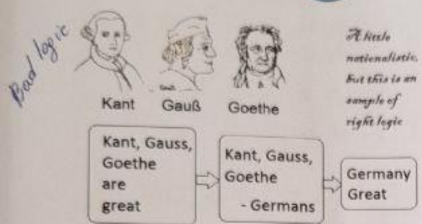
+0.1 to A
+0.1 6.6.25 +0.1 to final Exam Grade

Lecture by Pr. Bob Gallagher **Aristotle** (384–322 BC), **Boole** (1815-1864) & **Shannon** (1916-2001)

Bad logic

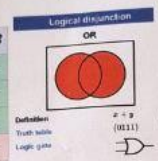


George Boole (1815-1864) developed
The principles of logical thinking have been understood (and occasionally used) since the Hellenic era. Boole's contribution was to show how to systemize these principles and express them in equations (Boolean logic) LOGIC

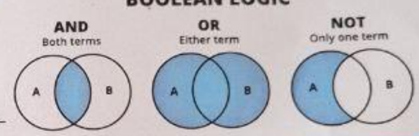
Logical addition (disjunction)

A	B	F=A∨B
0	0	0
0	1	1
1	0	1
1	1	1

A	B	$A \vee B$
True	True	True
True	False	True
False	True	True
False	False	False



BOOLEAN LOGIC



Claude Shannon (1916-2001) showed how to use Boolean algebra as the basic for swithing technology

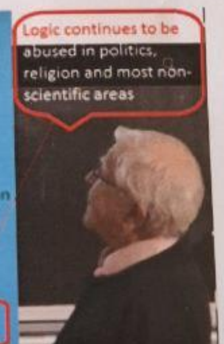
George Boole (1815-1864) developed Boolean logic

The principles of logical thinking have been understood (and occasionally used) since the Hellenic era.

Boole's contribution was to show how to systemize these principles and express them in equations (called Boolean logic or Boolean algebra).

Claude Shannon (1916-2001) showed how to use Boolean algebra as the basis for switching technology. This contribution systemized logical thinking for computer and communication systems, both for the design and programming of the systems and their applications.

Logic continues to be abused in politics, religion, and most non-scientific areas.

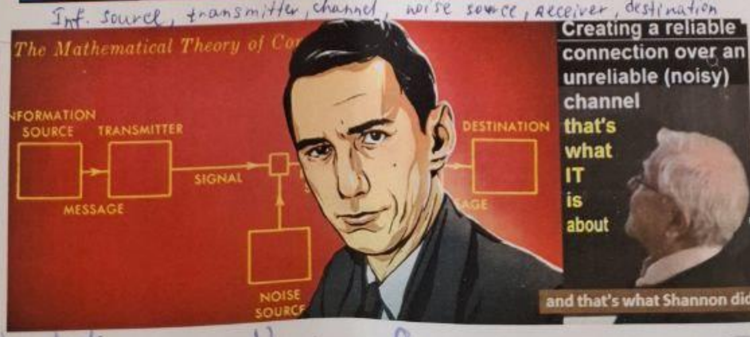


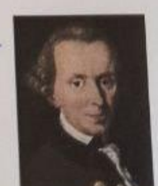
Resume of Lecture by Pr. Bob Gallagher from MIT

Massachusetts Institute of Technology (MIT)

+1
-1
-1

Inf. source, transmitter, channel, noise source, receiver, destination





Sapere aude!

0 - 0.1
1

0,5 - handout
1 - answer quest
0,31 - coin

Handout						
10 Lection	+	11 6 Projects	16 8 8	9 Exam	→ 8.5	+0.1 +0.1 8.7 9

1. How many ways to order the letters GALOIS

$n! = 6! = 1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 \cdot 6$

If we randomly reorder the letters what prob. that the vowels are all before the consonants.

