Networking Basics

03 - The Internet Protocol (IP)

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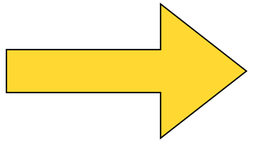
Where networks meet

Networking Basics

DE-CIX Academy



01 - Networks, Packets, and Protocols

02 - Ethernet, 02a - VLANs

03 - The Internet **Protocol** (IP)

- 03a - IP addresses, prefixes, and routing
- 03b - Global IP routing

04a - UDP, 04b - TCP, 04c - ICMP

05 - Uni-, Broad-, Multi-, and Anycast

06a - Domain Name System (DNS)

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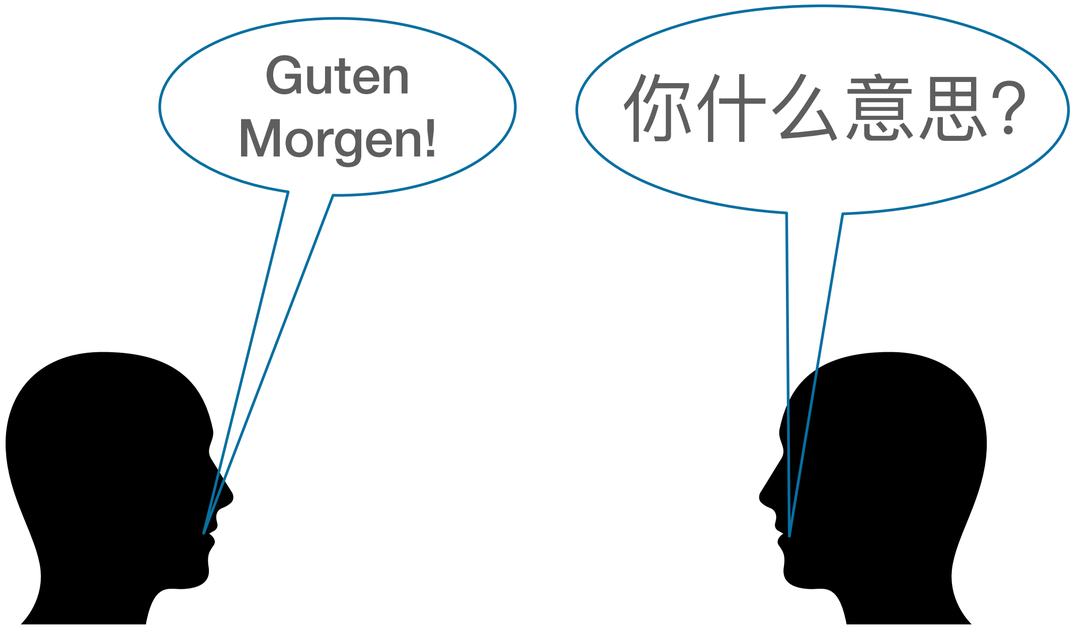
Protocol

What is a "Protocol"?

