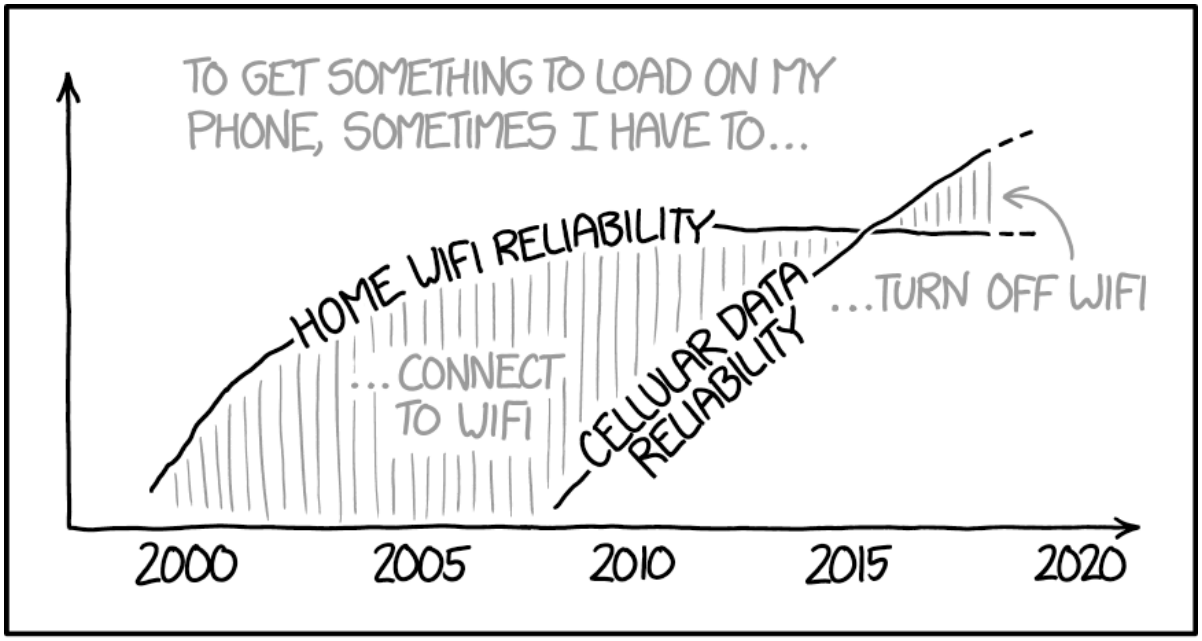
ENGSCI 233 Lecture 11.1

Low-Level Networking



IT SEEMS WEIRD FROM A NETWORKING POINT OF VIEW, BUT SOMETIME IN THE LAST FEW YEARS THIS FLIPPED FOR ME.

