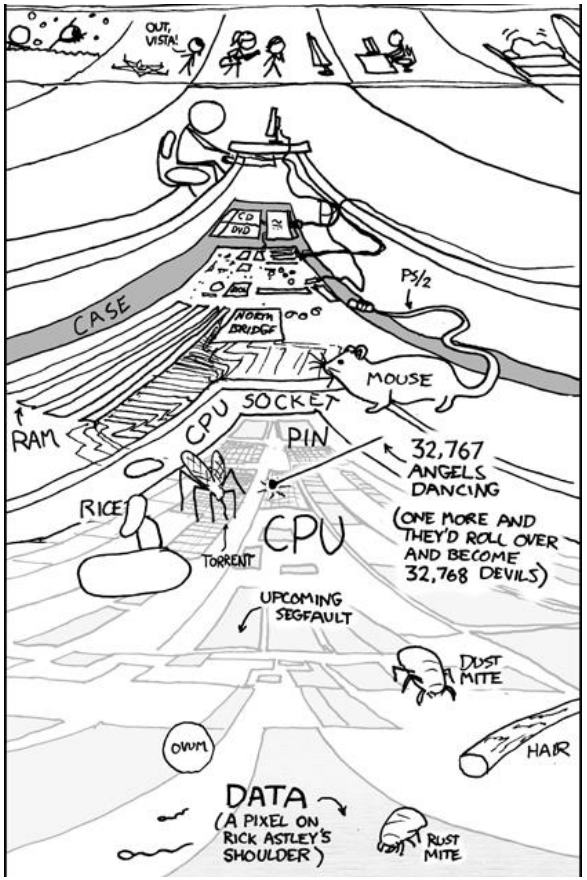
ENGSCI 233 Lecture 10.2

Data storage and transport



Today's learning objectives:

- Understand the concepts of latency and data rate
- Solve problems involving trade-offs between latency and data rate
- Understand the major types of data storage and their benefits and limitations
- Understand the major types of data transport
- Understand input and output devices

Memory goes from bytes to exabytes.

12 bytes, 256 GB, and 10 EB!

How fast is it?

- Data rate: bytes per second (B/s)

- RAM: 20 GB/s
- Hard drive: 3 GB/s
- Memory card: 10 MB/s

How long do you have to wait?

- Latency: seconds
- Delay until transfer starts

- RAM: 100 ns
- Solid-state drive: 10 µs
- Hard drive: 10 ms
- Memory card: 500 ms

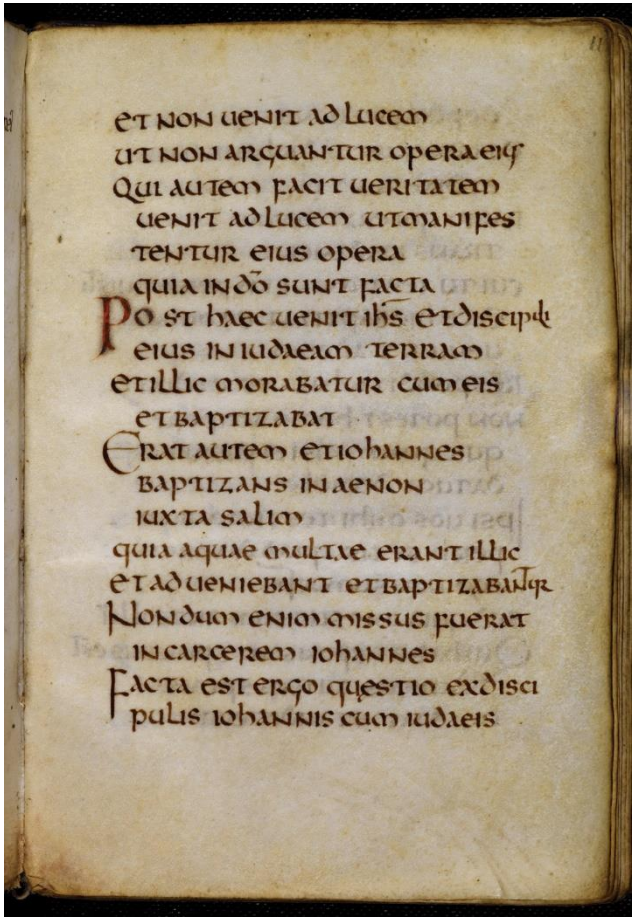
How long do you have to wait?

- Example: 1 MB/s, 1 µs vs. 1 GB/s, 1 ms
- How much data after 1 ms? What about 2 ms?

How long does it last?

- RAM: 64 ms
  - Constantly refreshed
- Flash/SSD: 1-2 years
- Hard drive: 3-5 years
  - Wears out
- DVD/Blu-ray: 100 years
  - If you buy the right kind

How long does it last?