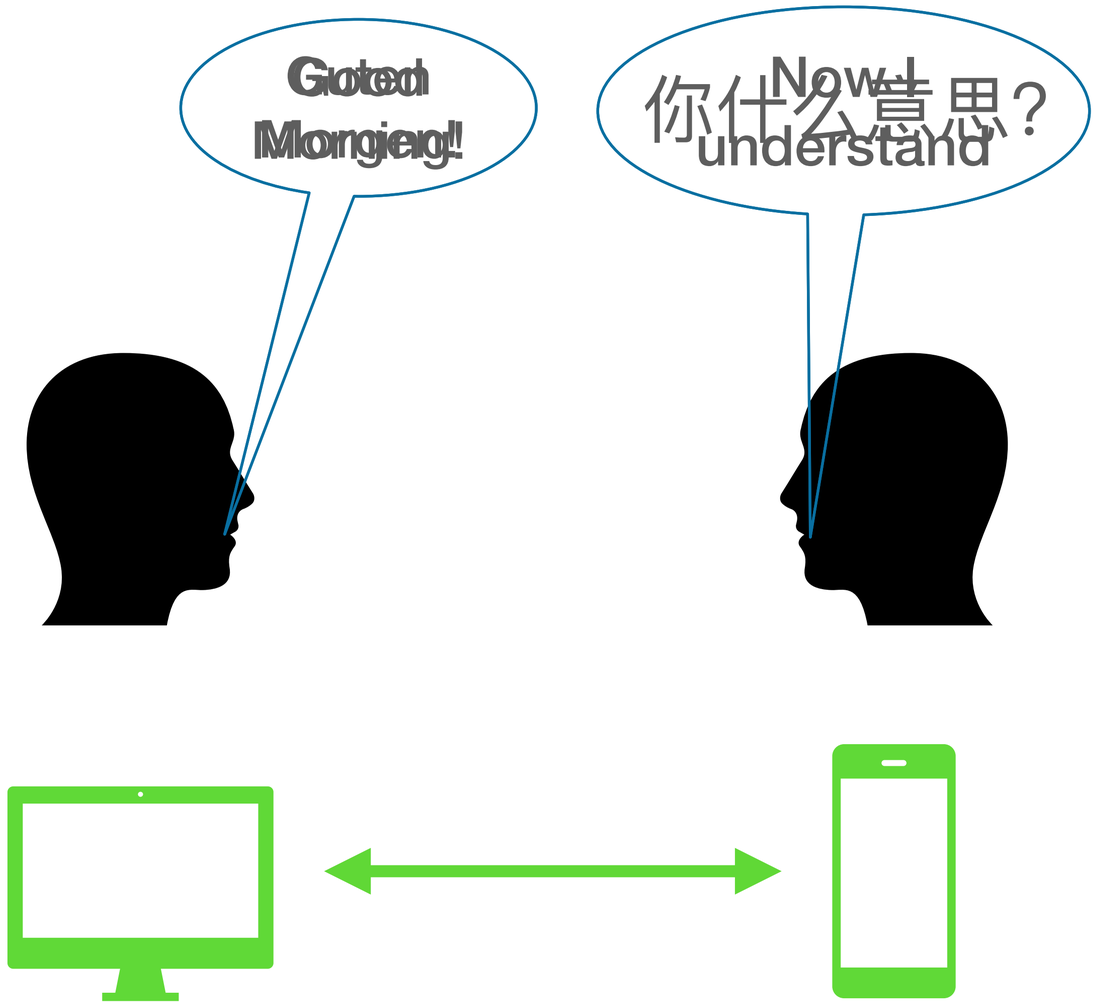
- If you want to communicate, you need to speak a common language
- Otherwise you will not understand each other



PS: I used Google Translate. Hope it says "I do not understand"

What is a "Protocol"?

- If you want to communicate, you need to speak a common language
- Otherwise you will not understand each other
- The same is true for computers or other network devices



Protocol Stack

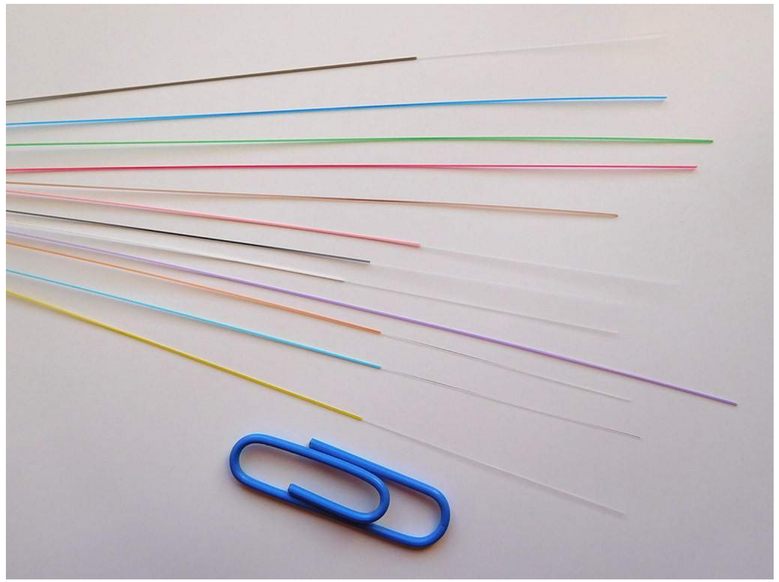
Multiple protcols building on each other

Internet Model

Physical Layer

- Light pulses and electrical signals
- Lasers and fibres
- Electrical cables

Layer	Name
5	Application
4	Transport
3	Internet
2	Link
1	Physical



Attribution: Cjp24
https://commons.wikimedia.org/wiki/File:12_Optical_fibers_(1).jpg

