

INFORMATION AND COMMUNICATIONS TECHNOLOGIES ARE LEARNING FROM NATURE'S "RESEARCH" TO PUSH THE PERFORMANCE LIMITS

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Abstract

The paper analyzes the way information and communications technologies (ICT) faces the actual challenges for their development, starting from the fact that science and technology power is generally recognized as the main factor of human kind progress in the last centuries, but ICT have a huge role in refining the dynamic legacy knowledge -the support of developing information society (IS) toward knowledge based society (KBS).

ICT premises to enable "the technology power to do more good than bad" in the IS/KBS, exceeding the ICT field and lending a power instrument of analysis and management for actual most complex decision processes on Earth, are also analyzed, as not few literature discussed the two edge force of science and technology.

On the other hand, the paper analyzes the actual context where ICT must bring new approaches/innovations, answering to the major challenge of pushing the performance limits and then expanding them to all other scientific and technological fields, especially in this crucial phase of apogee/decline they are facing because of soon reaching physical limits of conventional semiconductor technologies and Earth resources fading.

*The paper main conclusion, after presenting some actual technological examples and premises, is that using **the million years nature's research in living things** is perhaps the best way to identify some ideas for the long expected revolutionary optimal technologies humankind and Earth need.*

Keywords: supercomputing, nanotechnology, brain diagram, OLED, communications and information technologies, information society, knowledge based society.

JEL Classification: L63, L86, M15, O13, O33

1. Enabling the technology power to do more good than bad

The evolution of science and technology is undoubtedly the most important, fascinating and complex process of humankind existence on Earth in the last centuries, which created the

huge dynamic legacy we call knowledge and became the support of the actual *information society (IS) toward knowledge based society (KBS)*.

We have to remember, in order to benefit from it, that on the large scale of the history, the life evolution on Earth, up to the *Homo sapiens*, is by far a prominent and amazing phenomenon of the Universe.

Perhaps one of the most inspired synthetic evaluations of the mentioned process was given by the famous American physicist Richard Feynman, who said in 1955 [2], addressing to the US National Academy of Sciences:

“Scientific knowledge is an enabling power to do good or bad – but it does not carry instructions how to use it”

This is the context we further consider, where humankind has to analyze every day and every year which are the optimal directions to develop information and communications technologies (ICT), as the main factor to support the evolution of IS on the complex way toward KBS.

As usual, the beginning of a new year, this time 2014, comes with a packet of challenges for everyone.

As long as ICT exponential pace and Moore Law are still alive, a new year is bringing an upper limit to fight for.

If, for ICT, the challenge would be that “simple” it still would be usual, but we have to notice that the already long competition of ICT with itself (Moore Law) is counting more than 50 years and the last years became harder as the “traditional” semiconductor technologies reached, on one hand, amazing levels of performance, but on the other hand close to their physical limits.

For ICT and further IS/KBS, the stable development challenges include as main factors the mutual and complex influences between development/progress and its negative consequences on Earth environment: material resources, climate changes and social evolution.

The paper space would not allow to approach all these issues but will only try to emphasise some of their reflections on the main ICT actual challenge: keep the pace and push the performance limits by ***learning from the long history (millions years nature’s “research”) as the recent history knowledge resources are fading***.

As we have earlier expressed [14] and more and more is confirmed in the literature [2], [15], the ICT development must be carefully analyzed and planned, in spite of its amazing pace, in order to optimize the influences on IS/KBS.

It is also important to recall [11] that in this complicate puzzle of decisions, ICT have the proved feature to bring products, services and “know-how”, which are leveraging all humankind activity fields, directly by their applications, but also indirectly by extending ICT new concepts and methods, as refined knowledge (instruments and ways of thinking), in a diversity of areas outside ICT.

The most prominent example is perhaps the “network centric” concept [11], which has been extended from ICT to defence or non-defence applications and then to social networks and social models.

Now the time has come that ICT bring new approaches, first for its above mentioned challenge of pushing the performance limits and then expanding them to all other scientific and technological fields.

A very significant expression of this reality is the approach of IEEE [2], among the ICT most prominent international standardization institutes besides ITU and ETSI, which emphasised the crucial importance of the fact that IEEE (ICT) specialists (perhaps the largest professionals association in the world) “*are both well qualified and well positioned*” to sustain the two fold (two directions) mechanism by which the scientific and technological power/development could be optimally led.

Essentially, the first direction is based on the social importance and benefits of the specialists forum when contributing to the identification of the optimal solutions in the complex decision processes supporting the ICT and further IS/KBS development, based on their well-known expertise.

An even more complicated direction is that generated by the Richard Feynman dilemma aiming to separate and prevent mixing of “good or bad”, in fact promoting **responsibility and ethics** in the ICT/IS/KBS and generally in the scientific and technological power/development.

