

Q: What is the probability? How to talk about it rigorously?

The study of **random experiments**/events.

i.e., Experiments that don't turn out the same way every time you do them.

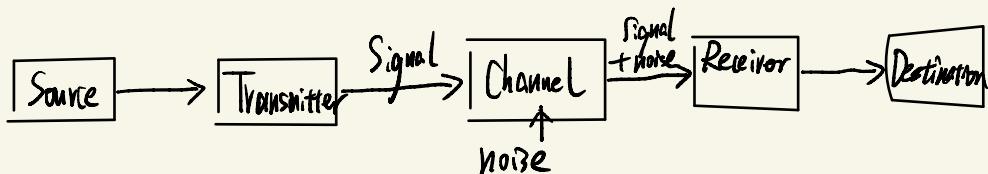
Opposite to the **deterministic** procedures/^{experiments} that always give the same results, e.g., math/physics laws, $E = IR$
Ohm's law.

Random experiments are everywhere / Applications of probability:

- Games, Gambling
- Financial markets (stock market, insurance company)
- Simulations of large systems (transportation system, power system)
- Signal and image processing
- Communication and information theory
- Machine learning / Deep learning

ECSE
Courses-related

- A concrete EE example of random experiments



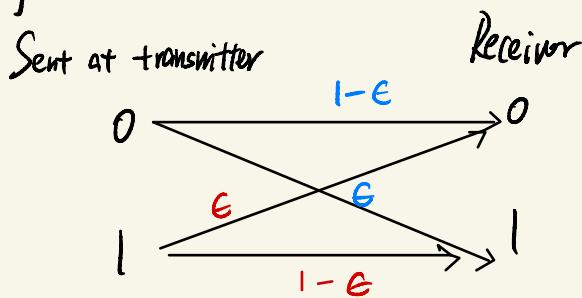
This model holds for many EE/CSE systems :

- cell phones (voice, text, image)
- Wireless network (wifi, bluetooth)
- TV (cable)
- Satellite systems

In those systems, messages at receiver come with noise, where the noise come from

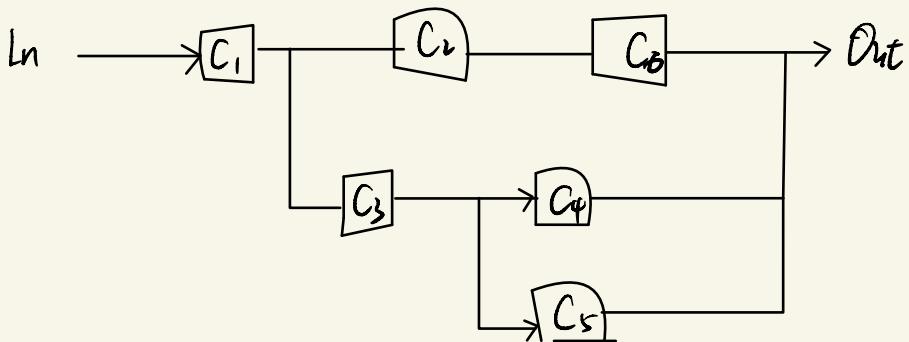
- Atmosphere interference (weather, fading)
- Acoustic noise
- Quantization noise
- Signal crosstalk

□ A good model for many digital communication system is the binary channel:



- What is $P(0 \text{ sent} | 0 \text{ received})$?
- How can we modify the coder/decoder to decrease the error probability?
- How can we compare the expected performance of different communication strategies?

A complex system example (computer, circuit system)

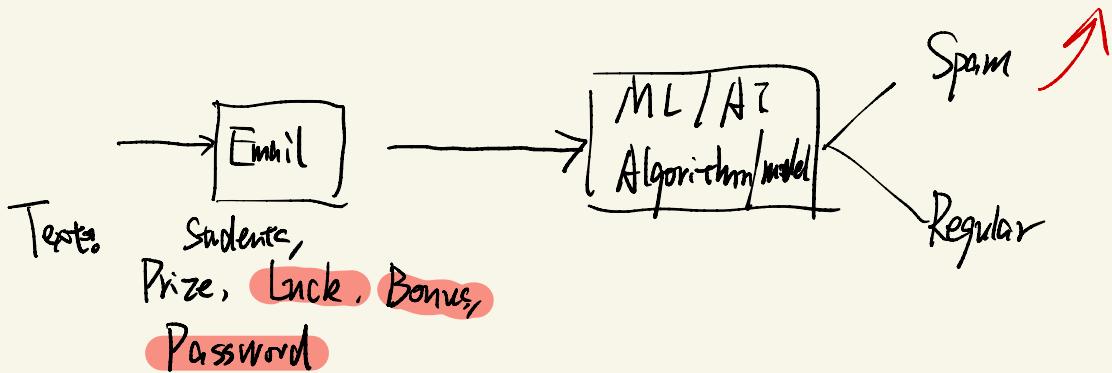


Each component has a probability of failure within T hours.

- What is the expected time to failure of the overall system?
- What is the probability that 3 out of the 6 components fail within the same interval?
- What is the probability that the system can last 6 months without failure?

- A machine learning example (Natural Language processing)

Spam email classification



- What is the probability of a spam email if it contains the word "Bonus", "Password", "Cash"?

- Many times, we can simply answer those complicated question related to probability using very basic models:

① Flip a coin < Head
Tail

② Roll a Die < $\frac{1}{2}$
 $\frac{2}{3}$
 $\frac{3}{4}$
 $\frac{4}{5}$
 $\frac{5}{6}$

③ Pick a ball out of a blind bag

