

THE EXPONENTIAL DEVELOPMENT OF THE INFORMATION AND COMMUNICATIONS TECHNOLOGIES – A COMPLEX PROCESS WHICH IS GENERATING PROGRESS KNOWLEDGE FROM PEOPLE TO PEOPLE

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Abstract

The information and communications technologies (ICT) are characterized by an exponential development which is unique in industry and has unprecedented consequences in the entire society.

The paper's analysis is focused on the features of this exponential development, which is for decades ruled by Moore's Law, but some premises of a slower pace are also presented.

Among the presented features, a systemic one is the large, often said ubiquitous, spreading and use of the ICT components, products and services over the whole humankind life and Earth including all other „industries“. Another feature is the essential contribution of ICT to the evolution of the human society as „information society“(IS) and to the transformation of IS towards the future „knowledge based society“.

The paper also presents the driving basics of the ICT, consisting in some characteristic models, where the main is the inherent convergence between the communications and the information technology. Another major feature of the ICT models consists of scalable, flexible, reproducible and highly multiplying (logic reusing) digital processing algorithms, software and techniques, which support the open design, implementation and functionality of the ICT components, products and services.

The analysis concluded that the global effect of ICT development could be expressed as a 3 dimensional process and it acts as a systemic liant for these dimensions by the knowldege involved in all human activities leveraged by ICT.

Finally, the paper analyzed the most relevant systemic exemples of the ways ICT development generates refined knowledge. In a systemic approach, the exa-scale supercomputers targets, including human genom, wiring model of the human brain, artificial intelligence and spatial projects are considered.

The main paper's conclusion is that ICT's exponential development leverages the generation of the refined knowledge in IS/KBS, for the people's well and mankind progress on Earth and beyond.

Keywords: *communications and information technologies, Moore Law, exa-scale supercomputers, human genom, smartphones, open design, solar wind monitoring.*

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

1. Introduction

The information and communications technologies (ICT) represent a phenomenon which surprises us everyday by its huge influence on actual mankind activity, irrespective the domain where we analyze it, from industry to finances, from medicine to entertainment etc.

Some features that make ICT very different („a phenomenon”), among other fields we may generally call „industries”, include the ICT’s unique exponential speed of development and the subsequent power to inovate, with unprecedented efficacy and efficiency, all they „touch”.

Another prominent and systemic feature is the large, often said ubiquitous, spreading and use of the ICT components, products and services over the whole humankind life and Earth, including all other „industries”.

Before starting to analyze some concrete mechanisms and consequences of ICT dynamic development, we must remark that these features only tend to define ICT phenomenon as a revolution, similar as consequences, for the mankind, to the „industrial revolution”.

It is also worth to note the essential contribution of ICT to the evolution of the human society as „information society” (IS) and to the transformation of IS towards the future „knowledge based society” (KBS) [10], both being very complex processes where ICT is included as a main driving factor.

2. The exponential consequences of the Moore Law and other ICT trends

When searching for the ICT developing mechanisms, we already have some obvious premises in the above mentioned features, as they represent essential factors for the development of the entire world (IS and so on) and this way high priorities in investments and research.

In this direction perhaps it is very significant a simple example: only the games sector of the entertainment industry has annual revenues of the billions of US dollars order. Here the point is, for a further discussion, that the weight of the „online” games and associated services has an amazing increase.

Of course we have to observe first the rest of the iceberg that ICT represent, as applications, investments and research, versus other monster „industries” or social domains as energy, auto/transportations, chemistry, food, commerce, defence/security, communications, informatics, finances, medicine, media and so on, where the applications and the „social commands” are huge and so the figures of investments.

The main mechanism which explains the exponential evolution of the ICT, without being an independent one versus the above examples, is given by the intrinsic technological and theoretical basics of the ICT.

The basics of the ICT have some characteristic models, but the main systemic one is the inherent convergence between the communications (notice that the first electric „computer” was the telephony switch!) and the information technology.

