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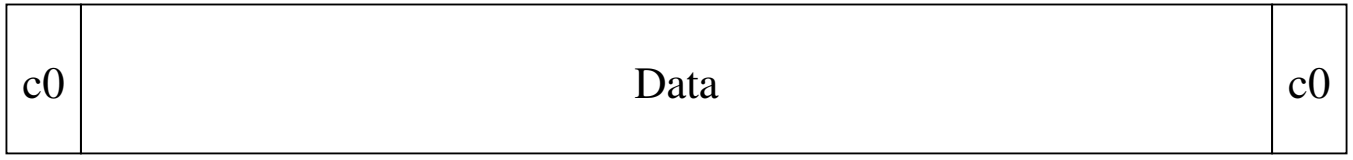
Serial Line Internet Protocol (SLIP) is an early protocol used on modems to encapsulate IP traffic over serial (telephone) lines

It is a *point-to-point* protocol, meaning it links just two machines to each other: the normal requirement in early dial-up systems

SLIP



SLIP frame

A very simple frame encapsulation with a terminating byte (hex) `c0`; also often a starting `c0` byte, too

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A minor expansion of data, but it enables transparent transmission of data

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An interactive response of over 100-200ms is felt to be slow

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Exercise Compute the average latency for 296 byte frames on 9600b/s; and 1500 byte frames on 56Kb/s

Exercise And how big a frame could we have on a 10Mb/s Ethernet for the same latency?

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No authentication: no way to check *who* is connecting

PPP

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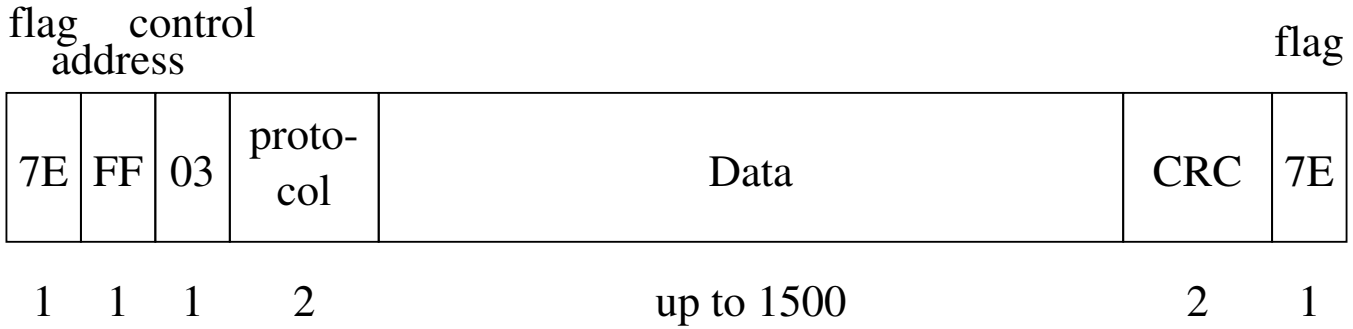
Like SLIP it is a point to point protocol

It has three parts

- A framing layout for packets
- A link control protocol (LCP) for managing and configuring links
- A set of network control protocols (NCP) to manage network layer specific options