- Paper: 1000 years

How much does it cost?

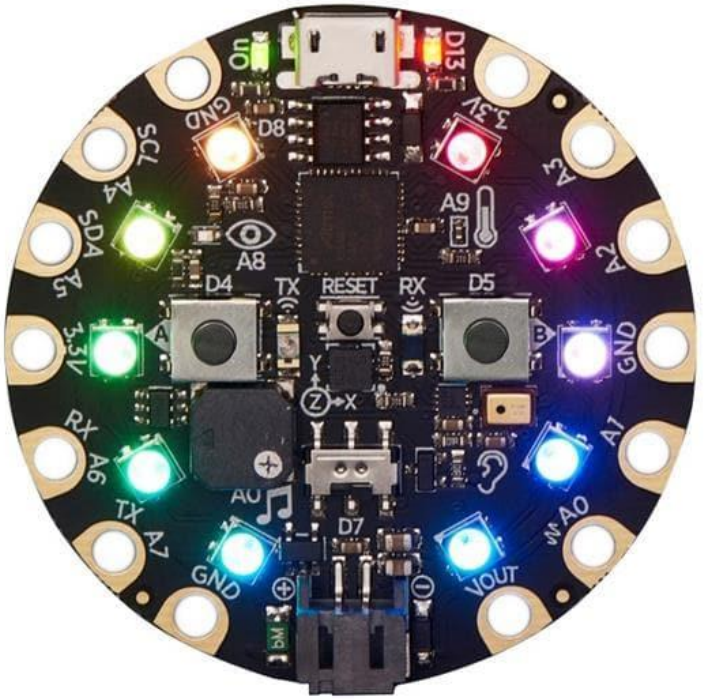
- RAM: $10/GB
- Solid state drive: $0.25/GB
- Blu-ray: $0.20/GB
- Hard drive: $0.075/GB
- Tape drive: $0.04/GB

Where does the data come from?

- I/O devices interface the outside world
- Examples:
  - Keyboard
  - Mouse
  - Printer
  - Monitor
  - Camera
  - Etc.

Not just words and numbers…

- Voltage measurement
- Indicator LED
- Pushbutton
- Accelerometer
- Motor
- Robot arm
- Etc.



How does the data get read?

- Devices can be *memory mapped*
  - Looks like memory, as far as the program is concerned
  - Mapping handled by OS and/or hardware
  - You will do this in Lab 9
- Important to consider safety for physical outputs

What holds all these bits together?

- Data links connect the other parts
- Local wired connection = *data bus*
- Computers can be distributed with long-distance data links

One bit at a time…

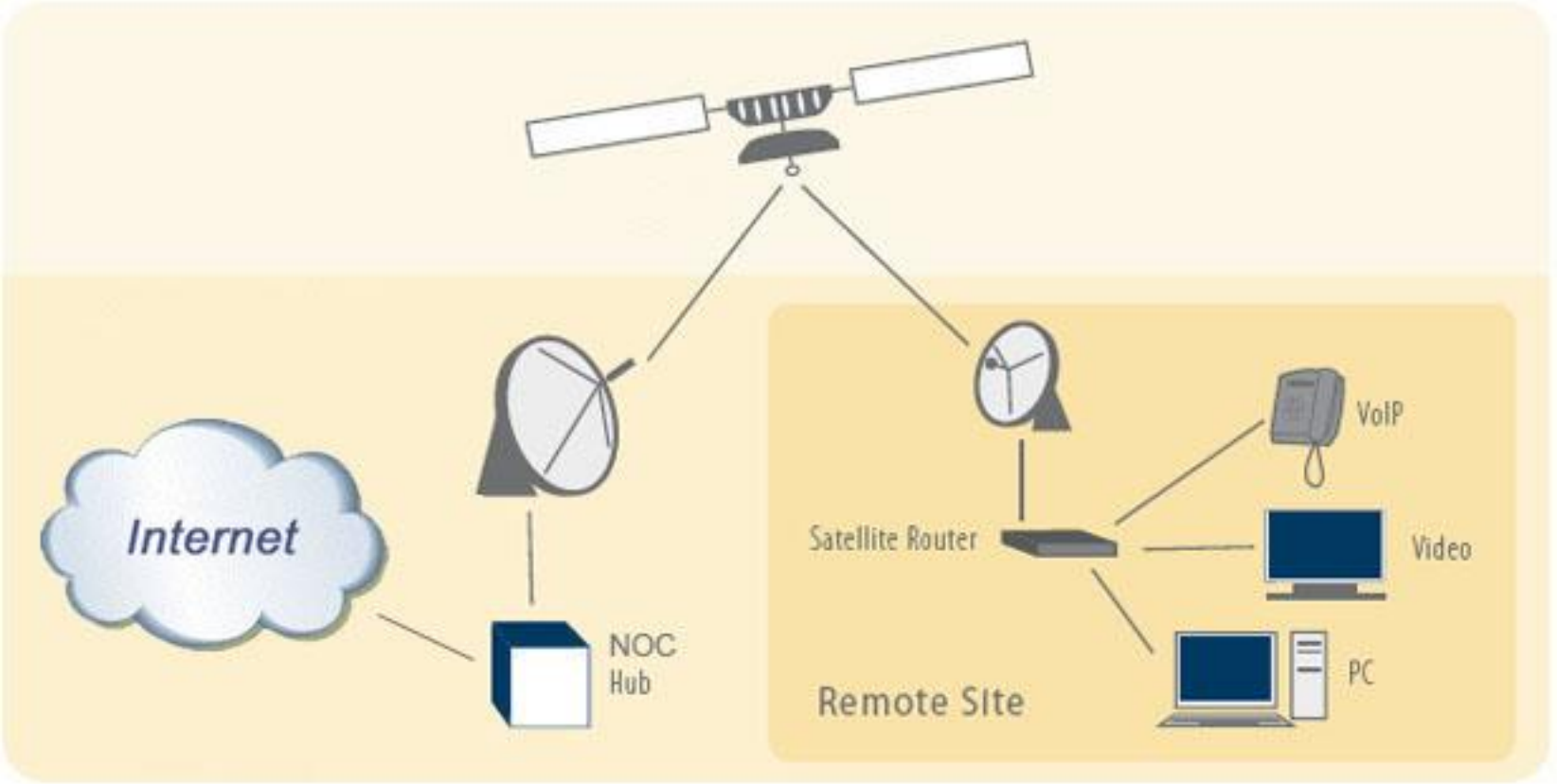
- A wire can only have one thing on it at a time
  - Used to do several at once, but obsolete now
- Data must be broken down to bits for transport
- Speeds rated in bits per second, not bytes

