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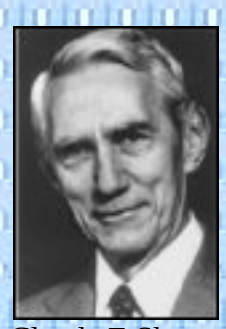
Shannon, Bits and Bandwidth

Claude Elwood Shannon, Professor at MIT laid the corner stone of the fantastic advances in telecom that the last 50 years have seen, says S.Ananthanaryanan.



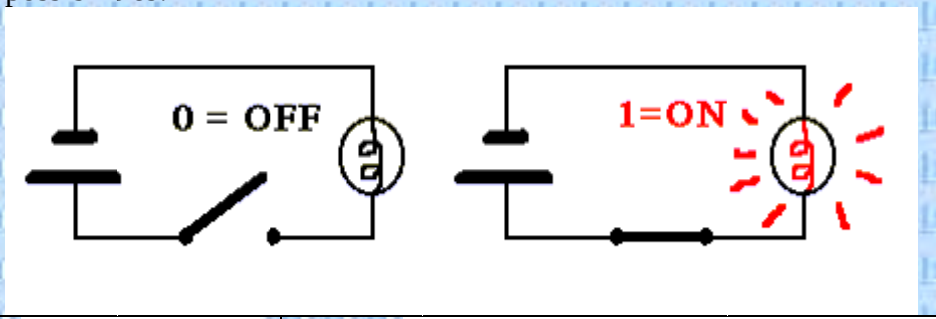
Claude E Shannon

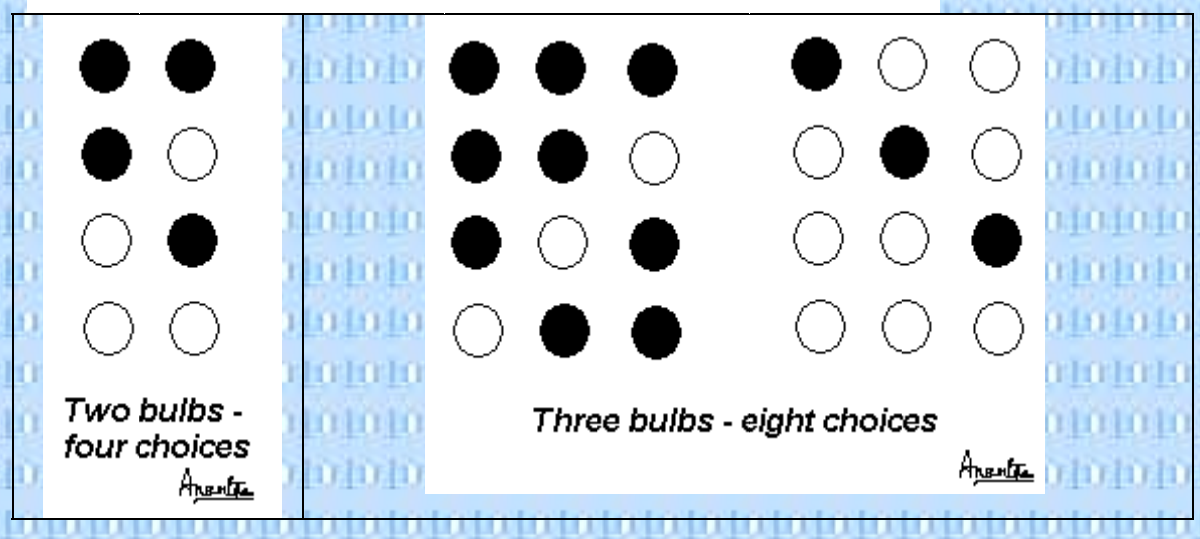
Shannon worked out the maximum information that could be carried over a medium like a telephone wire,

Information Theory

In 'Information Theory' a 'unit' of information is the quantity of information that enables a selection from a range of two. Thus, because a light bulb can be either 'on' or 'off', its state at any moment is one unit of information.

With 2 bulbs, then there are 4 choices possible: ON-ON, ON-OFF, OFF-ON and OFF-OFF. The state of 2 bulbs, or 2 units of information, hence enable a choice out of 4. In the same way, 3 bulbs can be in 8 states, which means you need 3 units of information to choose out of 8 possibilities!





You may notice that 1,2 or 3 units of information resolve uncertainty out of 2,4 or 8 choices, which are the powers of '2'. For this reason, it becomes possible to work with 'information', in an abstract way, using arithmetic based on the number '2'. This is known as 'binary ' arithmetic and the word, ‘bit’, short for ‘binary digit’, for the unit of information was coined during Shannon's research.

Bits and Bytes

In computers, capital or lower case alphabets, digits, punctuation marks, etc. are coded using 8 bits, called a 'byte', which represent 256 choices.

When computers communicate, text, pictures, even sounds are converted into a stream of bits, or '1's and '0's, and these are passed over the telephone wire or other medium. And how fast we are communicating depends on how many bits cross over every second.

Now it turns out that above a certain speed for each kind of wire, the '1's and '0's get too close together and cannot be made apart! Being able to make out 'sharply' a change in the signal on the wire depends, actually, on how high pitched a sound the wire can carry. The higher the pitch that can be carried, the more sharply changes can be made out. This frequency range usually called its 'bandwidth'.

With our usual telephone wires, we may have noticed that a telephone voice is not the same as the 'real' voice, face to face. The reason is that that the full quality of our voice depends on several overtones, or harmonics, of the pitch in which we speak, upto about 20,000 cycles per second (cps), which is the highest pitch that we can hear!

But because the telephone lines are 'sluggish' and cannot respond fast enough to higher frequencies, sounds pitched higher than 3000 cps just do not pass through and this distorts the quality of the sound Over the radio, or TV, or through the special cable the cable operator uses, of course, we do get nearly perfect sound, but not over the telephone.

Computers and Telephone Lines

This 3000 cps 'bandwidth' limits the maximum bit-rate that a telephone line could carry, no matter how clever the computer, to about 15,000 bits a second, or '15 kbps'. The '28.8 kbps’ and '56.6 kbps' rating of modems that we hear about are really workarounds, using 'data compression' or other ways to 'summarise' information, and not really faster transmission.

Claude Shannon's work, in the 1940s, used gifted insight into 'informaion', 'noise', mathematics, some aesthetics, to lay down principles that helped incredible evolution of telecommunications within his very lifetime.