PPP



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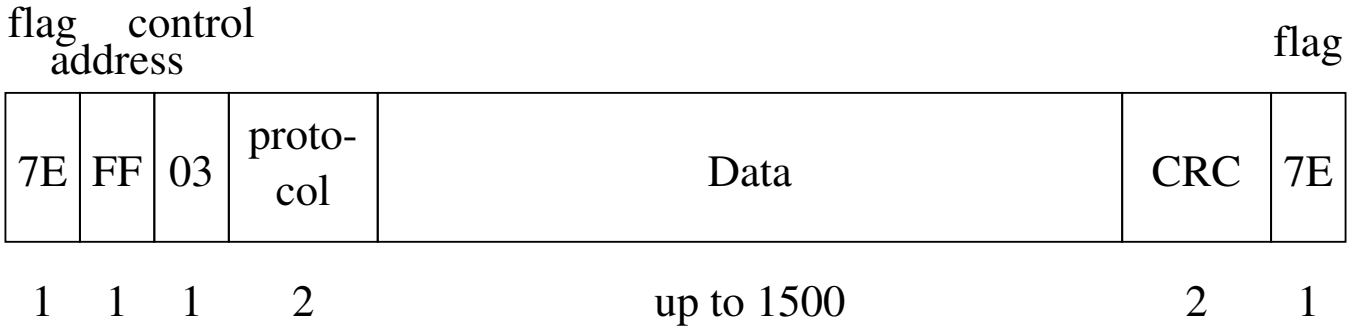
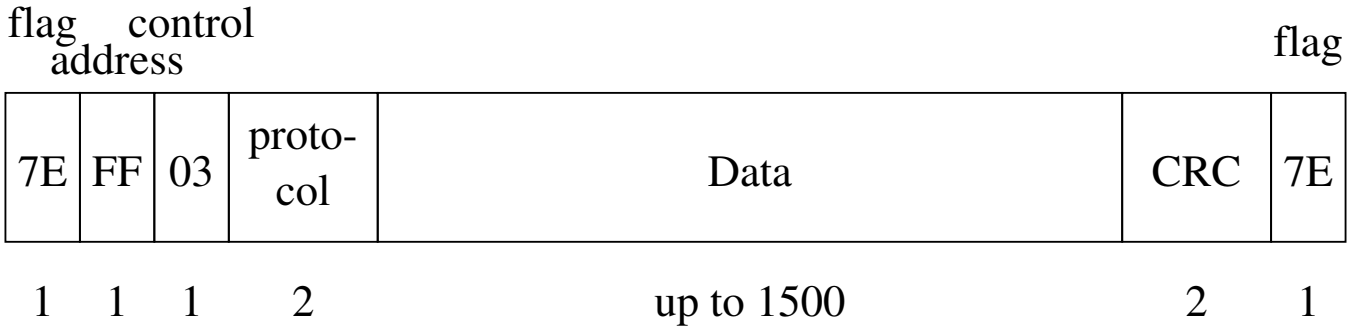


PPP frame

- Frame delimiters `7E`, start and end

PPP



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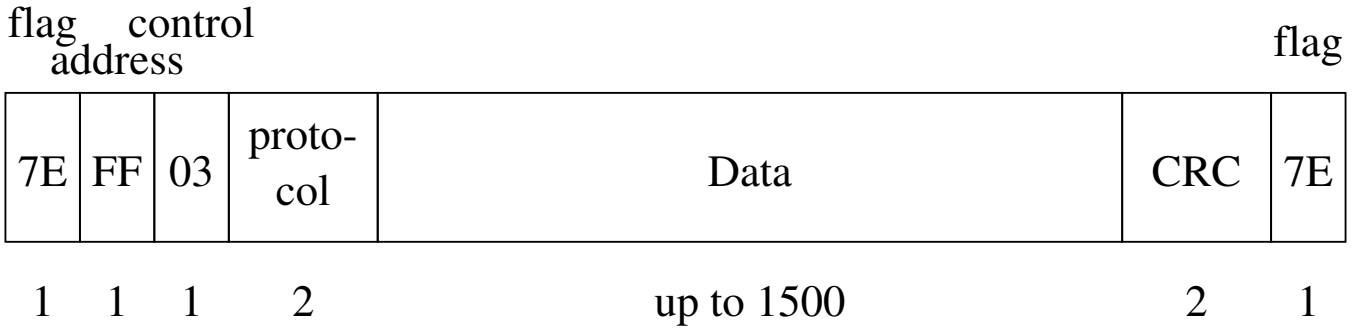

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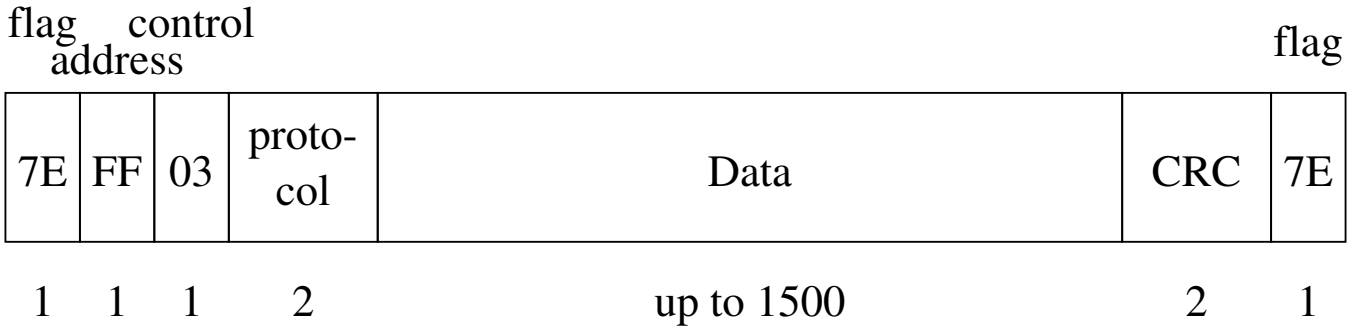

