Resume of Lecture by Pr. Bob Gallagher from MIT

Massachusetts Institute of Technology (MIT)

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 conribution 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.

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

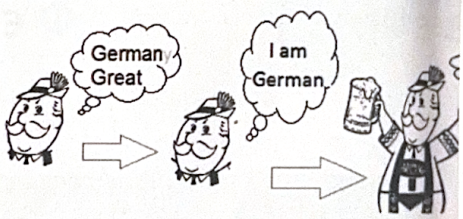
Kant Gauß Goethe

A little nationalistic, but this is an sample of right logic

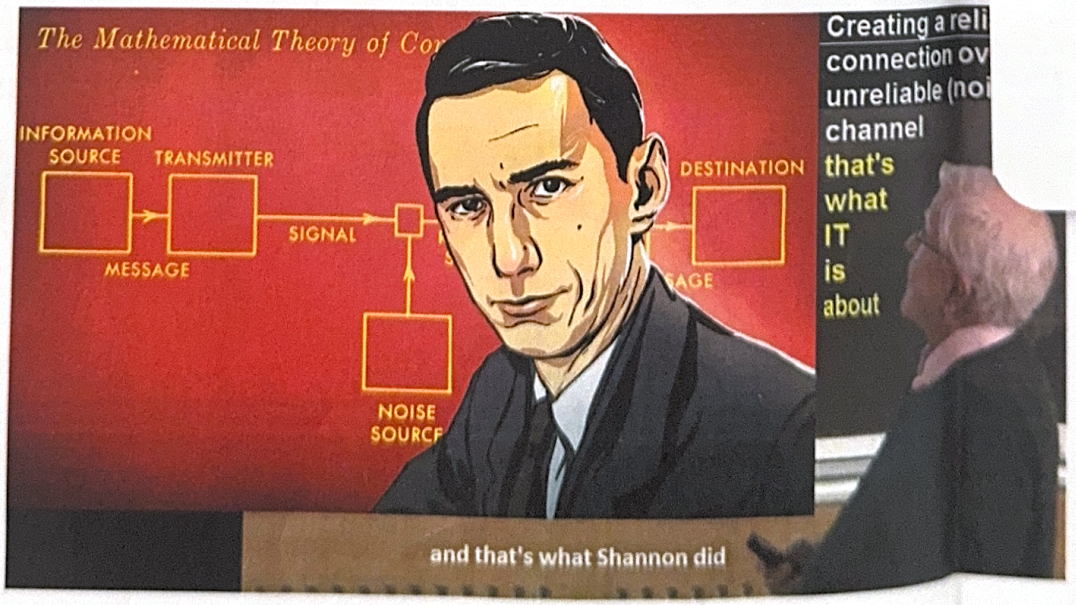
Kant, Gauss, Goethe are great

Kant, Gauss, Goethe - Germans

Germany Great



Bad logic (abuse of log

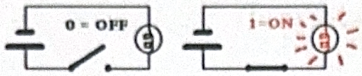


Born to fin Grade.

Massachusetts Institute of Technology (MIT)

Lecture by Pr. Bob Gallagher
Boole (1815-1864) & **Shannon** (1916-2001)

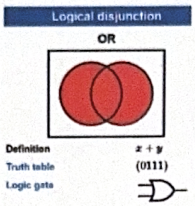
Sapere aude!

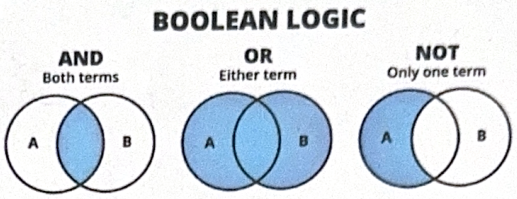


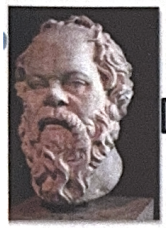
gical addition
disjunction)

A	B	F=A∨B
0	0	0
0	1	1
1	0	1
1	1	1

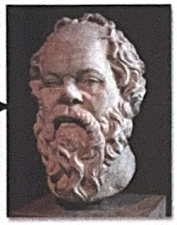
A	B	$A \vee B$
True	True	True
True	False	True
False	True	True
False	False	False