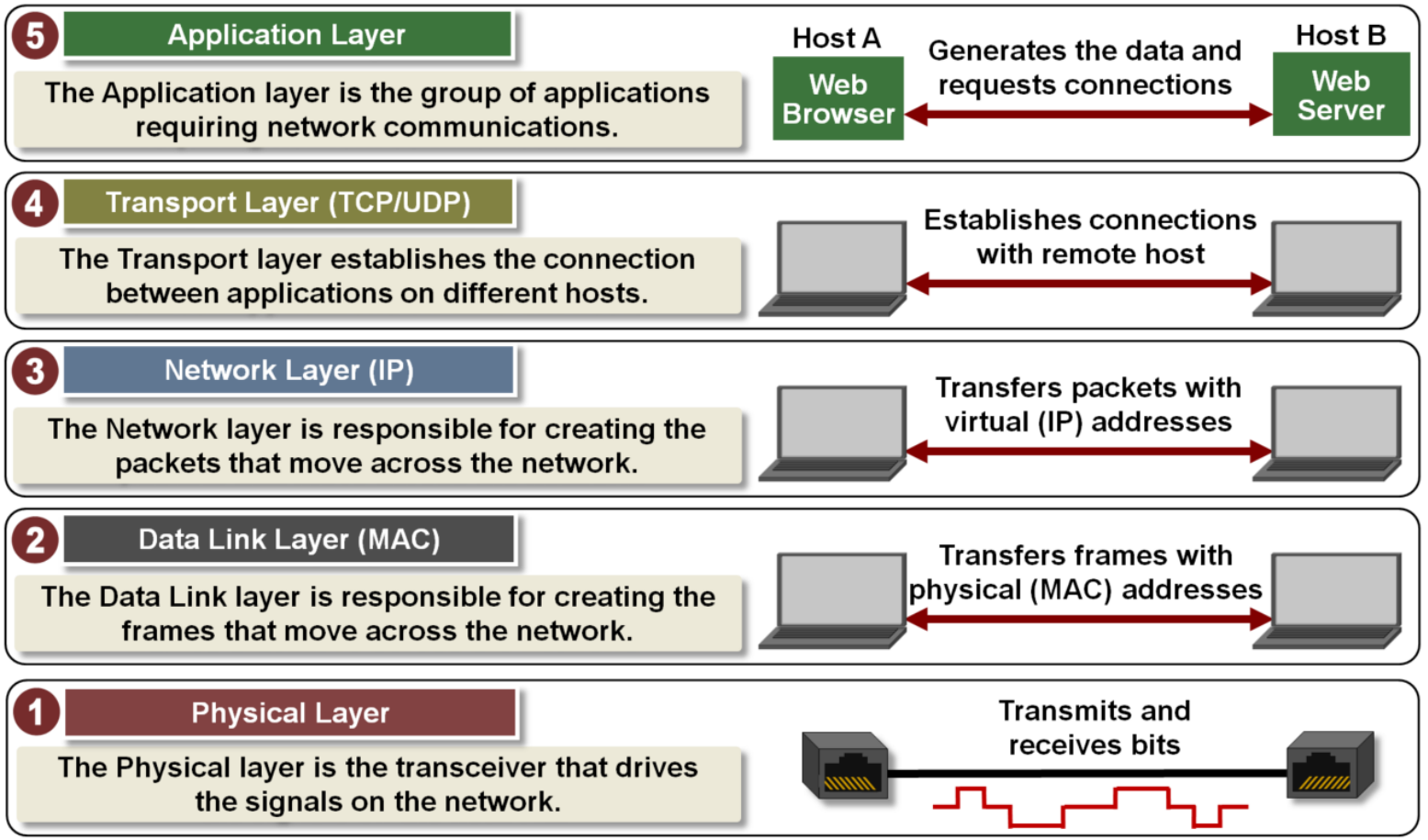
Today's learning objectives:

- Understand the physical means used to transfer data from one computer to another
- Discuss different ways that information can be encoded
- Understand the use of error-correcting codes
- Describe the key characteristics of ethernet

How does data transfer work?