⊔⊔⊔⊔⊔⊔ ← probability

⊔ ⊔ ⊔ a n d y

a n d ⊔ ⊔ ⊔ ⊔

↑ } 2 a y n d

a d n y a n d $2 \cdot 2 = 4$

a y d n

y a d n

$n! = n \cdot (n-1)(n-2) \ldots 2 \cdot 1$ $m_1 + m_2 = n$

$$P(A) = \frac{m_1! \cdot m_2!}{n!}$$

How many arrangements

$A_1 A_2 A_3$ B C D

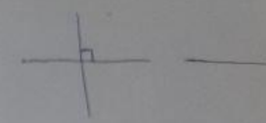
$B A_2 D A_1 A_3 C$

$B A D A_1 A C$

B A D A A C

Events and probabilities

(A) tossing coin $\Omega = \{H, T\}$



(B) throwing a die (red) (blue)

$\Omega = \{ (i,j) \quad i,j \in [1,2,3,4,5,6] \}$ Set of possible outcome

A subset of Ω is called event

a) coin comes up tail $A = \{T\}$

b) $A = \{ (3,6) \}$ - event (red, blue)

$\omega \in \Omega$ is the outcome, we say that A occur if $\omega \in A$

Complement of A

(A^c) $\bar{A}$ occur when A doesn't occur

Set difference $A/B = A \cap B^c$

Intersection : $A \cap B$ occur if both A and B occur

$A \cup B$ occur if any A or B occur

Elementary combinatorics

Arrangement of distinguishable objects

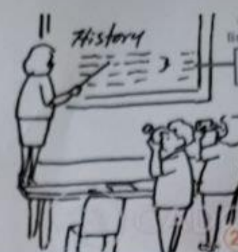
Suppose we have n distinguishable objects

$3! = 1 \cdot 2 \cdot 3$

$C_4^2 = \frac{4!}{2! \cdot 2!} =$

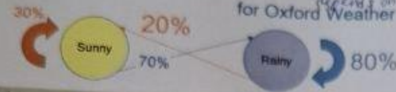
OK

+0.1 to fin grade Grade n! (4!



1 listening
2 first way of processing
3 Writing, incl. sth., you're not quite sure about

Markoff Chain Probability Model for Oxford Weather — The next state only depends on the current state not the whole history



CHALK+TALK ink+think

take notes on the lecture yourself

Motivation: 80% chance of rain

Let A_j be the event of rain at 9am on day j of this term, $1 \le j \le n$

Suppose the events A_j each have probability p, independently

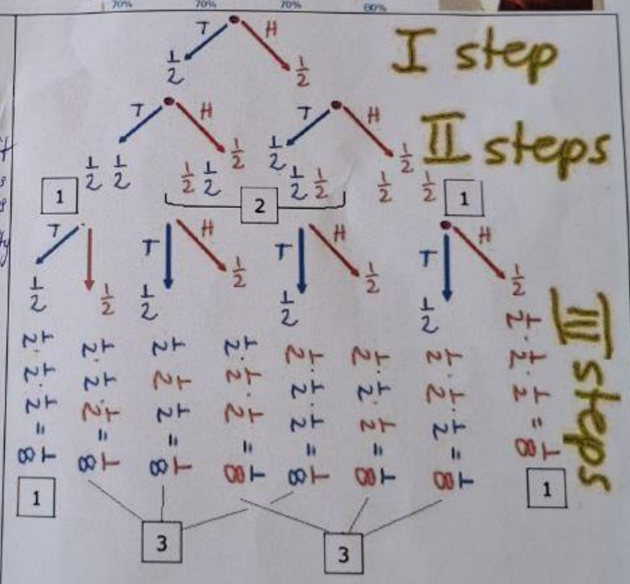
School =formalism=> Uni

Pascal's triangle

where each num is the sum of the two nums directly above it

?: counting things, solving equations, figuring out probability

1								← 1
1	1							← 2
1	2	1						← 4
1	3	3	1					← 8
1	4	6	4	1				← 16
1	5	10	10	5	1			← 32
1	6	15	20	15	6	1		← 64
1	7	21	35	35	21	7	1	← 128



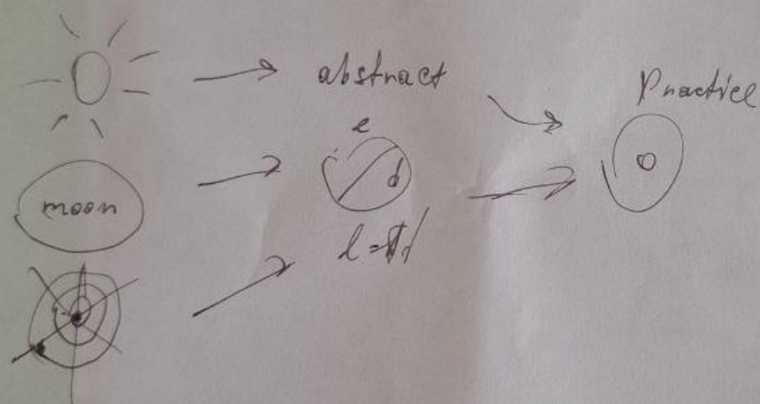
$$(a+b)^0 = 1$$
$$(a+b)^1 = a+b$$
$$(a+b)^2 = a^2+2ab+b^2$$
$$(a+b)^3 = a^3+3a^2b+3ab^2+b^3$$
$$(a+b)^4 = a^4+4a^3b+6a^2b^2+4ab^3+b^4$$
$$(a+b)^5 = a^5+5a^4b+10a^3b^2+10a^2b^3+5ab^4+b^5$$