It is easy now to observe that both approaches have the premises to enable “**the technology power to do more good than bad**” in the IS/KBS, exceeding the ICT field and lending a power instrument of analysis and management for actual most complex decision processes on Earth.

We also notice that changing, a little, the Richard Feynman’s dilemma “*good or bad*” into the proposal “**more good than bad**”, we have suggested the crucial and practical importance of analyzing and eventually optimizing the complicate decision processes of ICT/IS/KBS development, as a realistic approach of the actual and future World, where ***it will be more and more difficult to (completely) separate bad of good.***

The above conclusion is congruent with the already mentioned two directions, as IEEE expressed the crucial importance of expertise (refined knowledge) and debate (communications) in IS/KBS.

In order to observe the concrete ways these action directions are implemented in ICT, we will further analyze some actual ICT development ideas and solutions aiming to approach the above mentioned challenges of ICT and beyond.

2. Prominent ICT solutions for the actual challenges are inspired from the million years nature’s research in living things

When we want to start drawing the image of a huge and diverse collection of things, it is better to first evaluate which is the largest of them, choosing a common metric.

This goal is not simple when we analyze ICT areas, but as we have earlier mentioned [14], there is a relatively largely accepted fact that ICT performance limits have as a central issue the computation power and memory capacity, i.e. the main features of the future supercomputers.

The literature confirms [13] and we have also pointed out [4] that the principals applications of future supercomputers include brain diagram and Earth climate changes.

The complete study of human brain diagram is perhaps the greatest challenge facing 21-st century research.

In order to express the dimension of the „brain diagram” World program, we have to notice that one of its most prominent projects, Brain Research Through Advancing Innovative Neurotechnologies (known as **BRAIN Initiative**) was supported in 2013 by the USA Government with 110 millions USD, as Barack Obama announced in april 2013[3].

The realistic technological image of the program target could be expressed by the actual state-of-the-art neurological activity recording applied for the *zebra fish* is involving 80000 neurons, but a mouse has 75 million neurons and a human has... ***about 86 billion neurons*** [3]. More than the above facts, there are 150 trillion estimated connections linking the neurons in the human brain.

A preliminary estimation of the computing power for the above program (**BRAIN Initiative**) would require over 10^{17} bytes memory(storage) and 10^{18} Flops for brain simulator [5].

The ICT actual responses to the above challenge include, after the 3-D transistor technology approach, the new memory approach - which is aiming smaller, faster and cheaper solutions, based on two new models: 3-D NAND and Hybrid memory cube [8].

A crucial observation is that the mentioned technological solutions and even the adding of other similar improvements, could not solve a future expected challenge, we also earlier expressed [14], generated by the perspective that the „classical” semiconductor technology is coming to its physical limits and the „usual” ICT pace, expressed and „powered” by Moore Law, will stop unless revolutionary technologies will be discovered, i.e. inspite of the new architecture and algorithm models which are actually researched or applied.

Among the forecast models we may recall [4], [7], are the life (biology) inspired and optical approaches.

This is the point where we have to point out that the (**BRAIN Initiative**) could reveal important knowledge, which could be extremely useful for the future and revolutionary ICT, as the „human brain” is in fact an archive of the million years research made by the „mother” nature, that is clearly expressed, among other, by the above evolution/revolution of the neuron numbers (zebra fish - 80000 neurons and human - **86 billion neurons**).

This way an essential preliminary conclusion could be expressed, as this program (**BRAIN Initiative**) is a **feed back** process, a kind of self leveraging one, **similar with nature/life progress/research on Earth**, but with obvious future benefits for all ICT applications and generally for IS/KBS progress.

It is worth to recall that the target applications of the ICT progress in supercomputers exceed **BRAIN Initiative** and are also aiming [5]:

- Scale Genomic Correlation;
- Data Assimilation in Large Scale Sensors;
- Exascale Atmospherics (climate changes);
- Extreme Big Data (Social networks, multi-sources unstructured data etc.).

As the applications line is larger than mentioned, the ICT innovations number are larger too.

Nanotechnology is already largely applied, much outside ICT, but we will not analyze the diversity of applications/innovations, which include cleaner water, new materials, safer food/clothes/cosmetics etc.

The paper point is, on the other hand, very well revealed by a new family of applications/technologies, the nanosensors.

„Sniffing for cancer” (melanoma) is a health research field which is based on nanosensors which can detect the odors [10].

This case is very relevant not only by its crucial social importance (for people’s life), nor for the fact that the „e-nose” could have a large diversity of applications.

The really impressive fact is that the researchers of those nanosensors have identified the *technological solutions starting, **again**, from the living things*.

