

Networks

Security in the IP

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And the models are also weaker on security than they ought to be

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Compounding the issue of lack of support for security in the Internet protocols, early TCP/IP implementations were woefully poor: many exploitable bugs

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- Many protocols used are not resistant to malicious interference
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And the implementations were very fragile and easily hacked

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New protocols and secure (we hope) extensions to existing protocols are now available: e.g., HTTPS for the Web, SMTPS for email

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Management and use of cryptography has an overhead. This is an extra workload on servers: some people are unwilling to pay this price

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More on this later

Long term plan

We shall now work our way up the layers, looking in detail at what TCP/IP does for each

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This is going to be a long journey!

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Hardware

First, hardware

Networks

Hardware

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There are several popular hardware implementations. Some you should have come across are

- Ethernet: a wired network
- ADSL and VDSL: telephone networks
- Wi-Fi: a short range wireless network
- Cellular: mobile phones

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- ADSL and VDSL: telephone networks
- Wi-Fi: a short range wireless network
- Cellular: mobile phones

We shall look at some of these

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Hardware

Exercise How many different wireless systems does your mobile phone support?

Networks

Ethernet

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In comparison, current consumer Ethernet runs at 1Gb/s, while typical top-end Ethernet runs at 100Gb/s, with 400Gb/s starting to be used in datacentres and plans for 800Gb/s and 1.6Tb/s

Networks

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The signalling rate is the rate of delivery of bits across the physical network

Due to layering encapsulation and other physical overheads, this is overwhelmingly *not* the rate of delivery of bits to the application you are running

For example, there is always a gap between packets where data is not being transmitted!

Networks

Ethernet

However, the signalling rate is the number marketers like to use

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The rate actually realised can be much lower; e.g., a 54Mb/s Wi-Fi network might only deliver half that figure to an application

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Ethernet

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And we begin with the frame format

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Ethernet

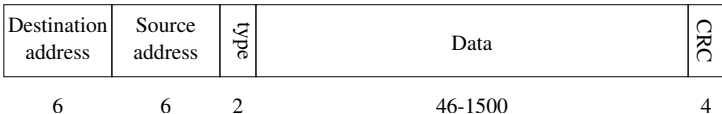


Ethernet frame

Numbers are byte counts: so, e.g., the destination address is 6 bytes long

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- 2 byte type indicates what kind of network layer data follows, e.g., (hex) 0800 for an IP packet
- The data, maximum 1500 bytes
- **Minimum 46 bytes.** The data must be padded with extra bytes if fewer than 46 bytes are supplied

Networks

Ethernet



Ethernet frame

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Ethernet frame

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- 4 byte checksum, also called *cyclic redundancy check* (CRC)
- Use to check for corruption errors in the frame

Networks

Ethernet

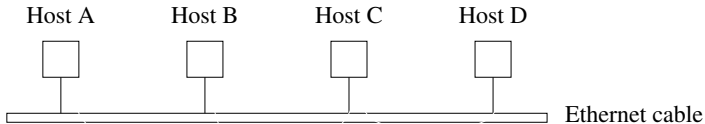
How is a frame matched up to the intended destination host?

Networks

Ethernet

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(Original) Ethernet is *shared*, so every host sees every frame on the local network



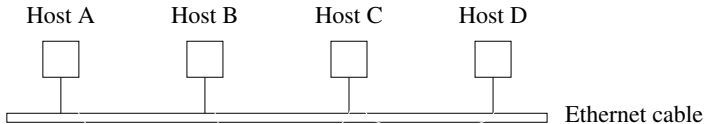
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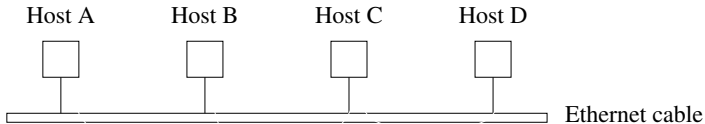
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Original Ethernet

However, every Ethernet card has a unique address built into it

(Not the full story, but true enough for now)

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For convenience we write this as 08:00:20:9a:34:dd, six hexadecimal numbers

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This is the job of the next layer, IP, which we look at later

Networks

Ethernet

What of the signalling on the wire?

Networks

Ethernet

What of the signalling on the wire?

Ethernet uses *carrier sense, multiple access with collision detection* (CSMA/CD)

Networks

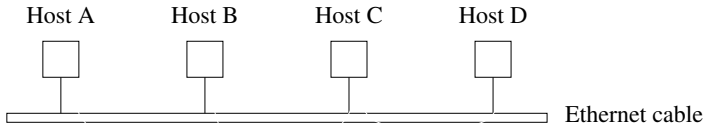
Ethernet CSMA/CD

Ethernet is a *multiple access* (shared) medium, meaning that several hosts use the same piece of wire to send data to one another

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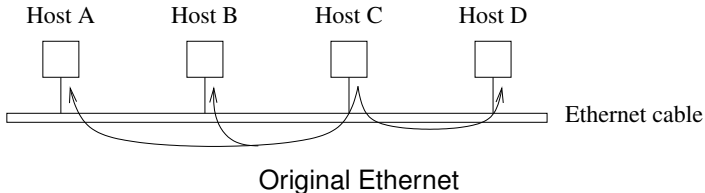
Original Ethernet

Suppose A wishes to send to B

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Ethernet CSMA/CD

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Suppose A wishes to send to B

If C is already sending to D, the whole network is occupied with its signal, so A must wait

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Ethernet CSMA/CD

If two hosts try to send simultaneously, there will be a *collision*

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So before they send data, a host *listens* to the Ethernet to see if anyone else is using it at the moment: *carrier sense*