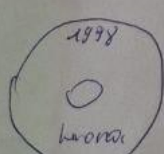
Cat + bird = cabird

+0.1 to fin Exam

5% – $70.000 /y
1% – $7.000 /y

Harvard releases course with a free certificate





1kr = 0,15 $

In 1998 = ...

1 kR = 0,15 $

in 1998 = ...

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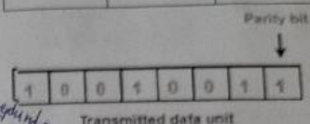
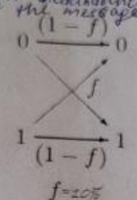
public void Bark() - prints "Woof woof"
static void Main(string[] args) - method where the prog. starts
public Dog() - we initialize objects with constructors
this.name = name - assign values
private, public, protected - All C# access levels
class AFather - base class with protected and internal members
class ASon - inherits from AFather

Sir **Dr. D. MacKay,**
University of Cambridge
(22 April 1967 – 14 April 2016)

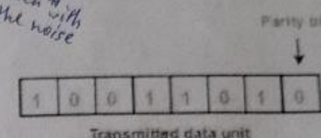
"I believe in clean energy,
but I also believe in mathematics"



The visual metaphor for redundancy. The glass is labeled redundant but the message still can be understood even with the noise



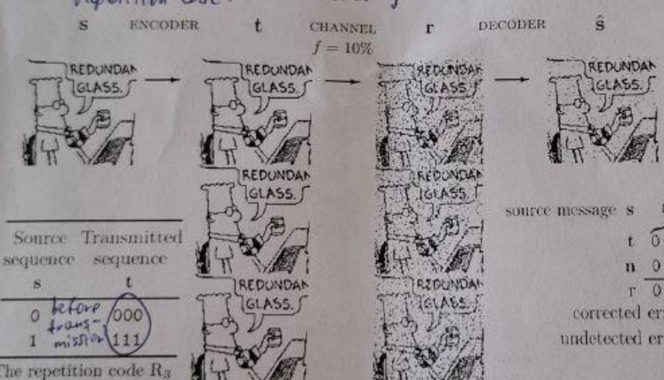
f=20%



A parity bit is a simple error-checking tool used in digital data transmission or storage

1 extra bit added to a set of bits to check if the data is correct

Repetition code. Error-correcting code



Source sequence s	Transmitted sequence t
0	000
1	111

(before trans-mission)

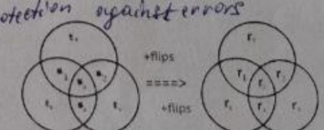
The repetition code R_3

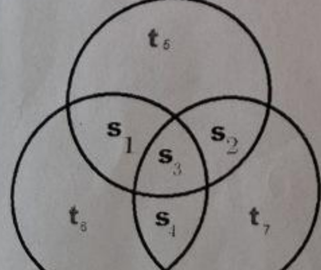
source message s	0	0	1	0	1	1	0
t	000	000	111	000	111	111	000
n	000	001	000	000	101	000	000
r	000	001	111	000	010	111	000
corrected errors		⋆					
undetected errors					⋆		

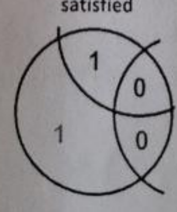
error-correcting method that adds redundancy bits to the original data for protection against errors

7.4. Hamming code.

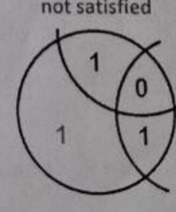
$$\frac{4}{\Sigma} \rightarrow \frac{7}{t}$$