As a concrete and essential result [10], the researchers found that the human nose has about 5 million sensors (scen receptors), but the bloodhound’s has ...**300 million!**

Now, **again** [4], we can undoubtedly conclude that life (living things) is the supreme, „natural” and reliable inspiration source, not only for ICT but especially for ICT, as they are the most complex and dynamic technologies, as this source is provided by the „mother” nature’s million years research, performed by the well known natural selection processes. This nano life-inspired new technologies family is clearly similar with the above „brain” inspired, along with all pertinent mentioned implications.

The importance and the impact of nanotechnology are very well reflected by the magnitude and maturity of its IEEE standardization processes.

These standards[6], being centered on carbon nano-tubes (one of most extended nanotechnology field), are covering a larger diversity of areas involving ICT, like:

- Standard for Test methods for measurement of electrical properties of carbon nano-tubes;
- Standard for Test methods for the characterization of organic transistor and materials;
- Standard for Test methods for the characterization of organic transistor-based ring oscillators;
- Standard for Large scale manufacturing for nanoelectronics.

The most interesting and relevant fact we can observe is, **again**, the prominent and increasing contribution of nature inspired innovations (technologies) as above we may observe the dominance of „organic transistor”, which confirm, **again**, the forecast we made on a revolutionary ICT trend based on biology as nature’s research result[4].

On the same line of the solutions for **extending the performances after reaching the semiconductor ICT physical limits**, the optical nanophotonic circuits seems to be the base of a promising technology, which could improve also the conventional optical laser and fiber systems technologies by guiding and routing the light at nanoscale [7].

The organic materials are proving to be an emerging performant solution also for the display technology - the base of one of the most productive ICT industry, due to the huge number of manufactured TV-s, laptops, tablets and...smartphones.

Although the OLED (Organic LED) display is a mature technology, there are 2 limiting factors for its development.

The first problem of OLED is their low efficiency (emitted/consumed energy), but the researchers just developed new kinds of carbon-based molecules which have the capacity to influence electrons spin behaviour in order to increase the emitted light energy [9].

The second problem of the actual OLED is the fact that they need rare metals (iridium; platinum) in order to make the device efficient.

The good news is the fact that the above mentioned carbon-based molecules can provide even better efficiency without adding rare metals, i.e. having solved one of the crucial problem of Earth resources fading, without speaking about the device cost reduction.

The last, but not the least, the „carbon cost” (carbon dioxide emission) is one of the actual „hardest” challenges of ICT, sometimes called „green ITC”.

It is worth to notice that carbon cost is not an independent problem versus the above supercomputers technologies/innovations, as the performance/power is crucial for any new technology.

Why cloud (computing) is perhaps the greatest emerging paradigm in ICT is almost clear, as we also expressed [11], but in a similar way we may conclude that „cloud” could be the biggest ICT carbon dioxide generator.

The dimension of cloud carbon cost is very well reflected by the fact that in 2012, the Facebook’s data centers have determined 298000 metric tones of carbon dioxide – the equivalent of about 55000 cars [1].

In this case, one of the new ICT approach is aiming a software solution, at networked data centers scale, which could manage the tasks in order to optimize energy consumption efficiency.

At the first glance this idea seems not very new, but, any way, it is obviously inspired, **again**, from the mutual functionality of human brain and its amazing redundancy.

The impressive fact of the above solution is that, inspite of its software base, it suppose a huge „hard” infrastructure (based on Internet) to link, coordinate and optimize remote data centers, located, for example, in Finland, Ireland, New-York and California [1].

Of course, the ICT life-inspired trends could and will continue, but the above analyzed cases are enough relevant to express the signification and the importance of optimizing the

stable development of ICT and IS/KBS, especially in this critical phase of apogee/decline [14].

On the other hand, it is crucial to notice that the above examples proved that ICT eventually is almost recognizing that the mother nature's million years research results still could be, today, the best solution/inspiration.

3. Conclusions

The science and technology power is generally recognized as the main factor of human kind progress in the last centuries and the paper emphasised the ICT role in refining the dynamic legacy knowledge - the support of developing the actual IS towards KBS.

On the other hand we analyzed the ICT premises to enable "**the technology power to do more good than bad**" in the IS/KBS, exceeding the ICT field and lending a power instrument of analysis and management for the actual most complex decision processes on Earth.

Facing more and more complex challenges, ICT must bring new approaches/innovations, first for its above mentioned challenge of pushing the performance limits and then expanding them to all other scientific and technological fields.

We have also stressed the critical importance of optimizing the stable development of ICT and IS/KBS, especially in this crucial phase of apogee/decline they are facing because of soon reaching physical limits of conventional semiconductor technologies and Earth resources fading.

In this context, the actual technological examples and premises we have analyzed confirmed that using **the million years nature's research in living things** is perhaps the best way to identify some ideas for the long expected revolutionary optimal technologies humankind and Earth need.

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