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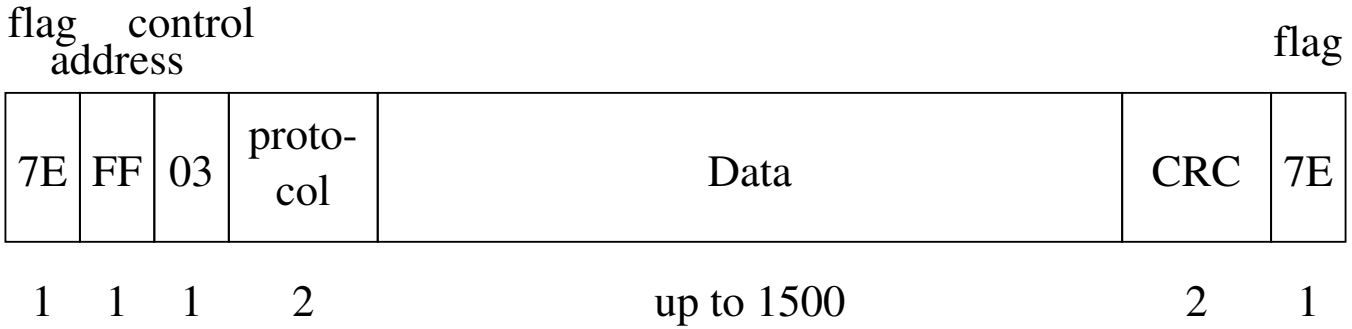

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- Cyclic redundancy check to spot corruption
- But no address fields (**Exercise** why not?)

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- x, where $x < 20_{16}$ $\rightarrow$`7d` [x+`20`], so, e.g., `01`$\rightarrow$`7d 21`

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Exercise Read about this

Exercise Look at the configuration of your home ADSL or VDSL modem

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There are many link layers for carrying data over long distances, at high data rates, both electrical and optical

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Exercise Read about ATM and PPPoA, that layers (IP over) PPP over ATM, as used in ADSL and DOCSIS

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Exercise Read about MPLS and how BT uses it in its 21C Network

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Ethernet Link Layer

We want to move up to the network layer: but before doing so there is one more remark on the link layer

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Recall Ethernet. The data on the wire:

Ethernet frame

Networks

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Which is shared (or switched), so the frame has no problem being seen by the destination host

Networks

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In the Internet Protocol, these addresses live in the network layer

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IP

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These are hardware independent, and in the same format across the entire Internet