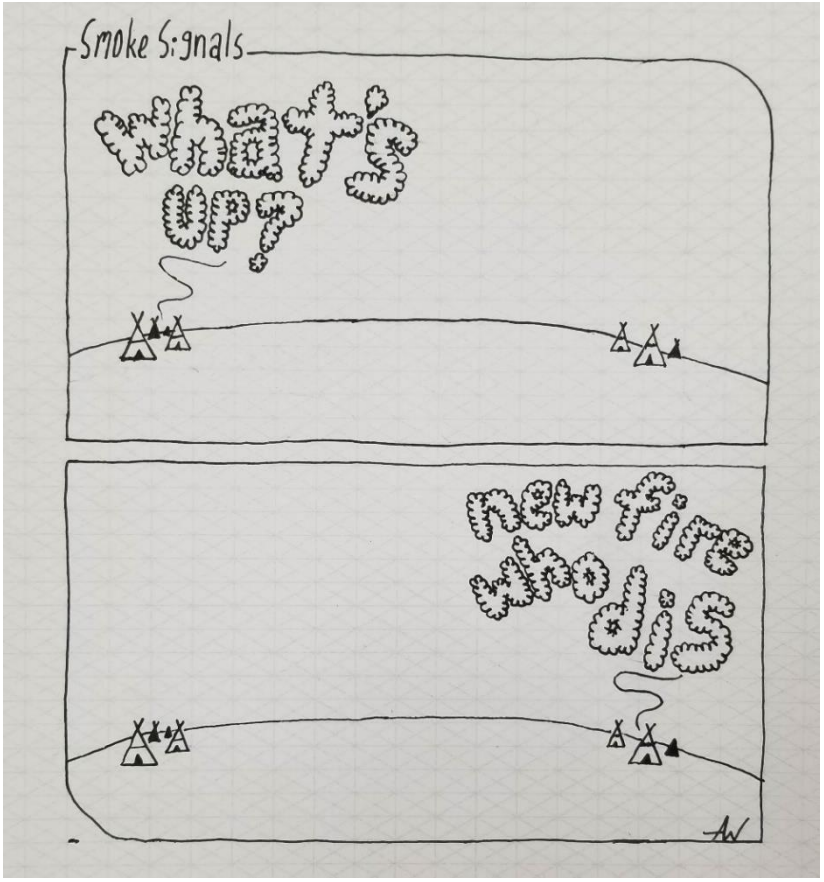
- How, exactly does that cat video get to your device?
  - Where does it come from?
  - How can you see it at home? On a train? At the top of a mountain?
  - How many engineers spent their lives figuring this out?
- Or, replace “cat video” with electrocardiograph signal, electricity price data, etc.

It’s a bit like an onion…



We need something physical.

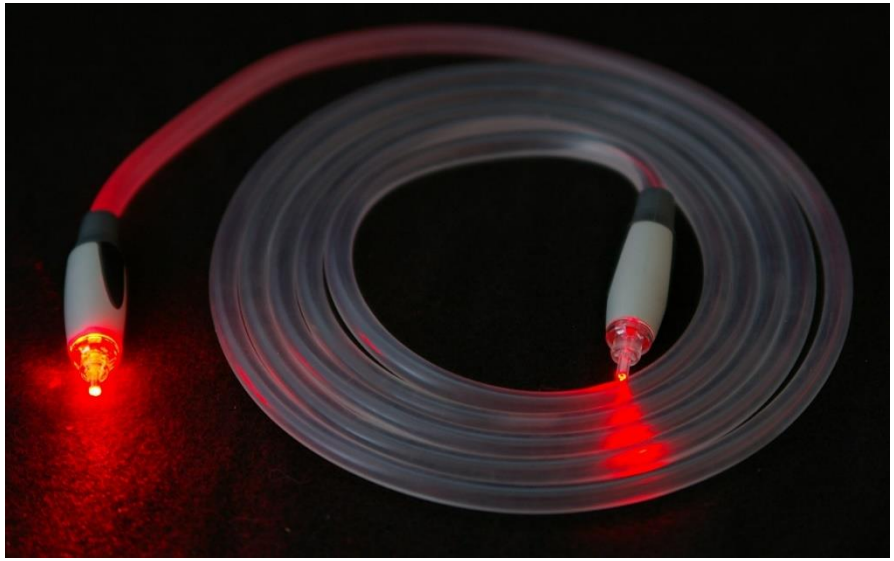
- The general idea is that we change a physical medium to communicate
- Some changes are simple
  - On/off
- Some are subtle
  - The shape of a smoke signal…
- There are limits to how fast we can change (“bandwidth”)



Wires are cheapest.

