Information Theory

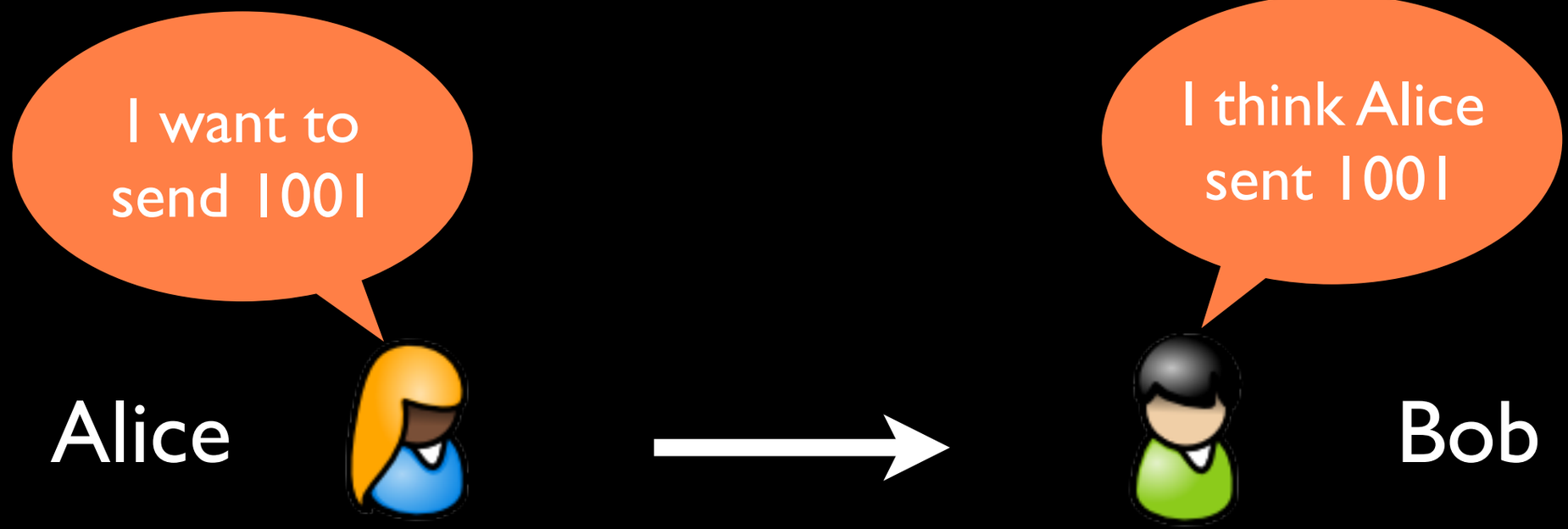
Master of Logic 2017/18

2nd Block, Nov/Dec 2017

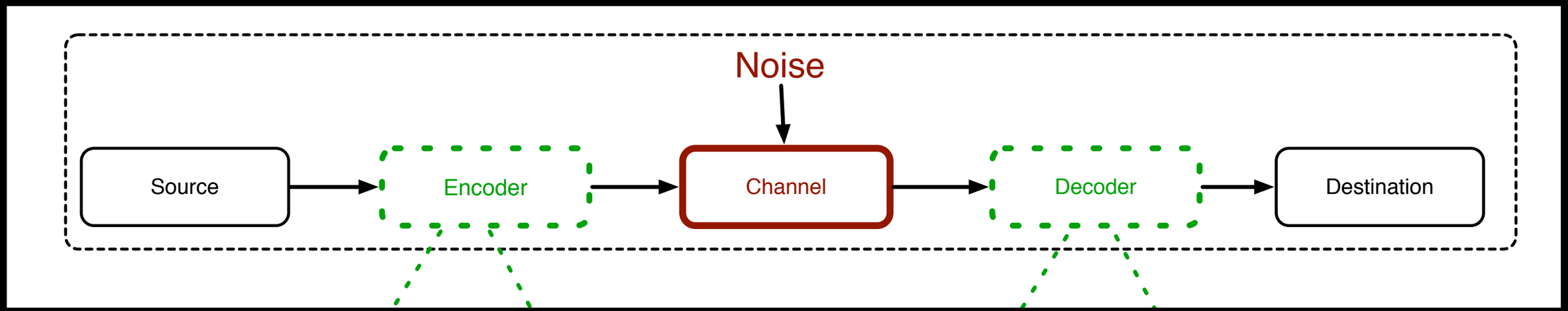
first class: Tuesday, 31 October 2017 9:00

http://homepages.cwi.nl/~schaffne/courses/inftheory/2017/

What is communication?



Generic communication block diagram



History of (wireless) communication

- Smoke signals
- 1861: Maxwell's equations
- 1900: Marconi demonstrates wireless telegraph
- 1920s: Edwin Howard Armstrong demonstrates FM radio

$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{enc}}{\varepsilon_0}$$

$$\oint \mathbf{B} \cdot d\mathbf{A} = 0$$

$$\oint \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} + \mu_0 i_{enc}$$

Big Open Questions

- mostly analog
- ad-hoc engineering, tailored to each application

- is there a general methodology for designing communication systems?
- can we communicate reliably in noise?
- how fast can we communicate?

Claude Elwood Shannon

1916 - 2001

- Father of Information Theory
- Bell Labs, professor at MIT
  - arguably, the first person to really define and use “bits”

- juggling, unicycling, chess
- ultimate machine

The Bell System Technical Journal

Vol. XXVII *July, 1948* *No. 3*

A Mathematical Theory of Communication

By C. E. SHANNON

- Introduced a new field: Information Theory

What is communication?

What is information?

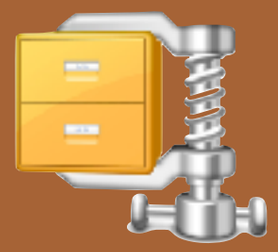
How much can we compress information?

How fast can we communicate?

Main Contributions of Inf Theory

Source coding

- source = random variable



- ultimate data compression limit is the source's **entropy H**

Channel coding

- channel = conditional distributions
- ultimate transmission rate is the **channel capacity C**

Reliable communication possible ⇔ H < C

Applications

- Communication Theory
- Computer Science (e.g. in cryptography)
- Physics (thermodynamics)
- Philosophy of Science (Occam's Razor)
- Economics (investments)
- Biology (genetics, bio-informatics)

Topics Overview

- Entropy and Mutual Information
- Entropy Diagrams
- Data Compression / Source Coding
- Perfectly Secure Encryption
- Error-Correction
- Zero-Error Information Theory
- Noisy-Channel Theorem
- Quantum Information Theory

Prerequisites

- contents of Basic Probability: Theory
- no programming skills required

Questions ?