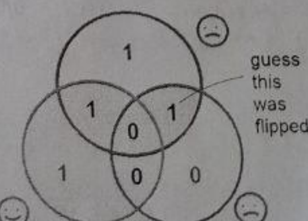




1+1+0+0=**0**



1+1+0+1=1



7 = total number of bits after encoding

I { 4 - number of data bits you want to send
  { 3 - remaining bits used for error checking

num 7 in bin: 0111
Positions: 1 2 3 4 5 6 7
Bits: P1 P2 D1 P3 D2 D3 D4
Final encoding
0001111

1. csc.exe - com.-line tool that compiles C# code into a prog. that runs on Windows
2. vbc.exe - compiles that code to create an executable file or a library
3. MSCoreEE.dll - is a dynamic link library file associated with Microsoft's .NET Framework

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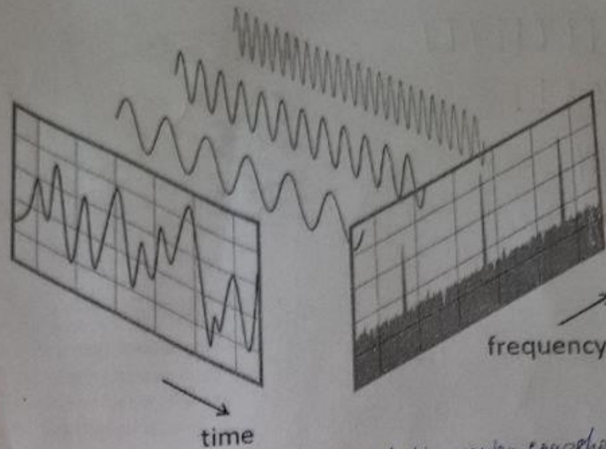
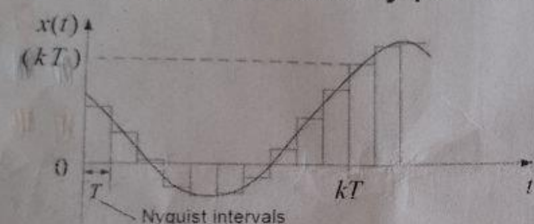
- N R3 denotes the space of three-dimensional vectors with real coordinates represented as R^3
- Amount of Inf. theory (Hartley)
  Is measured in bans and is defined as the logarithm of the number of possible messages.
- Amount of Inf. theory (Shannon)
  Shannon's amount of inf. consideres the probabilities of messages and is measured in bits, reflecting uncertainty
- Concept of entropy
  Entropy is a measure of uncertainty or randomness of a random variable, indicating the average amount of information.
- Hartley definition of entropy
  The log of the num. of possible states of a system
- Shannon entropy
  It generalizes Hartley's definition, taking into account the probabilities of diff. states.
- Entropic compression of inf.
  Entropic compression is the process of reducing the volume of data without loss of inf., based on statistical properties of the data.
- Nyquist interval
  It defines the max frequency that can be captured without overlaying for signal transmission.
- Kotelnikov - Nyquist Theorem
  This theorem states that to reconstruct a signal, it must be sampled at least at twice the max frequency of the signal.
- Pascal's Triangle
  Pascal's Tr. is a tabular representation of binomial coeff. used in combinatorics
- Binomial distribution
  It describes the num. of success in a series of independent trials with two possible outcomes.
- Boolean algebra and Aristotelian logic
  Boolean algebra is a system for working with truth values, while Aristotelian logic focuses on rules of ~~with~~ reasoning and logic

turns a signal from the time domain to the fr. domain

Fourier transform



Sampling. Kotelnikov-Nyquist Theorem

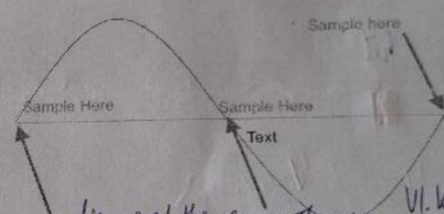


Time intervals T, through which readings s (kT) are taken, are called Nyquist intervals.