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Internet Model

Link Layer

- Data units are called "Frames"
- Provides hop-to-hop (node-to-node) data transfer
- Examples:
  - Ethernet

Layer	Name
5	Application
4	Transport
3	Internet
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1	Physical

Attribution: Wolfgang Tremmel

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Ethernet

Frame Structure

- EtherType
- Payload

Preamble				SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
10101010	10101010	10101010	10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	16 Bits 2 Octets	46 - 1500 Octets	32 Bits 4 Octets

Ethernet

Frame Structure

Encapsulation

Packets inside packets

- The payload of Ethernet is IP
- Encapsulation is like Russian dolls
- So we have an IP packet inside an Ethernet frame

Attribution: Fanghong. derivative work: Greyhood
https://commons.wikimedia.org/wiki/File:Matryoshka_transparent.png

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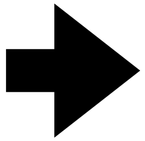
Internet Model

IP / Internet Layer

- Data units are called "Packets"
- Provides source to destination (end-to-end) transport
- Needs addresses for entities
- Examples:
  - IPv4
  - IPv6



Layer	Name
5	Application
4	Transport
3	Internet
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1	Physical

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IP - Version 4 (IPv4)

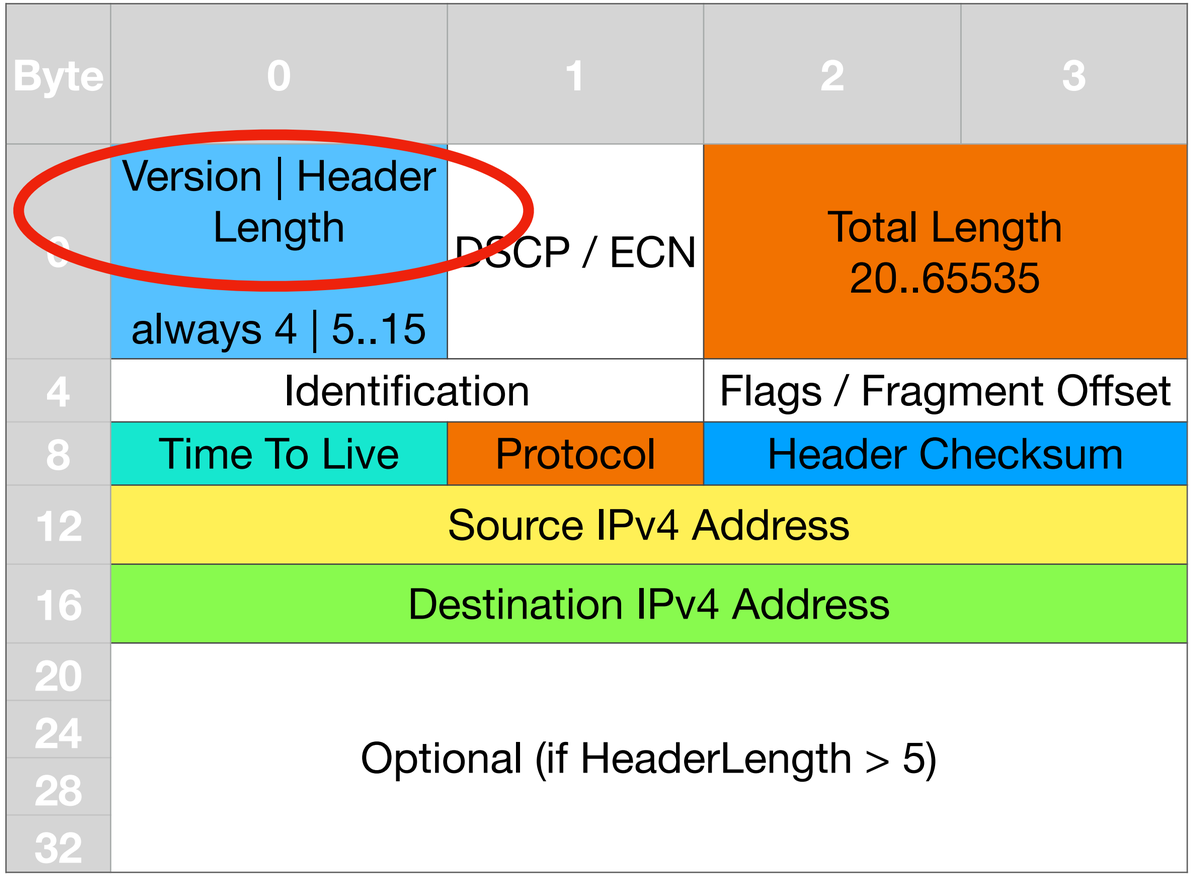
Header + Payload

Ethernet Payload	
IPv4 Header	**IP Payload**
20-60 Bytes	1440-1480 Bytes

IPv4 Header

Some parts to point out

- Starts with version and length
- Total length of packet
- Important: Time to live (TTL)
- Protocol: Type of payload
- Source / Destination address 32 bits
- Options (optional)



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IP - Version 6 (IPv6)

Header + Payload

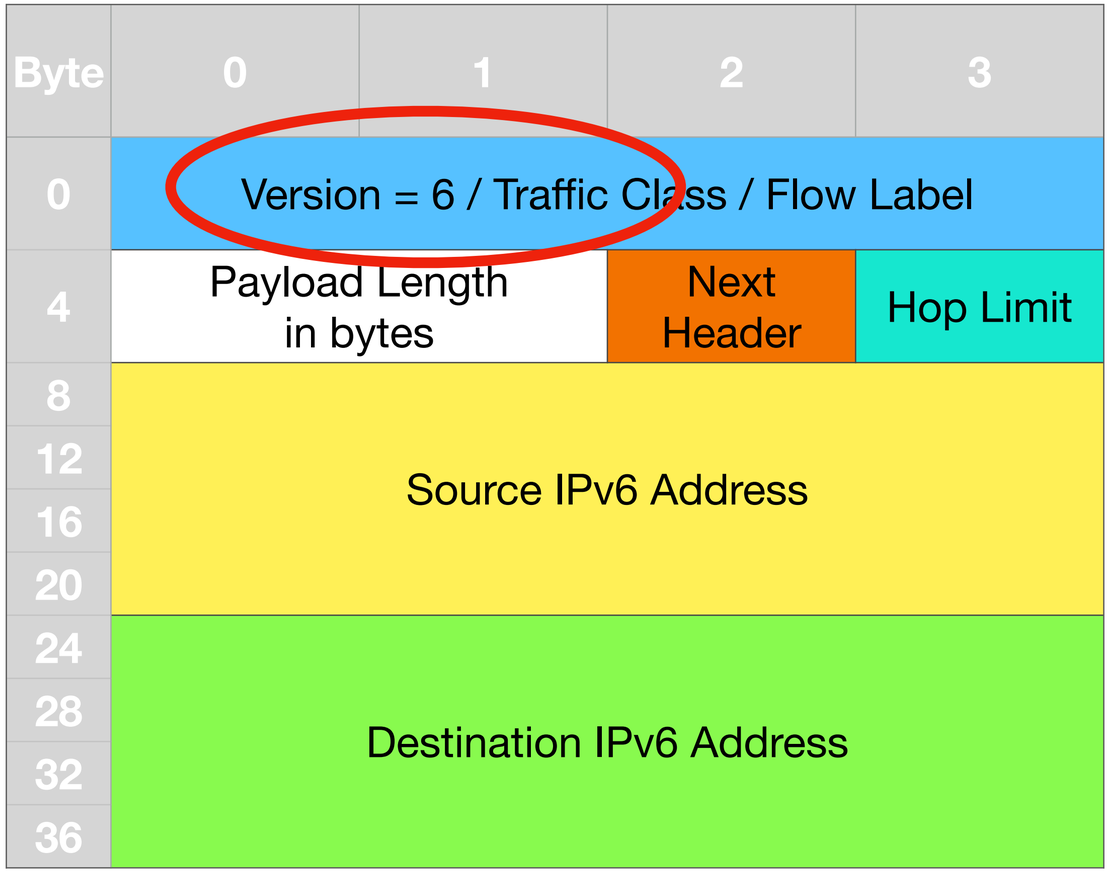
Ethernet Payload	
IPv6 Fixed*) Header	**IP Payload**
40 Bytes	1460 Bytes

*) IPv6 packets can contain "extension headers" after the fixed header

IPv6 Header

Looks less complicated!

