concepts

- IP addresses are assigned to Interfaces (not hosts or nodes).
- A host may have multiple interfaces.
- A Network Interface Card (NIC) may have one or more interfaces.
- A loopback address is an interface.
- VPN's create an interface.
- A host may have multiple NIC's each with its own interface referred to as "Multihomed".
- Interfaces make IP versatile.

IPv4 – Special Addresses

- Private, broadcast, and multicast are examples of special addresses.
- 10.0.0.0/8 common private address block
- 172.16.0.0/12 common private address block
- 192.168.0.0/16 common private address block
- 100.64.0.0/10 special mobile operator addresses
- 255.255.255.255 broadcast address
- 224-239.x.x.x multicast address

IPv4 – Fragmentation

- Maximum Transmission Unit (MTU) = the largest single data packet that a network device can accept.
- Different routers may have a different MTU.
- Standard MTU is 1500.
- If a router has a MTU < 1500 then fragmentation will occur.
- Packets will get broken into smaller payloads by the router with the smaller MTU.
- Packets are reassembled by the last router in the path.
- MTU > 1500 are considered jumbo packets and can cause unfairness in resource usage.

IPv4 – Subnetting

- General design philosophy: “switch when you can, route when you must”.
- Subnets are internal only and are not visible past the firewall.
- Subnets create isolation reducing congestion and adding a layer of security versus a pure “flat” address space.

IPv4 – Subnetting Video

https://www.youtube.com/watch?v=ecCuyq-Wprc

IPv4 – Network Address Translation (NAT)

https://www.youtube.com/watch?v=wg8Hosr20yw

References

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