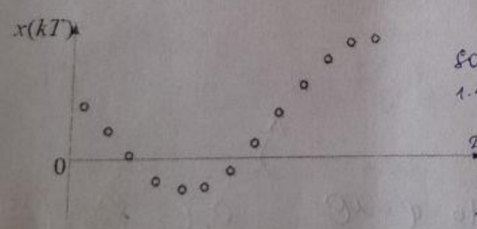
taking regular snapshots of a continuous signal to store or process it digitally

Sine with period T

Sampling at T/2

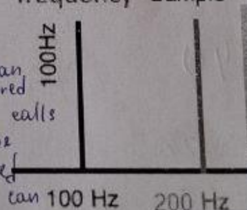


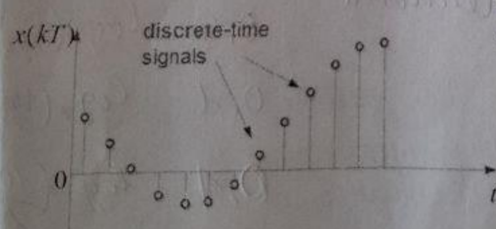
discovered the samp. Theorem. — Vl. Kotelnikov



so:
1. Music can be stored
2. Phone calls can be digitized
3. Data can be transmitted over the Internet

frequency Sample





$$F_{sample} >= 2 * F_{max}$$

$$(T_{sample} <= T_{min}/2)$$

to perfectly capture a signal you must sample at least twice the highest frequency in it

$\frac{4}{8} = \frac{1}{2} = 0,5$

$\frac{2}{8}$ $0,25 \cdot 2$

$0,125 \cdot 3$

$\frac{1}{8}$ $0,125 \cdot 3$

$\frac{1}{8}$

0,5 0,375 0,375

$0,5 + (0,25 \cdot 2) + (0,125 \cdot 3) + (0,125 \cdot 3) = 1,75$

$\frac{6}{10} = 0,6 \cdot 1 = 0,6$

$\frac{2}{10} = \frac{1}{5} \cdot 2 = 0,4$

$\frac{1}{10} = 0,1 \cdot 3 = 0,3$

$\frac{1}{10} = 0,1 \cdot 3 = 0,3$

$0,6 + 0,4 + 0,3 + 0,3 = 1,6$

2) Entrophy

$\log_2\left(\frac{1}{\frac{1}{4}}\right) =$ [illegible] $= \log_2 4 = 2$

$4 \cdot 4 = 16$ 5%

$5 \cdot 5 = 25$

+1 +1

$6 \cdot 6 = 36$

$7 \cdot 7 = 47$ 49

$8 \cdot 8 = 58$ 5%

64 6 → 12%

$$H = \sum_{x=1}^{n} p(x) \log_2\left(\frac{1}{p(x)}\right)$$

① По ф-ле Шеннона

$$I(x) = \log_2\left(\frac{1}{p(x)}\right)$$

Quantifying information

$$H(x) = \sum_{x=1}^{n} p(x) H(x)$$

$0.6 \cdot \log_2\left(\frac{10}{6}\right) = 0,4386$

$0.2 \cdot \log_2\left(\frac{10}{2}\right) = 0,4644$

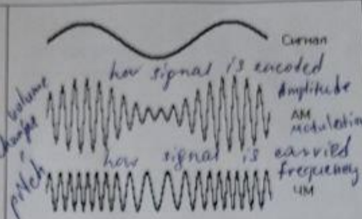
$0.1 \cdot \log_2\left(\frac{10}{1}\right) = 0,3322$

$0.1 \; \log_2\left(\frac{10}{1}\right) = 0,3322$

Σ 1,5674

Aristotelian logic ...

Reginald A. Fessenden
(October 6, 1866 – July 22, 1932)

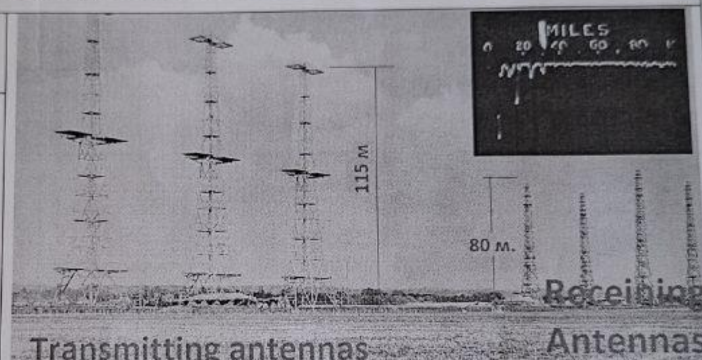


(October 6, 1866 – July 22, 1932)

first transmission of speech by radio (1900), and the first two-way radiotelegraphic communication across the Atlantic Ocean (1906)

"Ни одна организация, занимающаяся какой-либо конкретной областью деятельности, никогда не изобретает какие-либо важные разработки в этой области или не внедряет какие-либо важные разработки в этой области до тех пор, пока она не будет вынуждена сделать это из-за внешней конкуренции.." Oxford University Press. The Quarterly Journal of Economics , Feb., 1926, p. 262.