- Starts with version and some labels
- Payload length in bytes (0-65535)
- Next Header - you can chain more headers
  - replaces protocol field
- Hop Limit replaces TTL
- Addresses are now 128bits



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IP Addresses - IPv4

IP Addresses

IPv4

192.0.2.123

- 32 bit in length
- you might have heard of Class-A, -B, -C addresses
- there is no such thing anymore!
  - since 1993!
- all usable IP addresses are equal
- more about this in another webinar

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IP Addresses

IPv4

192.0.2.123

- 32 bit in length
  - 4.294.967.296 possible addresses
- written as 4 decimal numbers separated by dots "."
- some addresses are reserved / not usable
- all usable IPv4 addresses have been assigned to users

1100 0000 0000 0000 0000 0010 0111 1011

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 25 27 28 29 30 31 32

IPv6!

Development started: 1994
First published: 1995

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IP Addresses - IPv6

IP Addresses

IPv6

2001:db8:274f:400:226:b0ff:fed8:3d8a

0 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13 14 15 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 36 37 38 39 3a 3b 3c 3d 3e 3f 40 41 42 43 44 45 46 47 48 49 4a 4b 4c 4d 4e 4f 50 51 52 53 54 55 56 57 58 59 5a 5b 5c 5d 5e 5f 60 61 62 63 64 65 66 67 68 69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76 77 78 79 7a 7b 7c 7d 7e 7f

- 128 bit in length - possible addresses:
  340282366920938463463374607431768211456
- there are lots of IPv6 addresses available
- written as hexadecimal numbers separated by colons ":"
  - double-colon "::" means fill up with zeros here
- some addresses are reserved / not usable

2001:db8::1

2001:db8:0:0:0:0:0:1

2001:0db8:0000:0000:0000:0000:0000:1

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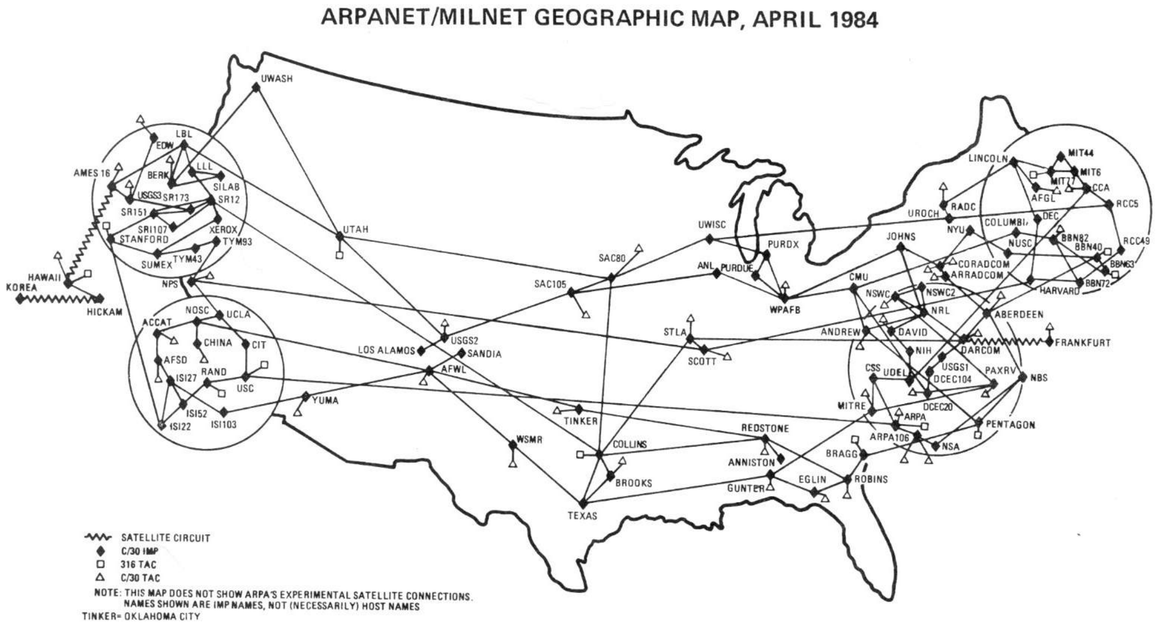
Internet Protocol

How did it all start?