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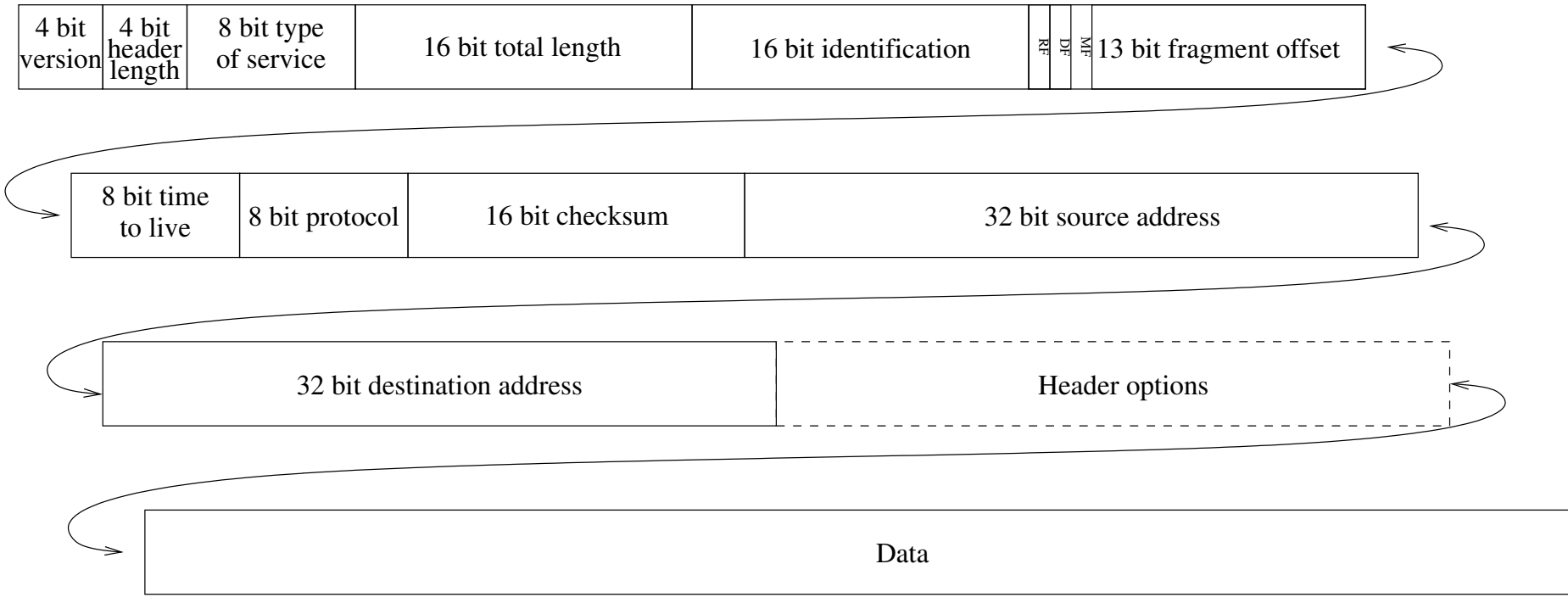
But, for now, assume this is true

