Information Theory and Networks

Lecture 1: Intro

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Lecture_notes/InformationTheory/

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Admin

- All the usual stuff: cover sheets, consulting, ...
- Assessment: weights to be determined
  - Exam
  - Assignments
    - ★ I will expect solutions to be LaTeX'd
    - ★ Some parts will involve some coding, mostly in Matlab
  - Participation in class
    - ★ I plan roughly 1/3 of classes to be more like a tutorial, with discussion of problems.
- I am away from 5-9, so there won't be any lectures that week. We will make them up as needed.
- Course materials on `http:`

Part I

Signals and Noise

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; ...

Claude Shannon, 1948 [Sha48]

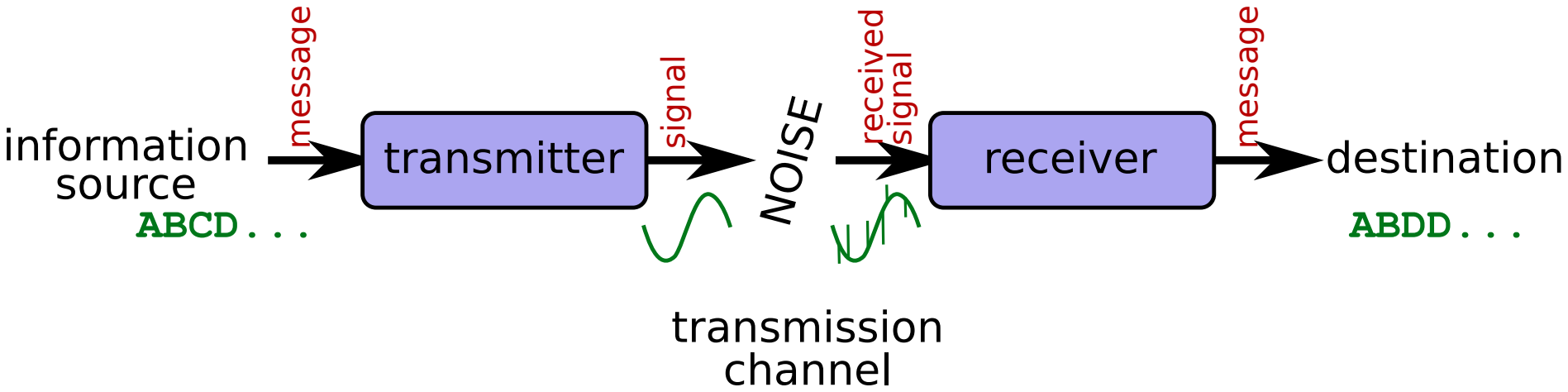
Discrete Signals

Most data today is stored and transmitted digitally:

- It means that it is discrete both in time and nature
  - basically it is made up of a string of numbers
  - most are stored in Binary bits (1s and 0s)
    - ★ The term *bit* was chosen by Shannon
- Examples:
  - images: JPEG
  - sound: PCM or MP3
- The alternatives: analogue data
  - e.g., vinyl LPs, audio cassettes, photographic film, ...

  are rare today.
- Conversions:
  - most signals in real life are analogue so we need A2D (Analogue to Digital converters)
  - we listen in analogue, so stereos (etc) have D2A (Digital to Analogue) converters
  - we may also need to convert digital signals into analogue for transmission (e.g. electrical impulses)

The basic setup



The setup

- Information/messages could be
  - text
  - audio (digitally coded, e.g., PCM)
  - images (digitally coded, e.g. PNM)
  -

  abstract it to be a series of symbols.
- Transmission channel could be
  - a wire (copper or fibre)
  - wireless
  - storage media (transmission over time)

  abstract it with some noise model.

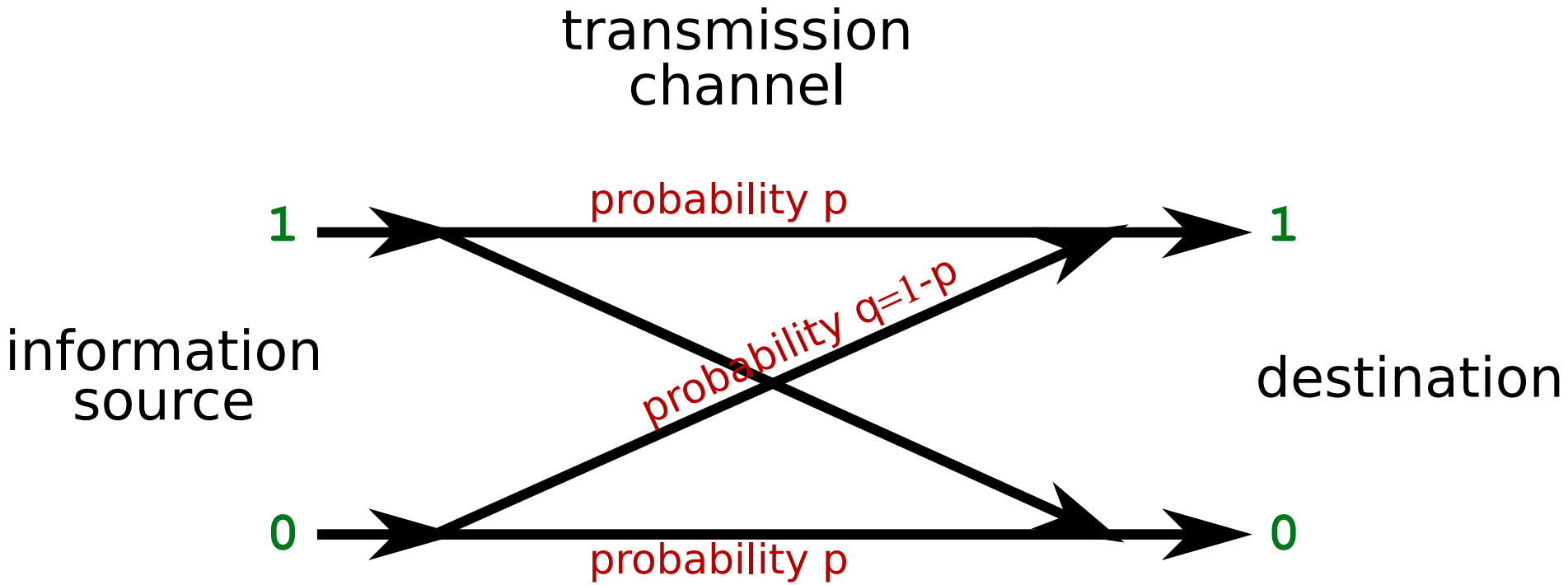
The fundamental questions

Questions:

- Can we have reliable communications?
- How much noise can we tolerate?
- How fast can we transmit? OR How much data can we store?

and how do these three issues interrelate?

Simplified setup



- What should we do?

Simplified setup

- What should we do if we want to transmit a particular signal, say

$$1, 0, 1, 1, 1, 0, 1, 1$$

Some ideas

- redundancy (repeating bits)

Some ideas

- redundancy (repeating bits)
- check and resend

Some ideas

- redundancy (repeating bits)
- check and resend
- true error correction from a geometrical viewpoint

Further reading I

C.E. Shannon, *A mathematical theory of communication*, The Bell System Technical Journal **27** (1948), 379–423,623–656, http://cm.bell-labs.com/cm/ms/what/shannonday/paper.html.