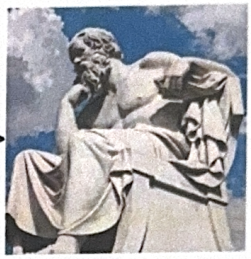
Socrates



Socrates

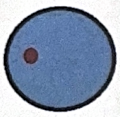
Plato

Aristotle



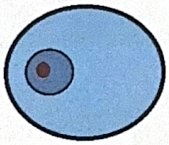
crates was philosopher

$\epsilon\ \Phi$



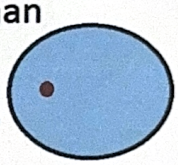
philosophers are men

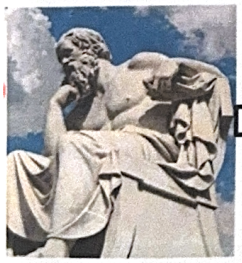
$\Phi\ \epsilon\ A$



Socrates was a man

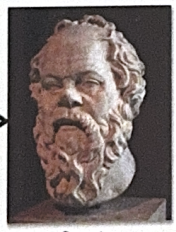
$S \epsilon A$





Socrates was a man

ϵA



Socrates

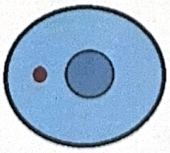
Plato

Aristotle

Socrates

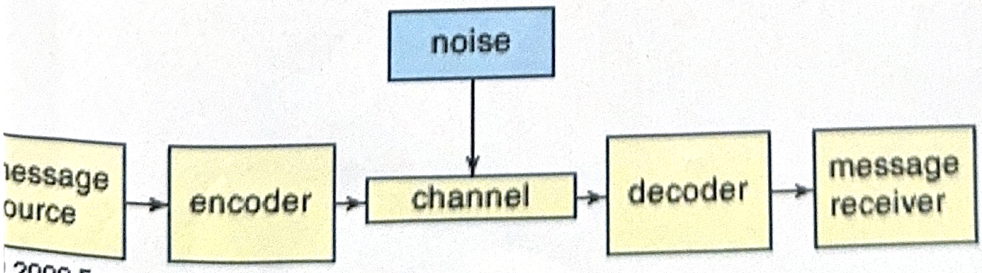
philosophers are men

$\Phi\ \epsilon\ A$



Socrates was a philosopher

$S\ \epsilon\ \Phi$



Boolean logic

↓

Modern mathematical system that works with True (1) or false (0) using And, OR, NOR, used in computers for processing info

Aristotlian logic was old system based on reasoning with words and categories (all man are mortal)

$P(A) = \frac{m_1! \cdot m_2!}{n!}$ - Bin. distribution

Arrangements are indistinguishable in objects

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

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

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

$\log_2 \left(\left(\frac{1}{8}\right)^{-1}\right) = 3$ $\log_2 \frac{1}{0,5} = 1$

□□□□ 0,5
◇◇◆ 0,25
○ 0,125
+ 0,125

++++
○○○
+.
♡

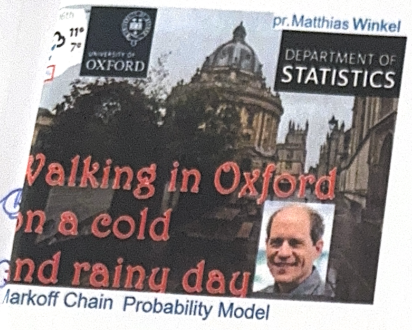
1. $\log_2 \left(\frac{1}{0,5}\right) = \log_2 2 = 1$ 1. 0,5

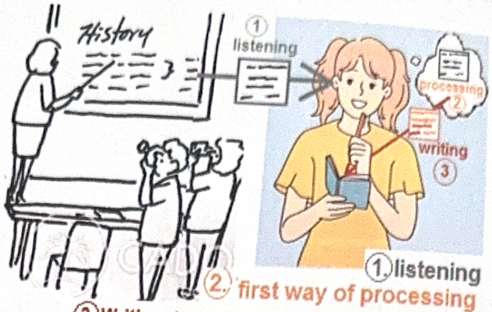
2. $\log_2 \frac{1}{\frac{3}{10}} = \log_2 \frac{10}{3} = 1,11$

$\log_{,} 3.3 = 1,772\,033$

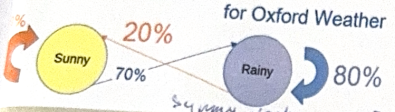
3). $\log_2 10 = 3,32$ (0,1 = 0,3)

1. + 1.11 + 3,33 = 5,43





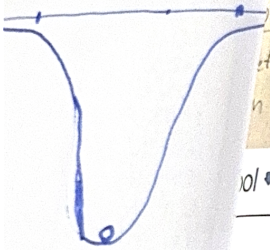
1. listening
2. first way of processing
3. Writing, incl. sth., you're not quite sure about



if it is rainy 80% - it stays rainy, 20% - other (sun)