Battle of Britain
(3 month 3 weeks)
10.07-31.10.1940



Radar played a major role in the Battle of England

H. Nyquist

$$W = K \log m$$

Where W is the speed of transmission of intelligence,
m is the number of current values,
and, K is a constant.

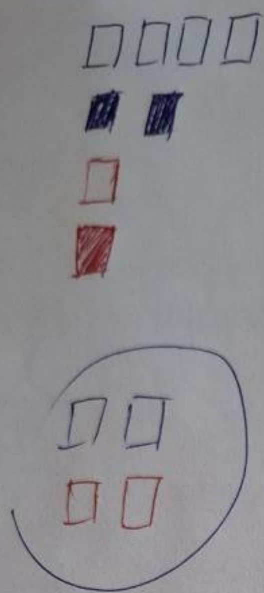
Ralph **Hartley**
(81:1888-1970)

$$H = n \log s$$
$$= \log s^n.$$

0,5 · 1
0,25 · 2
0,125 · 3
0,125 · 3

0,5
0,5
0,375
0,75

1.75



$\frac{2}{8} \cdot \frac{1}{4} \rightarrow 25\%$

$\frac{1}{8}$ - 12,5 %

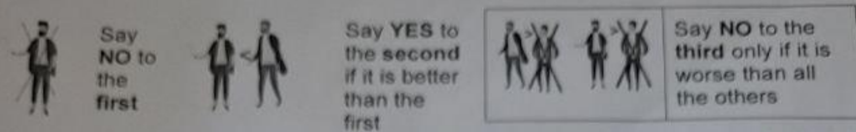
$\frac{1}{8}$ - 12,5 %

2 вопроса

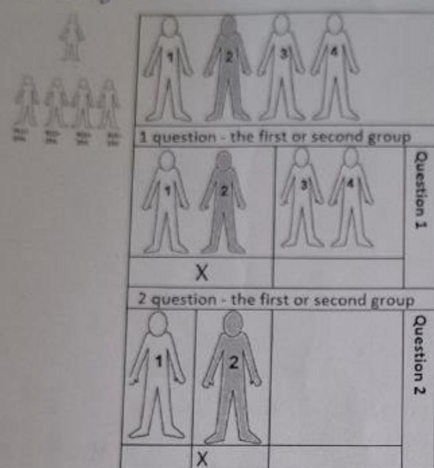
White (1)
Black (2)
(3)

$\log_2(4)$

Decision strategy for identifying an ind. from a group



A binary search-like strategy for identification with people grouped based on probability



Average number of questions =

2*0.25+ 2*0.25+ 2*0,25+ 2*0,25 =2

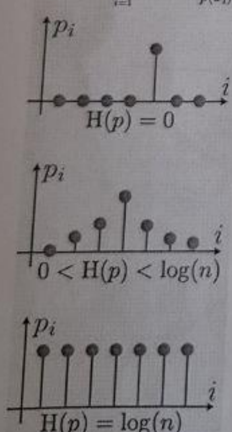
Average number of questions =

1*0.5+	2*0.25+	3*0,125+	3*0,125
			

Question 1. Is this Zuckerberg?	 50%	1*0.5
Question 2. Is this Sergey Brin?	 25%	2*0.25
Question 3. Is this Stefan from BMW?	 12,5%	3*0,125
So Prince Saud	 12,5%	3*0,125
Average number of questions =**1,75**		