Speed and latency also matter here.

- Bigger range of values than memory/storage
- Internal buses:
  - >100 Gb/s, nanoseconds
- Long-distance:
  - <10 Gb/s, > 10 ms
  - More in consolidated backbone (> 1 Tb/s)
- Wireless:
  - <1 Gb/s, > 10 ms

Long distance? Low speed.

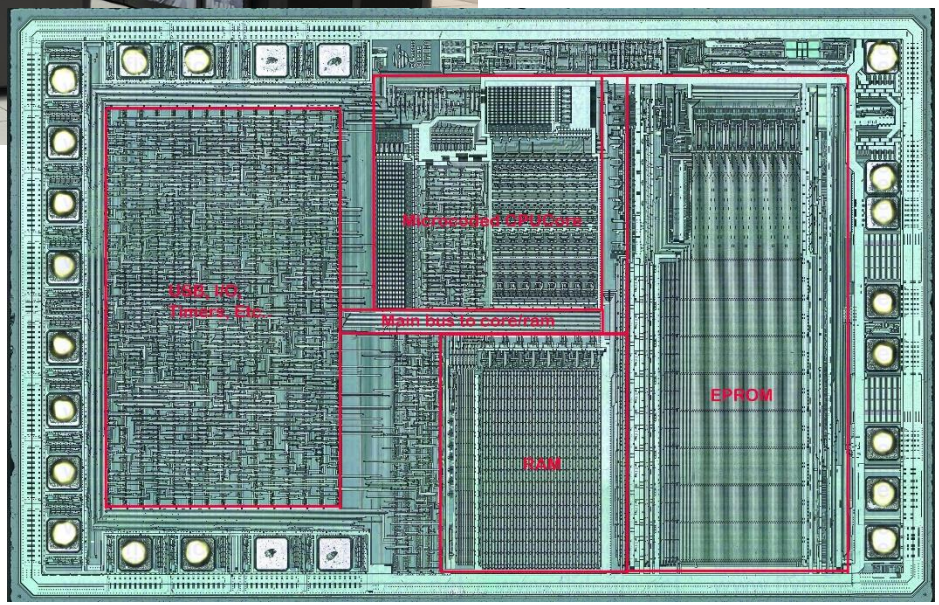
- Speed of light: 1 foot per nanosecond.
- Weak signals need more time to decode.



Sometimes sneakernet wins.

- Physically moving storage media has very high bandwidth
  - But large latency!

How does it all go together?



Example:
Local or remote computation?

Example: Local or remote computation?

- 1 MB voice data, 10^9 instructions to process
- Local device: 10^8 instructions per second
- Internet server: 10^{11} instructions per second
- Internet connection: 8 Mb/s
- Which wins?

Next week: Computer Networking

Image References

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