- Use the same electrical signals as internal data buses
- Physically robust
- Limited bandwidth
  - Capacitance/inductance smear out signals
- Limited length
  - Signals get weaker
  - More noise enters

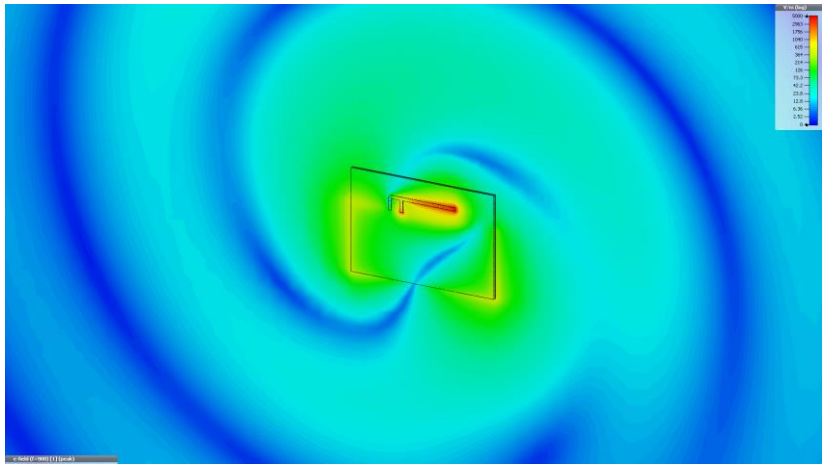
Optical fibres are fastest.



- Requires optical/electrical conversion
- Physically fragile
- Extremely high bandwidth
  - Limited by electronics
- Long lengths
  - Tens of kilometres
  - Across oceans with amplifiers…

Radio waves are most versatile.

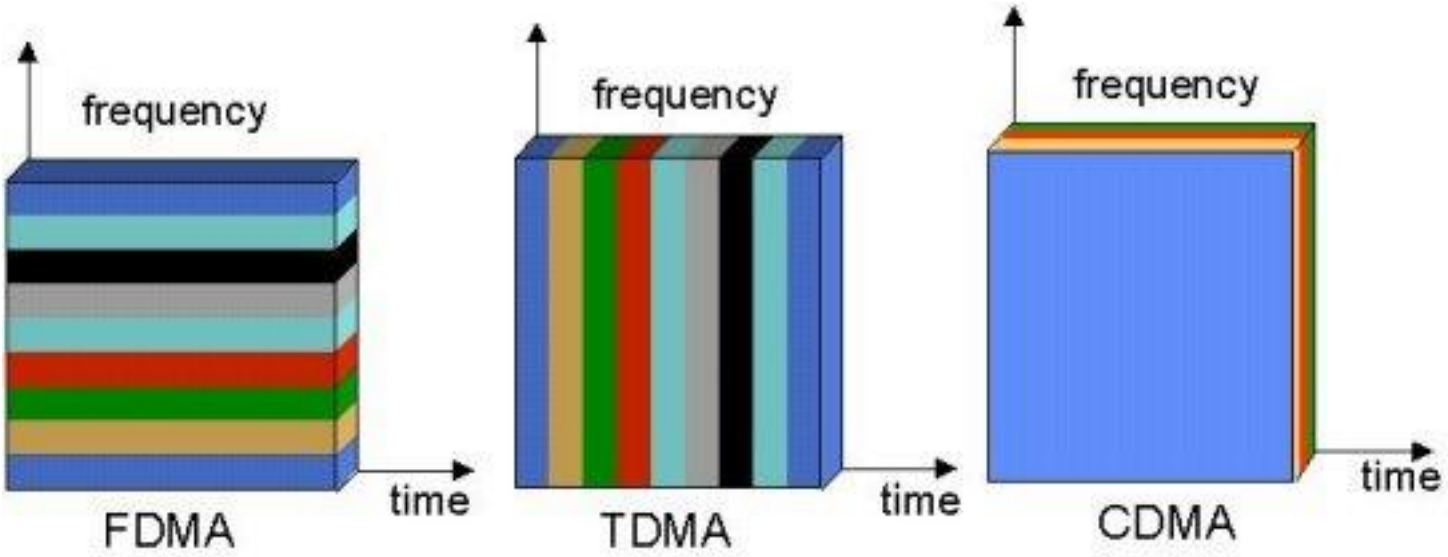
- No mechanical connection
- Pass through walls, trees, people, etc.
- Lose power rapidly with distance
  - Inverse square law, $1/r^2$
- Broadcast to everyone!
  - Serious interference possible
- Higher bandwidth = less range
  - Also more loss from walls etc.