History of IP

It started in the 60s

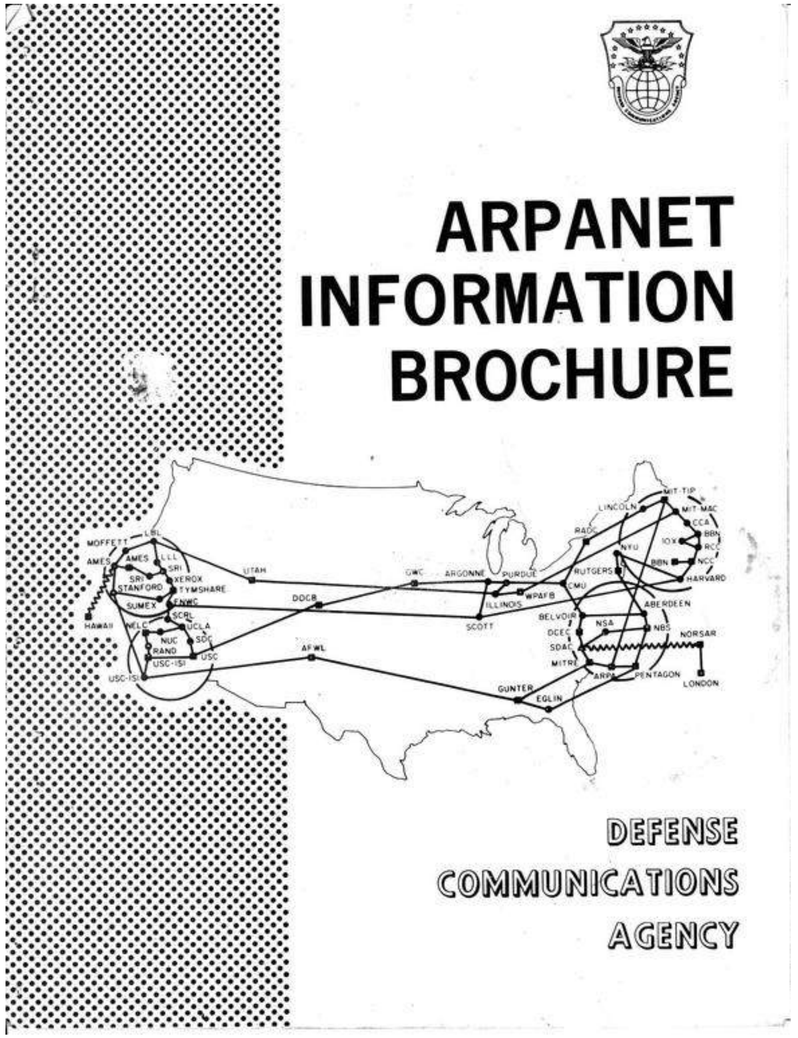
- To debunk a myth:
  - It was not invented to survive a nuclear war!
- But it was funded by DARPA - a military research agency
- To connect research facilities to share (computing) resources