Networks

IP Header



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Networks

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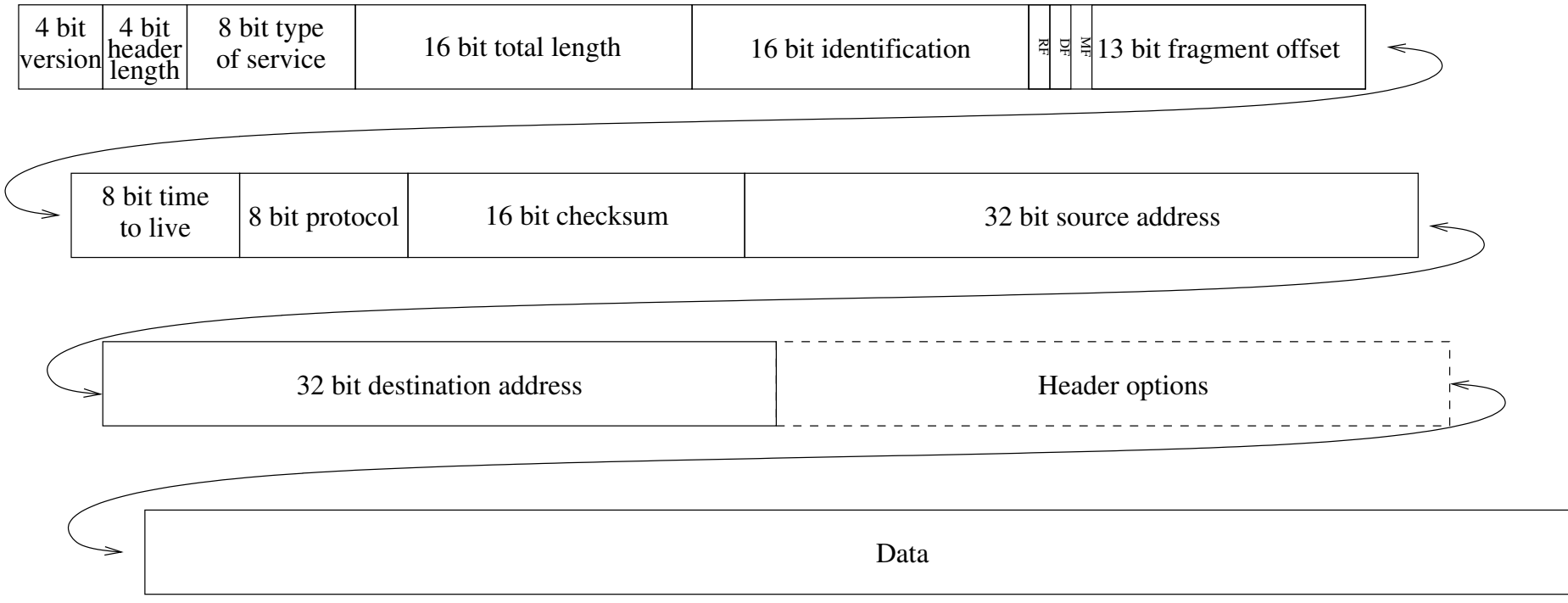
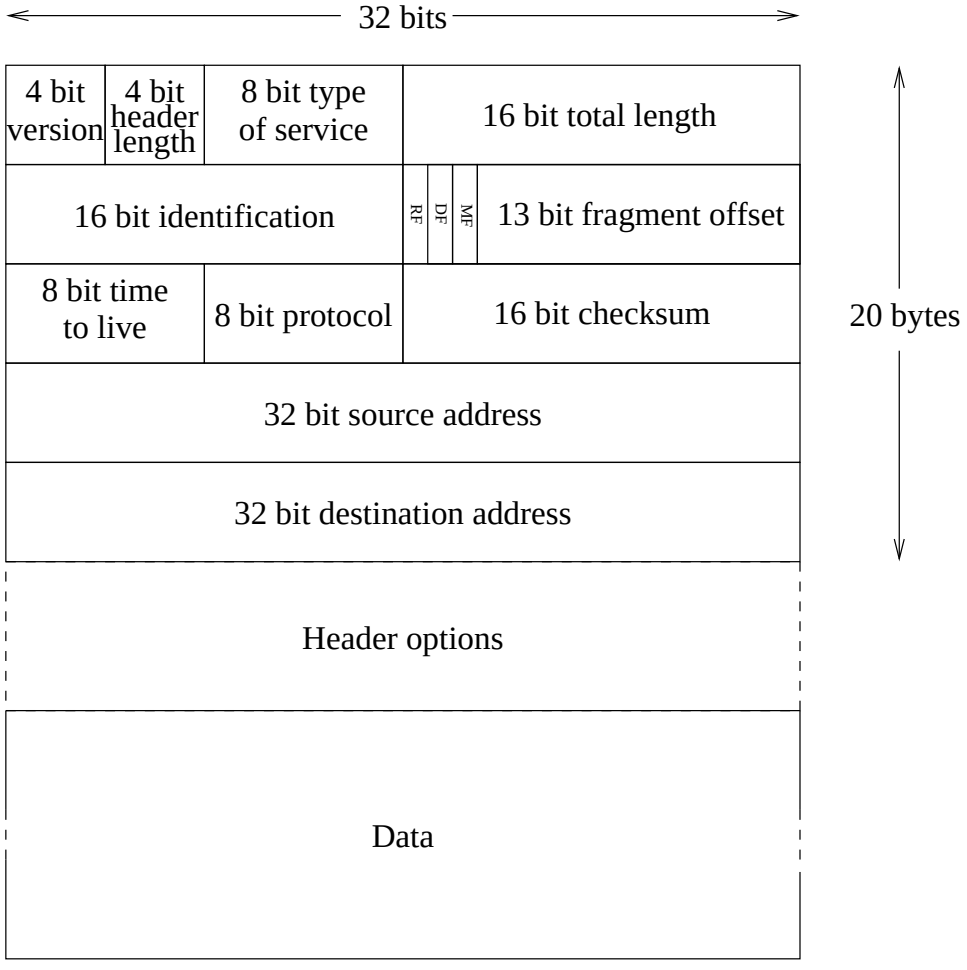


IP header

A bit hard to read, so conventionally we stack the header vertically

Networks

IP Header



IP header (usual layout)

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But, importantly, there is *structure* in an IP address which helps with routing

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Always remember that the dotted decimal notation is just a convenient way of writing a chunk of bits: there are no decimal numbers in the header!

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But the main point for now is that this IP address is independent of Ethernet and so can be used regardless of the hardware used

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Now the IP packet must be further encapsulated in a hardware frame, Ethernet in this example. The OS can't send the packet on the physical medium until it knows the Ethernet address of the destination

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And this separation of layers, as we know, is desirable

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(There are questions of security here. . .)

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Only now can the original packet be sent

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Once expired, the next packet to `138.38.3.40` will need a fresh ARP