How do we share a medium?

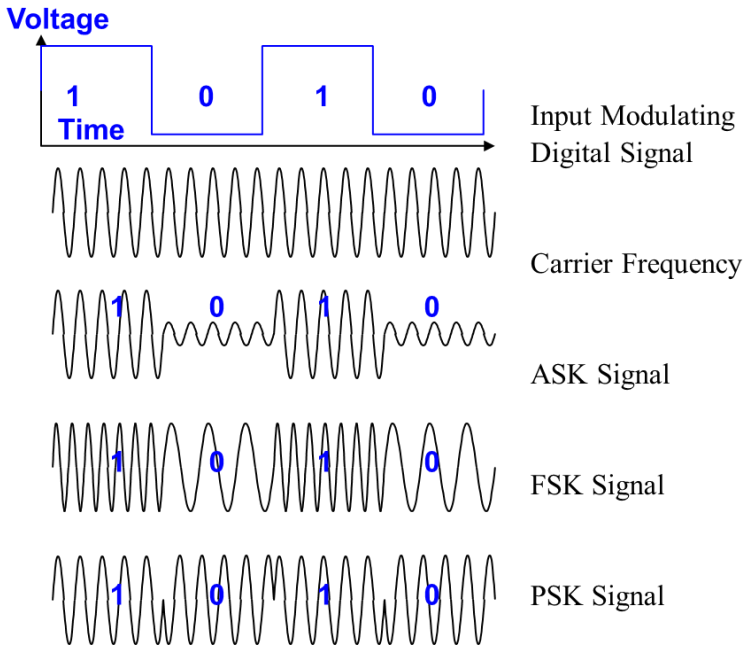
- Time division
- Frequency division
- Code division

- Multiple wavelengths (optical/radio)
- Beam forming (radio)

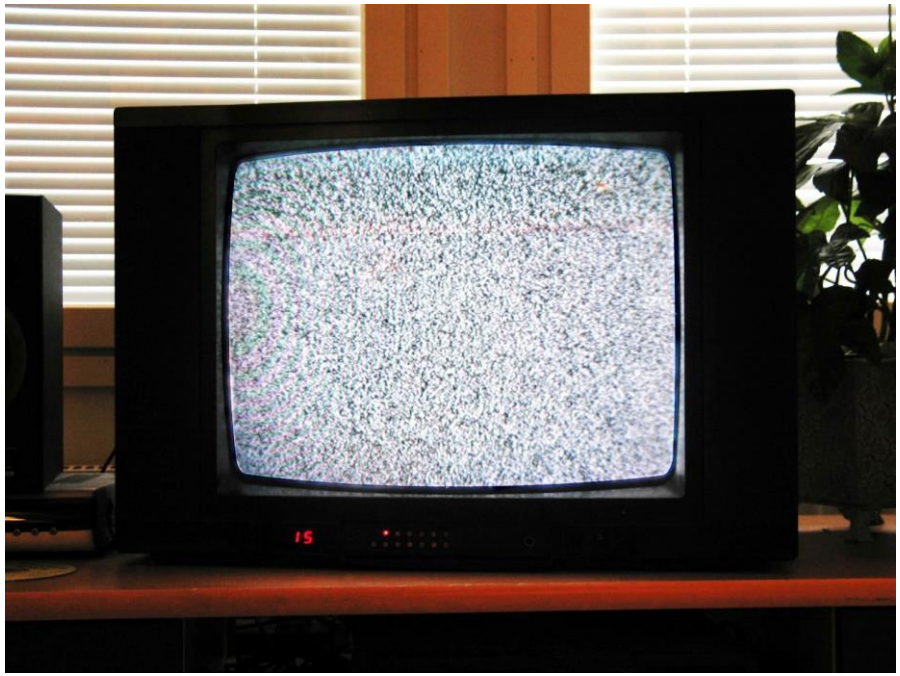


What do we put on the medium?