Timeline

Some days in the early history of IP

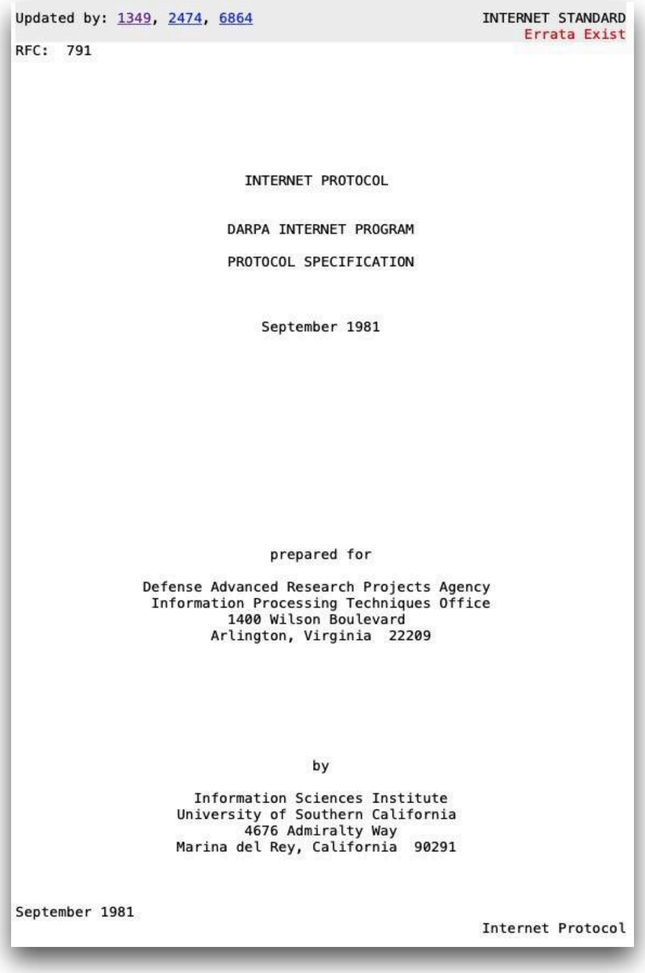
- 1961 - concept of packet switching network
- 1967 - Plan for "ARPAnet"
- 1969 - first ARPAnet node, first **RFC** published
- 1972 - first public demonstration of ARPAnet
- 1974 - TCP/IP protocol described, "Internet" first used
- 1983 - ARPAnet switches from NCP to TCP/IP



Why was IP so successful?

The role of documentation

- There were other, competing protocols
  - Do you remember BITnet, DECnet? OSI?
  - Either vendor-proprietary or just theory
- IP Protocols were evolving more quickly
- Everything was open - and still is
  - 1969 - first Request for comments (**RFC**) published
  - Memos, best practices, standards - published as RFC
  - Today: Well established and open standard for publishing



Updated by: 1349, 2474, 6864 INTERNET STANDARD
Errata Exist

RFC: 791

INTERNET PROTOCOL

DARPA INTERNET PROGRAM

PROTOCOL SPECIFICATION

September 1981

prepared for

Defense Advanced Research Projects Agency
Information Processing Techniques Office
1400 Wilson Boulevard
Arlington, Virginia 22209

by

Information Sciences Institute
University of Southern California
4676 Admiralty Way
Marina del Rey, California 90291

September 1981 Internet Protocol

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Conclusion

Things you should remember

The IP Protocol(s)

- Internet Protocol (IP) takes care of **end-to-end** communication
- **IPv4** and **IPv6** coexist
- IP packets consist of **header** and **payload**
- **IPv4** and **IPv6** headers are different
  - But both contain source- and destination **addresses**
  - IPv4 addresses are 32 bit long, IPv6 addresses are 128 bit long
- **Payload** can yet be **another protocol**

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Thank you!

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Links and further reading

Links and further reading

- Ethernet - https://en.wikipedia.org/wiki/Ethernet
- Internet protocol - https://en.wikipedia.org/wiki/Internet_Protocol
- Protocol stack - https://en.wikipedia.org/wiki/Protocol_stack
- IP Network Model: https://en.wikipedia.org/wiki/Internet_protocol_suite
- IP Version Numbers https://www.iana.org/assignments/version-numbers/version-numbers.xhtml#version-numbers-1
- IPv4
  - IPv4 - https://en.wikipedia.org/wiki/IPv4
  - IPv4 address exhaustion - https://en.wikipedia.org/wiki/IPv4_address_exhaustion
  - Map of IPv4 addresses in 2006, 2011
- IPv6
  - IPv6 itself - https://en.wikipedia.org/wiki/IPv6
  - IPv6 header - https://en.wikipedia.org/wiki/IPv6_packet
  - IPv6 addresses - https://en.wikipedia.org/wiki/IPv6_address
  - First standard: RFC1884, current standard: RFC8200
- History of Internet and IP
  - Internet Hall of Fame - https://internethalloffame.org
  - Defense Advanced Research Projects Agency (DARPA) - https://www.darpa.mil
  - ARPANET - https://www.darpa.mil/about-us/timeline/arpanet
  - The "Protocol Wars" - https://en.wikipedia.org/wiki/Protocol_Wars

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Internet RFCs (Standards)

- There are too many RFCs dealing with IPv4 and IPv6 to be listed here
- Just go to https://tools.ietf.org/html/ and use the search field
- How does something become RFC? https://www.rfc-editor.org/pubprocess/
- The IETF - Internet Engineering Task Force