If not, it sends the data

Otherwise it must wait, listening until the carrier is free

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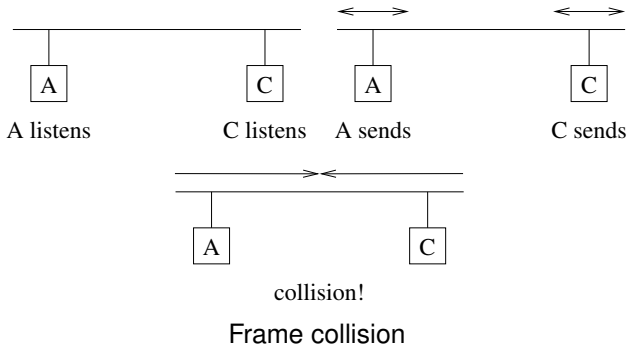
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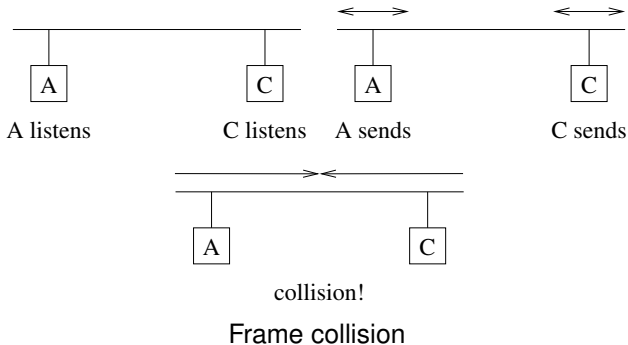
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Networks

Ethernet CSMA/CD

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So each host **continues to listen while transmitting** to make sure there are no collisions: *collision detection*

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If a collision is detected, each host stops transmitting, waits a (small) **random** period of time and retries with the carrier sense

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The random wait means that another collision is less likely as the one host will come in slightly later and see the other's signal in its carrier sense phase

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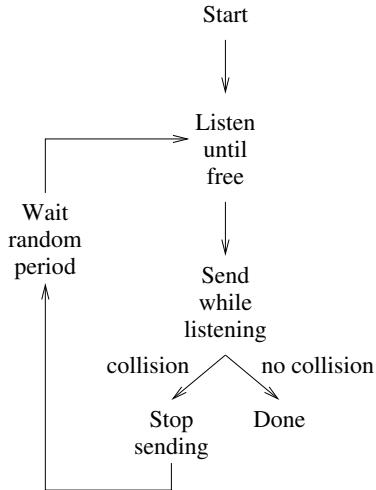
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Detecting collisions on an Ethernet is simple: if the signal you are seeing on the network is not the same as the signal you are putting on the network, that means someone else is transmitting, too

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Ethernet CSMA/CD



CSMA/CD flowchart

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Ethernet CSMA/CD

Exercise Explain why we need to go back to carrier sense after the random pause

Networks

Ethernet CSMA/CD

Exercise Explain why we need to go back to carrier sense after the random pause

Exercise Read further about jamming signals and what to do if the transmission repeatedly fails

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Ethernet CSMA/CD

Collision detection is why there is a minimum frame size

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(The speed of a signal in a cable is approx $2/3 c$; 100m is 520 cpu cycles of a 1GHz cpu)

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Exercise Find out how CSMA/CD differs from Aloha

Networks

Physical Ethernet

There have been many Ethernet physical layers

Standard	cable	max size	rate
10Base5	Thick coax	500m	10Mb/s
10Base2	Thin coax	200m	10Mb/s
10BaseT	Twisted pair	100m	10Mb/s
10BaseF	Fibre optic	2000m	10Mb/s

Base means *baseband*, namely using a single chunk of frequencies from 0 (the base) up to a single cut-off point

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Physical Ethernet

And these evolved (just a selection here):

Standard	cable	max size	rate
100BaseT4	Twisted pair	100m	100Mb/s
100BaseT	Twisted pair	100m	100Mb/s
100BaseF	Fibre optic	2000m	100Mb/s
1000BaseT	Twisted pair	100m	1Gb/s
2.5GBaseT	Twisted pair	100m	2.5Gb/s
5GBaseT	Twisted pair	100m	5Gb/s
10GBaseT	Twisted pair	100m	10Gb/s

Networks

Physical Ethernet

The cables used in these PHYs change over time. Unshielded Twisted Pair (UTP) comes in various qualities:

- Category 1: No performance criteria
- Category 2: Rated to 1 MHz (used for telephone wiring)
- Category 3: Rated to 16 MHz (used for Ethernet 10BaseT)
- Category 4: Rated to 20 MHz (used for Token-Ring, 10BaseT)
- Category 5/5e: Rated to 100 MHz (used for 1000BaseT, 100BaseT, 10BaseT)

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Category 5 has been replaced by Category 5e which has slightly better construction specifications

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All the twisted pair cables are bundles of 4 pairs of wires with an RJ45 plug on the end

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Physical Ethernet

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Then we have shielded cables, where each pair has a metal foil wrapper:

- Category 6: Rated to 250 MHz
- Category 6a: Rated to 500 MHz
- Category 8.1: Rated to 2000 MHz
- Category 8.2: Rated to 2000 MHz, special end plugs

Plus extra rules on how the connectors on the end are joined on

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Currently (2022) the best cable to buy is Cat6a as it supports any speed your home network is likely to have and is fairly cheap

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Currently very few home users will have anything faster than 1 Gb interfaces and switches