- Amplitude modulation
  - Change signal strength
- Frequency modulation
  - Change signal frequency
- Phase modulation
  - Change signal timing
- Can combine these for more information at once



How do we prevent data loss?



- There will always be noise…
- Sometimes we just live with the errors
- What if the data represent a bank transaction?
  - We have to prevent errors!

Error correcting codes help.

- Use redundancy to detect and fix errors
  - Redundancy = extra data
  - Reduces total throughput
- Simple example – triple redundancy
  - 0 = 000, 1 = 111
  - Any 1-bit error can be fixed
  - Only get 1/3 of total capacity
- Complex codes need less redundancy

Triplet received	Interpreted as
000	0 (error-free)
001	0
010	0
100	0
111	1 (error-free)
110	1
101	1
011	1

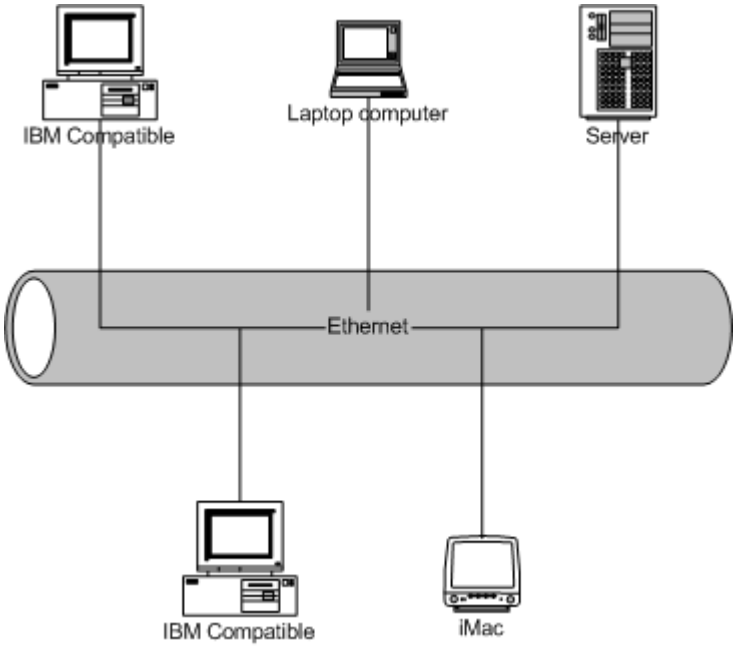
What else needs to be coded?

- Have to avoid long strings of zeros or ones
  - Otherwise lose track of bit position…
  - Newer tech is less sensitive
- May need extra codes to control the network device

How do we make a data link?

- We need to have an *address* where other computers can reach us
- We need to send our message to someone else
- We need to be connected to more than one other computer
- We need a standard for how to represent information

Ethernet originally was broadcast.