CHALK + TALK ink + think

take notes on the lecture yourself

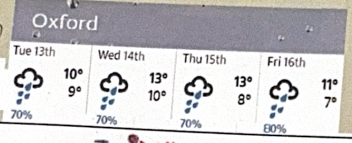


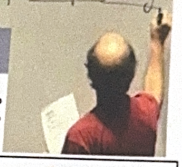
Derivation: 80% chance of rain

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_i each have probability p, independently

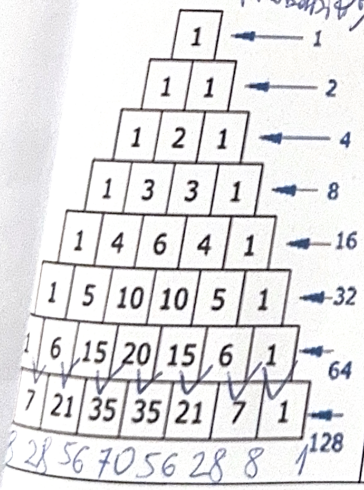
=formalism=> $E = mc^2$ ∫ ∂ Uni

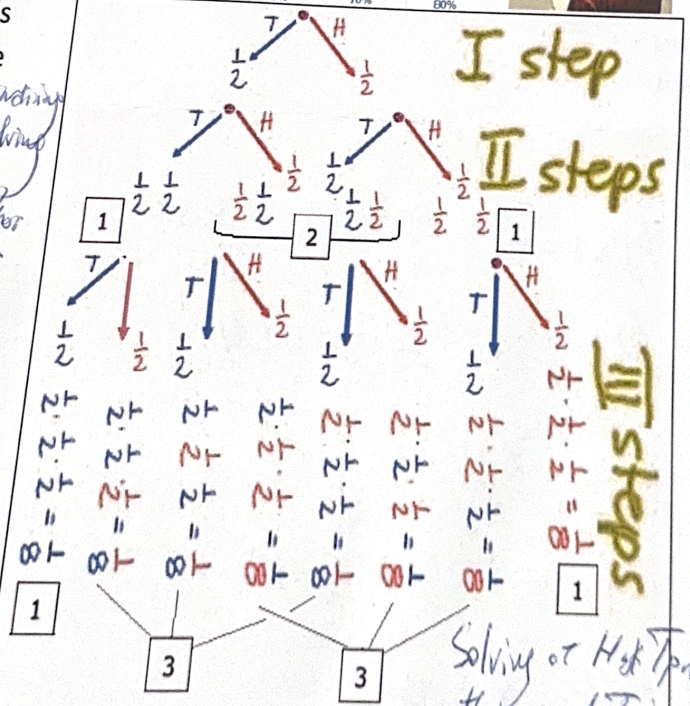




Pascal's triangle

is for finding patterns, solving binomials, answering for Probability





Solving of Hat Problem with Pascal Triangle

$$(a+b)^0 = 1$$

$$(a+b)^1 = a+b$$

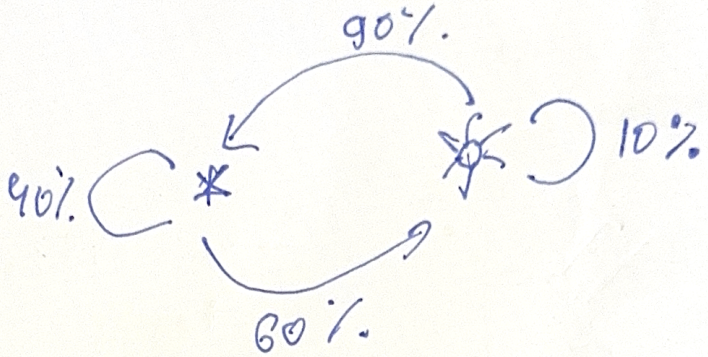
$$(a+b)^2 = a^2+2ab+b^2$$

$$(a+b)^3 = a^3+3a^2b+3ab^2+b^3$$

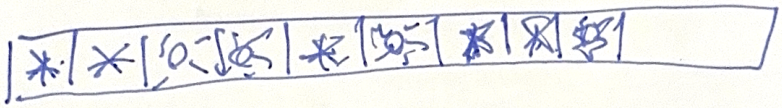
$$(a+b)^4 = a^4+4a^3b+6a^2b^2+4ab^3+b^4$$

