MOOC

Innovating in a Digital World

Lesson: The pace of digital technological change

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Introduction

April 1960: Theodore Maiman developed the first laser. During the Cold War, journalists dubbed this the death ray, but luckily there were more peaceful needs for this new technology and 50 years later lasers are everywhere.

November 1971: Intel develops the first microprocessor. Since then, its performance has doubled every two years with incredible regularity.

Today: The explosion of networks validating transactions on bitcoin has a power expressed in zetaflops. As for today’s micro-computer, it now has the power of a supercomputer of the early 2000s.

The progress in techniques used for the processing of information has become so fast over the last 50 years that it has given birth to an industrial revolution. This obviously refers to the “industrial revolution” of the 19th century where we saw the domestication of energy, however this revolution is occurring at a much faster pace.

Advancing at unheard of speeds

The growth in performance of digital devices is occurring at unprecedented speeds. The world has faced successive technological revolutions, but their progress was measured on an arithmetic scale, reflecting a constant factor of improvement every year. For the past 50 years, the performance of digital technology literally exploded and followed geometrical laws

. We no longer add a constant factor to the existing performance but rather multiply it each year by this constant factor. To account for this progress, it is necessary to resort to logarithmic representations that allow us to find the linearity of these developments. Everybody knows Moore's law, named after one of the founders of Intel.

This law illustrates the effects of technical progress on microprocessors: the number of transistors therein doubles every two years; this law is obviously not a physical law of nature, but a goal that the semiconductor industry has been able to meet for more than 40 years. It should find its limit with the achievement of molecular scales, but other parameters seemingly provide solutions around this "wall" of physics. Most digital technologies have similar progress which have to consider Moore's Law, or its equivalents on other digital areas, as emblematic.

Infinitely big and infinitely small

Expressed on the scales of the decimal system, digital performance goes through two scales: the infinitely big, which is that of system performances. In 10 to 20 years we jump from one unit to the next, which is 1000 times larger. And the scale of the infinitely small, the scale which one uses in matters, the miniaturization that goes along with the lowering of energy consumption. Technology currently offers a capacity in excess of 1 terabyte and is therefore between the petabyte and the exabyte while working at the micro, or even, nano scales. Doubling the capacity of a system every year is to say that we will have progressed as much as the original system within the coming year. Moreover, the evolution of performance does not lead to similar price increases. On the contrary, whatever the considered technical system (a computer, a smartphone, memory, processors, etc.), higher performance is rarely at fixed prices, but is rather associated with a decline in price.

Straining the digital economy

The upward velocity of technological progress brings about paradoxical effects, three of which must be emphasized:

1. Techniques are not progressing at the same speed, creating gaps that are very quickly exposed due to rapid progress, as with software technologies and hardware technologies. This lack of homogeneity in technical progress leads to frequent substitution techniques in complex systems. This explains why modularity is needed to allow substitutions of technical building blocks within these complex systems.
2. If progress frequently results from breakthrough innovations, as with the laser or the microprocessor, innovations paradoxically present themselves on a daily basis, very incrementally in order to control wait and see expectations both on the part of consumers and producers, and to not produce too strong a gap in competition or use.
3. Any project built in a digital platform must anticipate the digital world in which it will see the light of day. This can be very tricky, but it is crucial to understand that nothing will remain equal.

In 2025, our smartphones, our cars or our robots will have the power of the largest supercomputers of today.