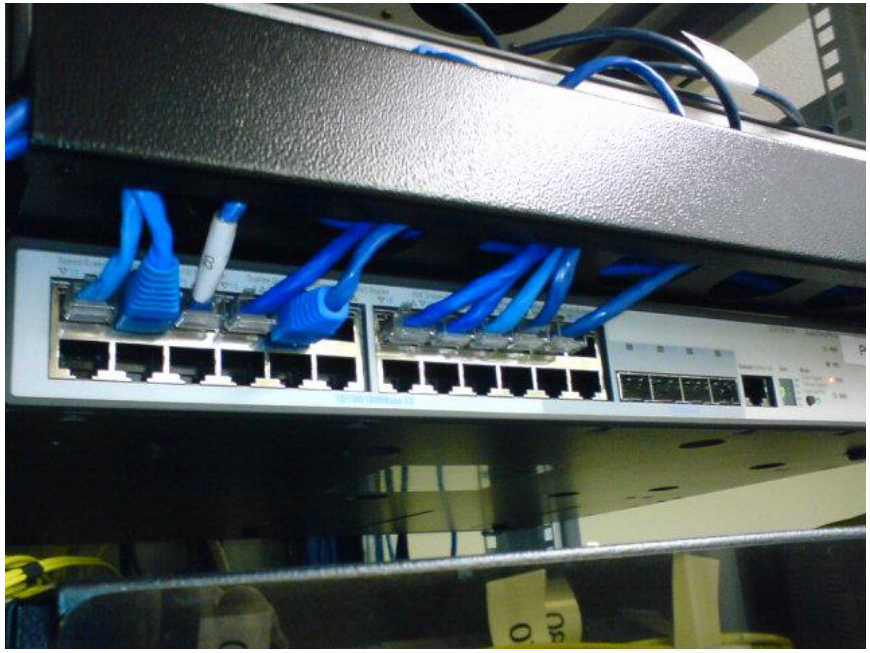


- All computers connected to the same wires
  - Everyone sees everyone else's messages
- Possible *collisions* if two computers transmit at the same time

We need a unique address.

- Called a MAC address
  - “Media Access Control”
- Typically 48 bits
  - Written as 12 hex digits
- Bad things happen if two devices share a MAC address

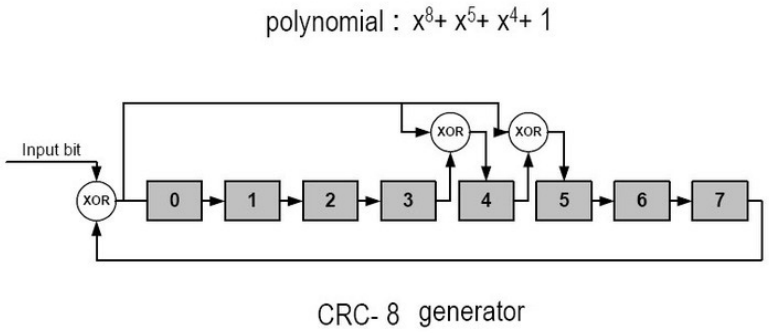
Modern networks are switched.



- Central switch knows the MAC address connected to each port
- Packets are sent only to the device expecting them
- More efficient (no collisions)

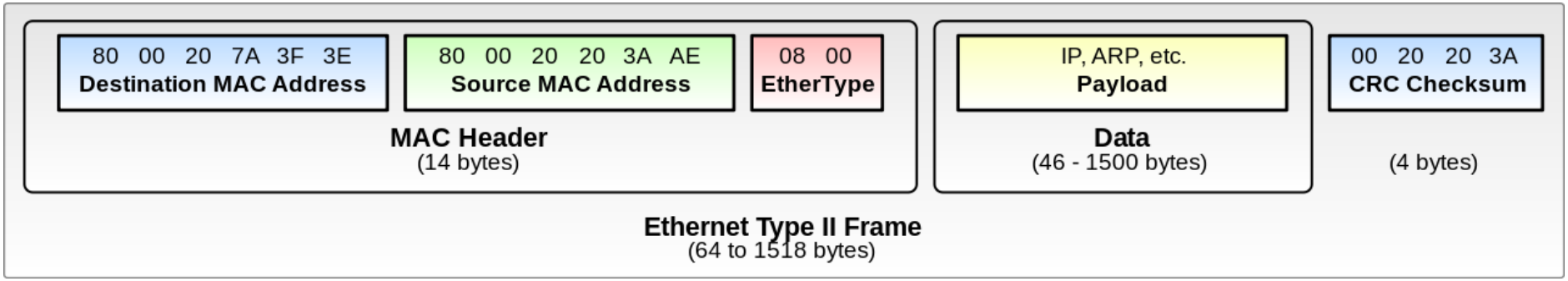
Correctness must be ensured.

- Just using error correcting codes is not enough
  - Some errors can slip through!
- We use a 32-bit cyclic redundancy check (checksum) to test for errors
  - Can’t fix them, but at least we know…
- Calculated like binary long division



It takes data to transmit data!

- (Not shown) 8 bytes before and 12 bytes after packet
- 14 byte header
- 4 byte checksum
- Maximum 1500 byte payload



Next time: beyond the local network

Image References

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