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

$$(a+b)^6 = a^6+6a^5b+15a^4b^2+20a^3b^3+15a^2b^4+6ab^5+b^6$$

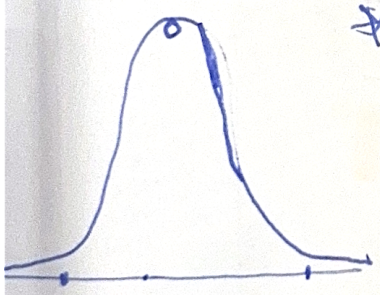


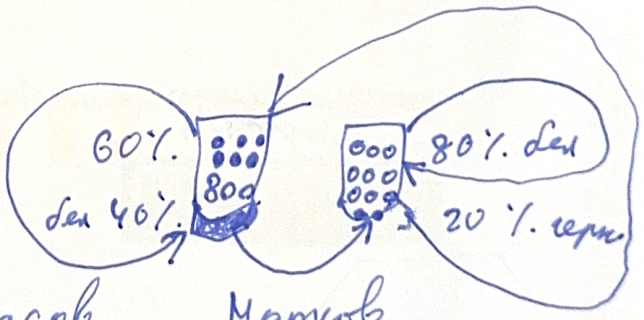
Февр



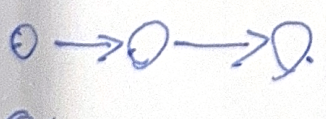
— 4

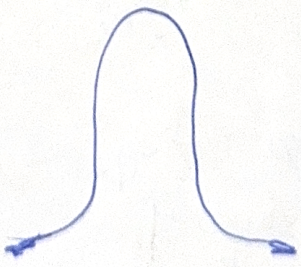
— 6





Некрасов Марков





12.
8

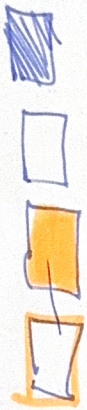
01NN
1000
1010
100N
0NNN
0010
110N
0000
00NN
0111
101N
0100
11NN
10NN
111N
0110
1101
010N
000N
1NNN
001N
0001
011N
1001
1011
1100

$\log_2 3 = 1{,}6$

Энтропийные сжатие ↘

$$E = \sum_{1}^{4} P_i(x) \frac{1}{\log_x(p)}$$

Ф-ла Шеннона

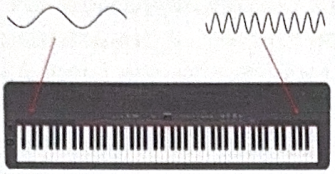


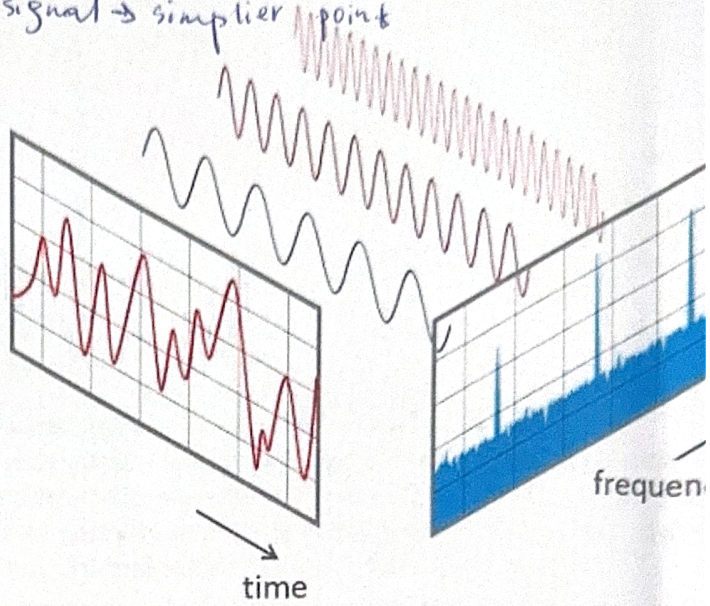
60% – 1 раз

1 символ

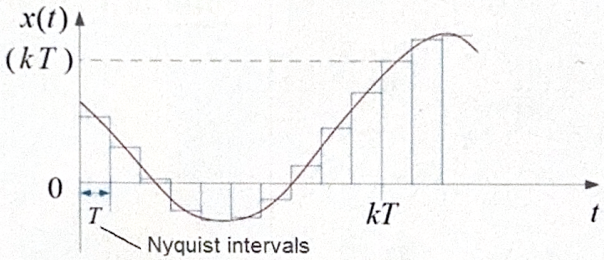
mathematical method do convert a signal from the time domain into frequency domain
complex signal → simplier point