Another major feature of the ICT models is achieved by the scalable, flexible, reproducible and highly multiplying (logic reusing) digital processing algorithms, software and techniques, which support the open design, implementation and functionality of the ICT components, products and services.

In order to understand the amazing consequences of the digital processing, counting only the communications field, it is very relevant the example of the evolution from the first analogue mobile cellular communications, as terminals and services, versus the actual cellular smartphones which fully benefit from the huge advances in radio digital processing of the last 20 years.

It is important to mention that one of the embedded models that strongly influence the amazing speed of ICT development is the open design, where the main component, also reflected in all the modern ICT, is the software based development of the ICT products and services.

All the mentioned features of ICT represent basic conceptual factors, but perhaps the most influent factor, strongly depending on the above ones, is a mix of concrete electronic technologies which effectively produce the main ICT electronic components and materials, mainly (but far from being exclusively – the best example being the sensors) represented by the processors and memories integrated chips (i.e. integrated circuits).

This way we just arrived to the „heart” of the ICT exponential development, where the well known „Moore Law” is ruling, so far (Intel co-founder Gordon E. Moore predicted the trend in 1965).

For decades this „rule” estimated that every 2 years (18 months by Intel) the number of transistors integrated on a chip will double.

The signification and the implications of this rule are also changing, because, as long as it was confirmed, it became a metric and mathematically speaking generated the exponential feature of the ICT development, which is a huge reality for an industry.

More than this, the Moore Law allowed some related estimations for the ICT (and associated areas) forecasts, one of the most daring referring to the „smarter-than-human intelligence”[1], which is quite advanced versus the old question: *would the artificial intelligence equal the human one?*

On the other hand we have to observe that recently the valability, in the future, of the Moore Law is more and more discussed.

At this point we came back to the above mentioned heart of ICT, because the actual period is dominated by the struggle of Intel and other few companies which lead the progress of ITC by implementing state-of-the-art models and technologies in order to continue the Moore Law’s era [2], [3].

With other words, it is a matter of fact that ***the evolution of ICT reached a pace and level of performance that is more and more difficult to maintain.***

The ICT’s just mentioned limit is very strong linked with an other challenge, this time of the IS and generally of the human kind, referring to the controversial apogee or decline stage we are living in on Earth [4].

Although the actual paper space is not suitable for a detailed analysis, we have to mention some trends of the ICT development, which are closely linked with the main challenges this development has to face.

The exponential increase of ICT is just correlated with an even greater increase of the request of communications and processing products and services, also called „data deluge”/”exa-data era”, which have already been analyzed [8], [5].

All these challenges and premises put a high pressure on ICT to increase processors speeds and memories performances, along with similar requests for the communications networks to offer unprecedented high transport and access capacities.

These trends are more and more addressed to the avalanche development of mobile ICT, as the dominant challenge for the features of the actual ICT products and services is „integrated, ubiquitous, wideband and mobile”.

All these features lead to the above mentioned pressure to design and develop new performant models and technologies, where ***the increase of speed and number of transistors on chip while keeping the dissipated (consumption) power low are phisically opposite tendencies - that is why the Moore Law tend to be obsolete.***

An even realistic image of the actual trends is completed with the request to have the performances increase on mobile devices, as laptops, smartphones, tablets etc. [10].

On this line we may notice the actual efforts made by Intel, as main research force and other very few forces, to design new models and technologies either on the „old” track, as 22nm MOS channel and future step around 14nm, or looking for revolutionary ones, including the 3D-FinFET or other undiscovered models, [6], [7].

The essential observation here is in the fact that the next steps (after 14nm or similar last mile resources) are not known yet and perhaps the mankind has again to learn from the nature (the biological world – for example the human brain) in order to add value and innovation to his apogee achievements [8].

We may now understand how important and complex are the processes of ICT development in their continue race with themselves and why their exponential or slower evolution is transferred to the similar consequences in the IS and then to KBS.

