Information

- What does the word "**information**" mean?
- There is no some exact definition, however:
- Information carries new specific knowledge, which is definitely new for its recipient;
- Information is always carried by some specific carrier in different forms (letters, digits, different specific symbols, sequences of digits, letters, and symbols , etc.);
- Information is meaningful only if the recipient is able to interpret it.

Information

- According to the Oxford English Dictionary, the earliest historical meaning of the word information in English was the act of *informing*, or giving form or shape to the mind.
- The English word was apparently derived by adding the common "noun of action" ending "*-ation*”

Information

- The information materialized is a message.
- Information is always *about* something (size of a parameter, occurrence of an event, etc).
- Viewed in this manner, information does not have to be accurate; it may be a truth or a lie.
- Even a disruptive noise used to inhibit the flow of communication and create misunderstanding would in this view be a form of information.
- However, generally speaking, if the *amount* of information in the received message increases, the message is more accurate.

Information Theory

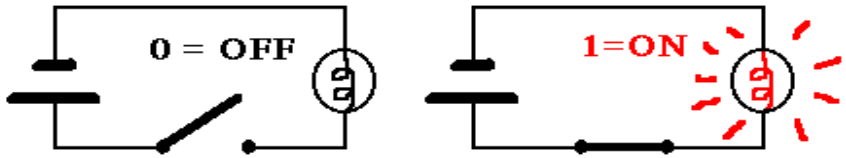
- How we can measure the amount of information?
- How we can ensure the correctness of information?
- What to do if information gets corrupted by errors?
- How much memory does it require to store information?

Information Theory

- Basic answers to these questions that formed a solid background of the modern information theory were given by the great American mathematician, electrical engineer, and computer scientist **Claude E. Shannon** in his paper "A Mathematical Theory of Communication" published in "The Bell System Technical Journal" in October, 1948.

Information Content

- What is the information content of any message?
- Shannon's answer is: The information content of a message consists simply of the number of 1s and 0s it takes to transmit it.



Information Content

- Hence, the elementary unit of information is a binary unit: a **bit**, which can be either 1 or 0; “true” or “false”; “yes” or “know”, “black” and “white”, etc.
- One of the basic postulates of information theory is that information can be treated like a measurable physical quantity, such as density or mass.

Information Content

- Suppose you flip a coin one million times and write down the sequence of results. If you want to communicate this sequence to another person, how many bits will it take?
- If it's a fair coin, the two possible outcomes, heads and tails, occur with equal probability. Therefore each flip requires 1 bit of information to transmit. To send the entire sequence will require one million bits.

Information Content

- Suppose the coin is biased so that heads occur only 1/4 of the time, and tails occur 3/4. Then the entire sequence can be sent in 811,300 bits, on average This would seem to imply that each flip of the coin requires just 0.8113 bits to transmit.
- How can you transmit a coin flip in less than one bit, when the only language available is that of zeros and ones?
- Obviously, you can't. But if the goal is to transmit an entire sequence of flips, and the distribution is biased in some way, then you can use your knowledge of the distribution to select a more efficient code.
- Another way to look at it is: a sequence of biased coin flips contains less "information" than a sequence of unbiased flips, so it should take fewer bits to transmit.

Information Content

- Information Theory regards information as only those symbols that are uncertain to the receiver.
- For years, people have sent telegraph messages, leaving out non-essential words such as "a" and "the."
- In the same vein, predictable symbols can be left out, like in the sentence, "only infrmatn esentil to understandn mst b tranmitd". Shannon made clear that uncertainty is the very commodity of communication.

Information Content

- Suppose we transmit a long sequence of one million bits corresponding to the first example. What should we do if some errors occur during this transmission?
- If the length of the sequence to be transmitted or stored is even larger that 1 million bits, then 1 billion bits… what should we do?

Two main questions of Information Theory

- What to do if information gets corrupted by errors?
- How much memory does it require to store data?
- Both questions were asked and to a large degree answered by Claude Shannon in his 1948 seminal article:
  use error correction and data compression

Shannon's basic principles of Information Theory

- Shannon's theory told engineers how much information could be transmitted over the channels of an ideal system.
- He also spelled out mathematically the principles of data compression, which recognize what the end of this sentence demonstrates, that "only infrmatn esentil to understadn mst b tranmitd".
- He also showed how we could transmit information over noisy channels at error rates we could control.

Why is the Information Theory Important?

- Thanks in large measure to Shannon's insights, digital systems have come to dominate the world of communications and information processing.
  - Modems
  - satellite communications
  - Data storage
  - Deep space communications
  - Wireless technology