Fourier transform

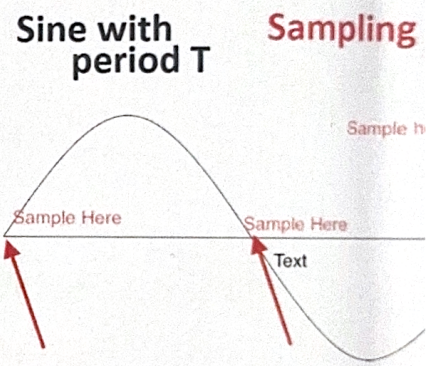




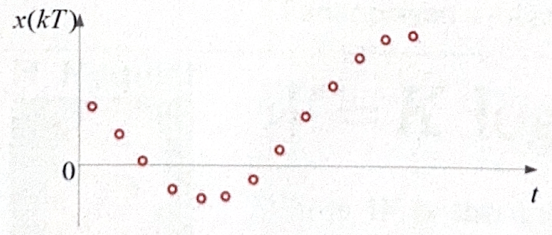
Sampling. Kotelnikov-Nyquist Theorem

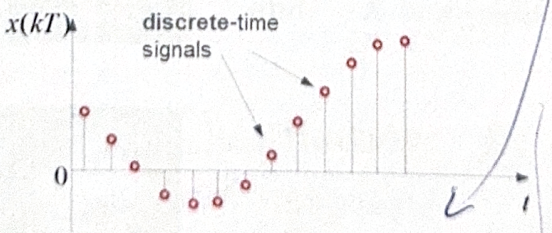


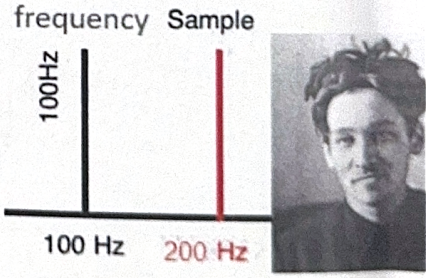
Time intervals T, through which readings s (kT) are taken, are called Nyquist intervals.



The process of converting a continuous signal into a discrete.







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

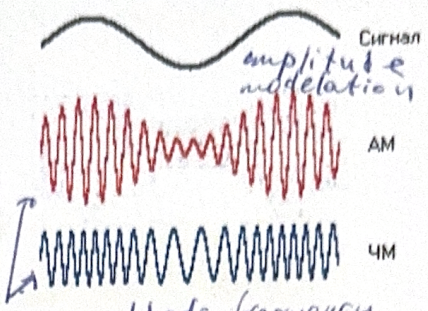
$(T_{sample} <= T_{min}/2$

To reconstruct the original signal the sampling rate must be at least twice the highest frequency present in the signal

Vladimir Kotelnikov

He develope telecommunication, radio, image processing. These works laid the foundation for dig signal processing, analogue signals can be converted into digital form

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



amplitude modulation

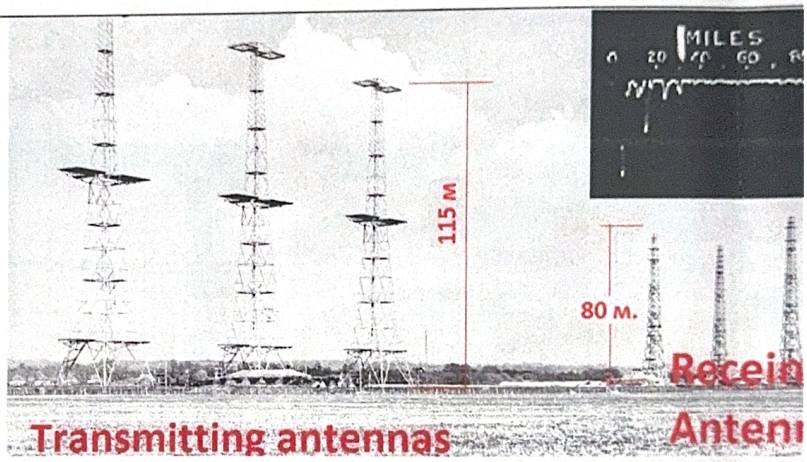
Two methods frequency modulation of encoding info in a signal

(October 6, 18
July 22, 1932)

first transmission
speech by radio
(1900), and the f
two-way
radiotelegraphic
communication a
the Atlantic Ocea
(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 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