Shannon Entropy

$H(X) = \sum_{i=1}^{n} p(x_i) \log_b \frac{1}{p(x_i)}$



$$\sum_{i=1}^{n} p(i) \log_2 \frac{1}{p(i)}$$

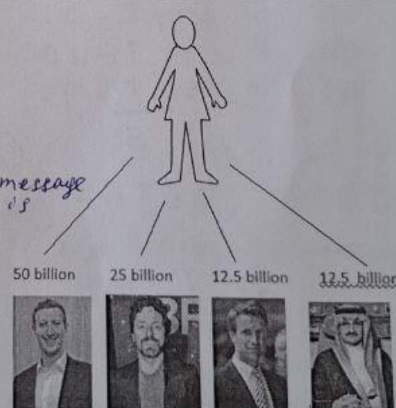
Quantifying information

How suprising the message is

$$I(x_i) = \log_2\left(\frac{1}{p_i}\right)$$

number of bits required to encode choice

$$\sum_{i=1}^{n} p(x_i)\, I(x_i)$$

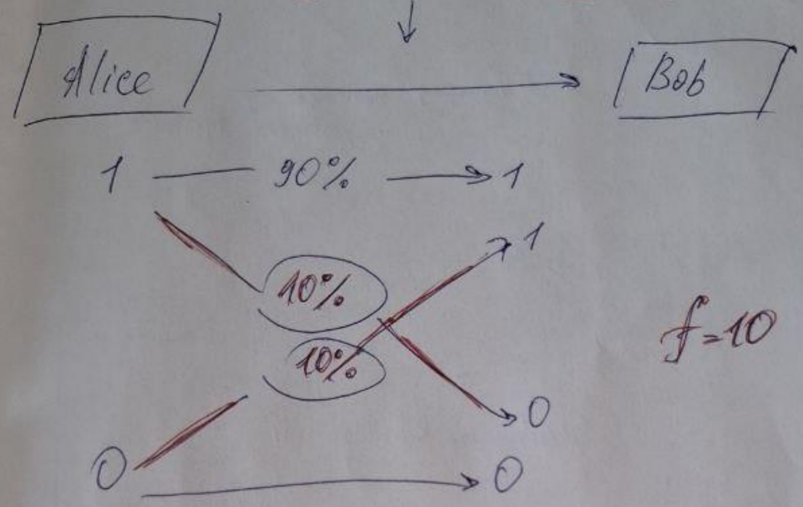


Mark Zukerberg	Sergey Brin	Stefan Quandt	Prince Al Saud
P(1)= **50%**	P(2)= **25%**	P(3)= **12,5%**	P(4)= **12,5%**

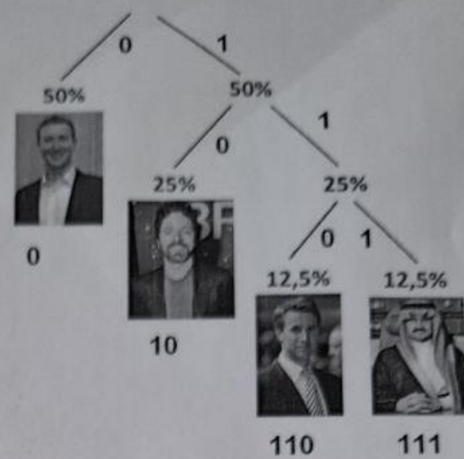
Maths explanation of Shannon Entropy

Binary Simmetrie

Channel Add Noise



$f=10$



First-order approximation (symbols independent but with frequencies of Belarusian txt).

Мама мыла ра

М - 3	— 30%	1-3 М
а - 4	— 40%	4-7 а
ы - 1	— 10%	8 -ы
л - 1	— 10%	9 -л
р - 1	— 10%	10 -р
10		

лла мамма р

Second-order approximation (digram (2-symbols) structure as in Belarusian)

Мама мыла ра

Ма	- 2	22%	1-2	ма
ам	- 2	22%	3-4	ам
мы	- 1	11%	5	мы
ыл	- 1	11%	6	ыл
ла	- 1	11%	7	ла
ар	- 1	11%	8	ар
ра	- 1	11%	9	ра
	9			

0. 4 6 7 3 1 9 1 6 7 3 5

ам ыл ла ам ма ра ма ыл ла ам мы

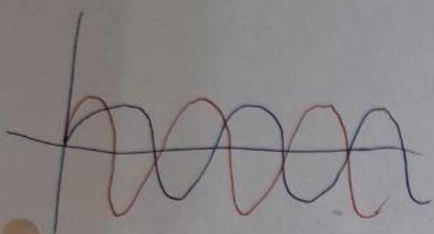
мылла рама

$t = 1 \quad T = 1$

$t = 2 \quad T = \frac{1}{2}$

$t = 3 \quad T = \frac{1}{3}$

$\Big\} \; T = \frac{1}{t}$



180

$t = 3$

$T = \frac{1}{3}$

T = 1сек

T = 0,5 cu

 Home

 1

 /root

 Home

Projects

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 1