$$W = K \log m$$

I.T. formulas

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

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

$$H = n \log s$$

$$= \log s^n.$$

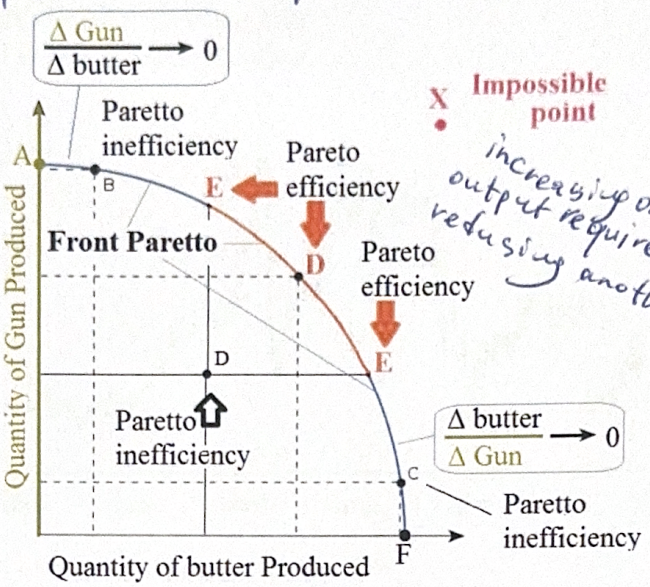
number of independent card selection
total number of poss

Peck 52 cards
Players 4 (each 13 cards)
Many possibilities

$$H = 13 \log_2 5 \leftarrow \frac{S = 52!}{13! \cdot 39!} \Big/ \log_2 4 = 2$$

entropy in bits to base-2 log

If is representation of optimal resource allocation in economy



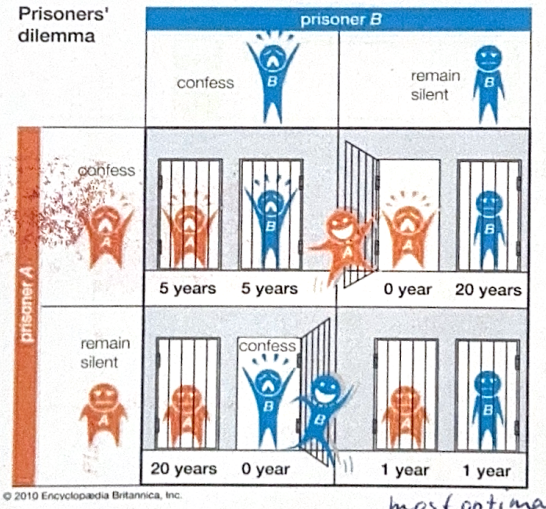
Impossible point

increasing one output requires reducing another one

by Vilfredo Pare

1848-19

The orange sector E-D-E is most Pareto efficient - since increase in one indicator lea to a decrease in another.



most optimal

Game Theory

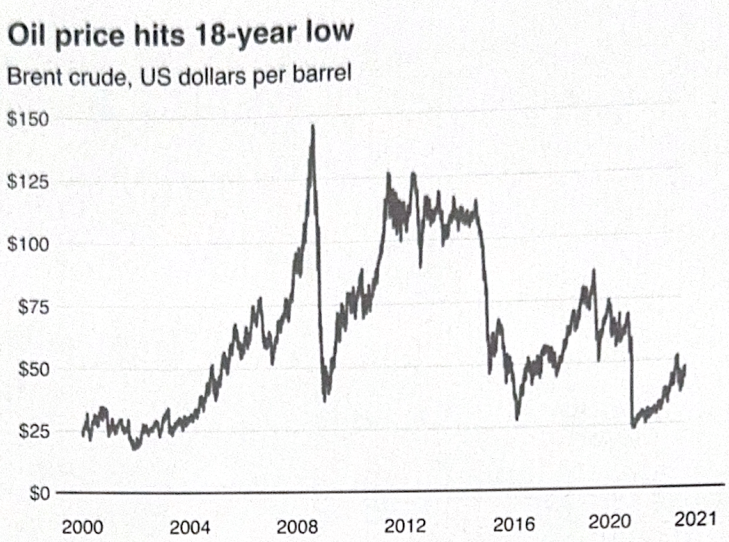
Nash Equilibrium

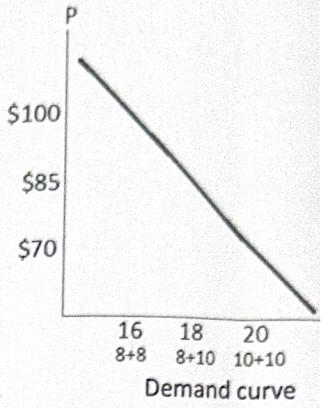
** => Nash equilibrium

$H_1(x)$ \ $H_2(x)$	Player 2	Recognition;	Non-recognition;
Player 1		1	2
Recognition;	1	* -5 / -5 *	-20 / 0
Non-recognition;	2	0 / -20	-1 / -1

-1-1

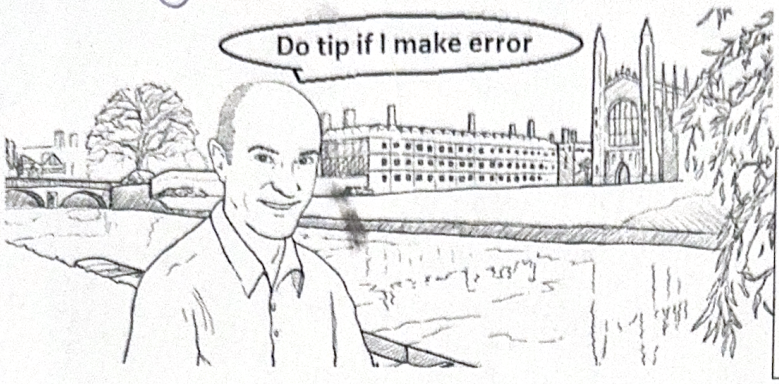
Pareto Optimalit



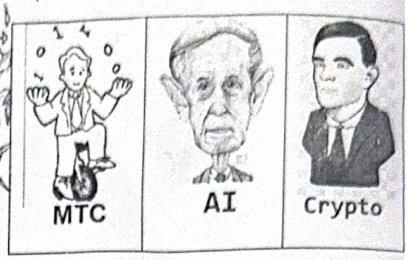


Barrel	1. $8 \cdot 10^6$ barrels/day	2. $10 \cdot 10^6$ barrels/day
1. $8 \cdot 10^6$ barrels/day	$800 millions per day $100 per barrel $800 millions per day	$850 millions per day $85 per barrel $680
2. $10 \cdot 10^6$ barrels/day	$680 millions per day $85 per barrel $850 millions per day	$700 millions per day $70 per barrel $700 millions per day

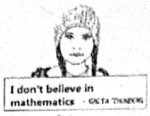
7 in binary 0111



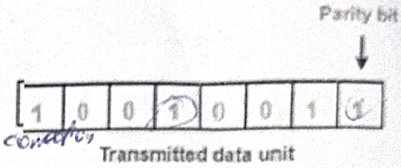
Sir **Dr. D. MacKay,**
University of Cambridge
(22 April 1967 – 14 April 2016)

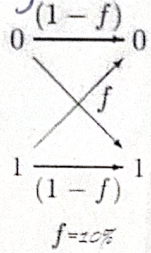


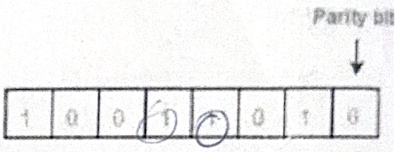
"I believe in clean energy,
but I also believe in mathematics"



redundancy system for error detection and correction



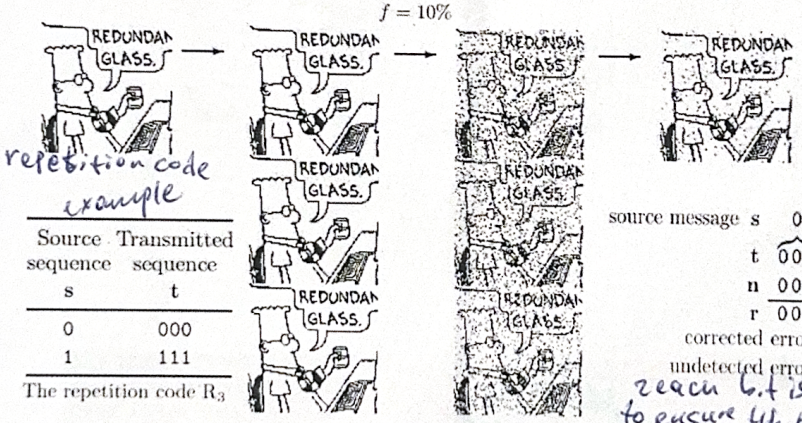




extra info is added during the transmission

s ENCODER t CHANNEL r DECODER ŝ
$f = 10\%$

ABC
DEF



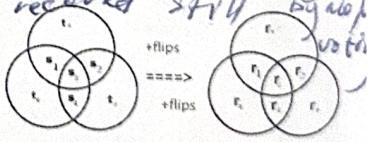
repetition code example

Source sequence s	Transmitted sequence t
0	000
1	111

The repetition code R_3

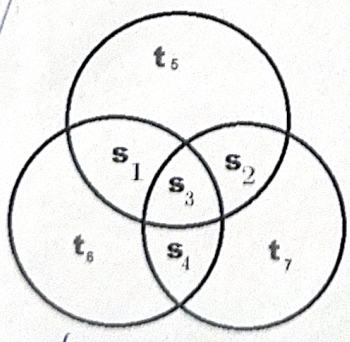
source message s	0	0	1	0	1	1	0
t	000	000	111	000	111	111	000
n	000	001	000	000	101	000	000
r	000	001	111	000	010	111	000
corrected errors		*					
undetected errors							

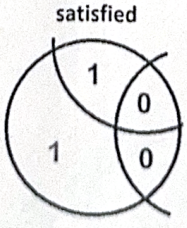
each bit is sent multiple times of
to ensure that if one is flipped, orig
can be recovered still. By



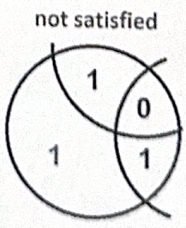
7.4. Hamming code.

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

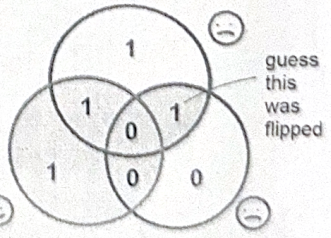




1+1+0+0=0



1+1+0+1=1



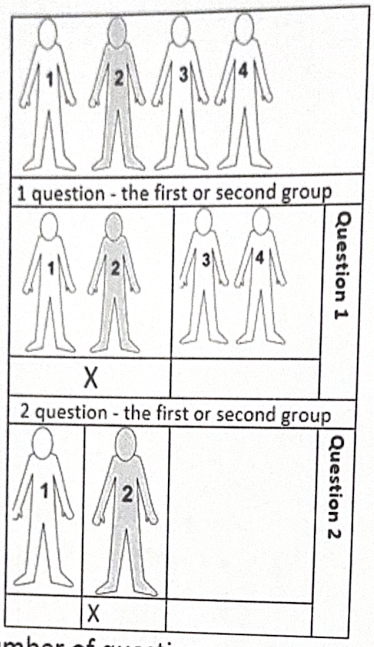
each codeword is 7 bits long
of those 4 bits - actual data
3 bits - parity (redundant bits)

orig: 1
111
received as 101
checked 2 bits = 1.

Say **NO** to the **first**

Say **YES** to the **second** if it is better than the first

Say **NO** to the **third** only if it is worse than all the others



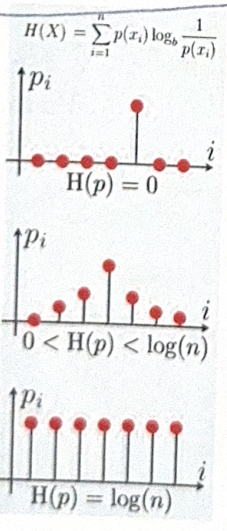
Average number of questions =

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		



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

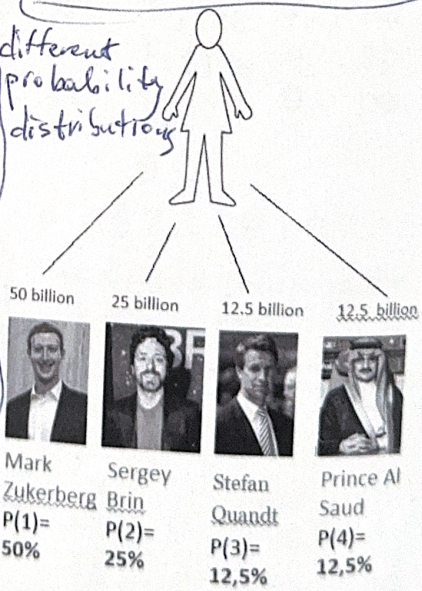
Quantifying information

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

number of bits required to encode choice

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

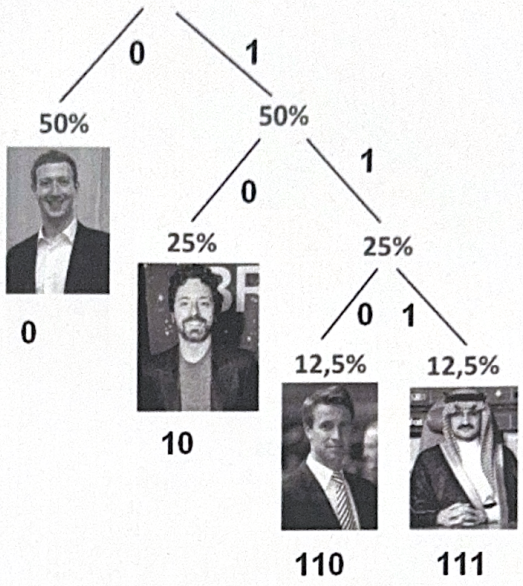
different probability distributions



Entropy ($H(X)$) - quantifies the average amount of information

Self information ($I(x)$) - measures how surprising the event, measurement, ... may be

- if every outcome is equally likely → entropy is high (lots of unpredictability)
- if outcome much more likely than others → entropy is low (more predictable)



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

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

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