On the other hand we have to imagine what if the mentioned race will slow and to what extent, but these are not easy questions just like to maintain the pace is not an easy way.

As a consequence, we believe that this is one of the actual and dramatic points where ***the mankind has to know exactly what is at the risk to be lost and it is better to also know the value of the things we could lose before that happens, in order to efficiently react and refine the knowledge.***

In the case of the ICT’s development pace, it is fair to also observe that the slowing does not necessary bring only bad consequences, while the ***progress is analyzed at the mankind, IS/KBS and Earth global scale and implications***, considering secondary effects as Earth resources fading, climate changes and human profile [10], [4].

3. How ICT generate refined knowledge from people to people, for progress on Earth and beyond

The importance of knowledge in the IS towards KBS is largely understood and analyzed [9], [10]. A particular feature is that the processes of knowledge generation became more and more complex and complicated as the mankind progressed by amazing scientific, technological, cultural and social advances.

As information too, the knowledge is an elementary category of concepts that is not precisely measurable, but on the contrary they could have dynamic content and time sensitive value.

On these premises the concept of refined knowledge is an realistic approach to characterize the essence of the knowledge as a process, so its content and value are subject to update and depending on the new context, which generally include a new level of global progress.

To be more precise, there are fundamental knowledges that keep their content validity and in most of the cases their value, but the majority of the new knowledge (which in time determine the average) are influenced by the above mentioned factors and features.

The role of ICT in IS/KBS is overwhelming and also very much analyzed and we think that their influence could be estimated by a 3 dimensional (3D) model [10]:

- ✓ on horizontal, by the number of influenced mankind activity fields;
- ✓ on vertical, by the depth of the influence inside every field;
- ✓ in time, by the period and speed of the generated influence.

Then the global effect of ICT development could be simulate by the multiplication of the 3 dimensions, resulting a “volume” – we may call ***the volume of changes*** (VOC).

If VOC reflects a quantitative feature, we can further discuss some detailed mechanisms which generate the above 3 dimensions.

Here it is essential to observe that a systemic liant for these 3 dimensions is the knowldege and then, even shortly, we have to analyze some examples of the ways ICT development generates refined knowledge.

An also systemic premise is the concept of „humanitarian technology” which was recently associated with ICT [1], as bringing together all the known social goals of ICT components, products and services.

On the the same systemic line, we think that all the refined knowledge are generated now (at least until „smarter-than-human intelligence” will be created!?) ***from the people to the people***.

With other words, irrespective the added technological ways, people are thinking (and then they could generate knowledge) mainly in order to innovate and improve their lives and ultimately the mankind life, so the final destination is to the people.

In this far from being simple process we must analyze the essential and exponentially increasing contribution of ICT in generating refined knowledge, as „the added technological ways” people create refined knowledge have radically changed, especially in the last decades, due to ICT.

That is why we may say that ICT exponential development generate knowledge, as they are strongly leveraging the people’s creative capacity, by some essential mechanisms.

A direct mechanism is generated by the new and powerful (thinking and acting) skills ICT offer to the people when they use ICT components, products and services (ICT-CPS), due to the higher levels of built-in intelligence and knowledge.

Another mechanism consists of the powerful and diverse ways people use ICT-CPS in order to achieve data, information and knowledge and then generate refined knowledge in all their activities.

Some relevant concrete examples of ICT-CPS, supporting the above features and keeping as much as possible a systemic criterion, will be shortly presented bellow.

Perhaps the most important refined knowledge class for the mankind is that referring to health and medicine. After the helix shape of DNA discovering (1953), now the interpretation of human genom is a revolutionary achievement where ICT-CPS have a dramatic role.

Chip based genetic sequencing is already possible and this provides, with only one drop of blood, to interpret (for about 1000 US dollars each) the entire human genom of 3 billions components, i.e. to determine the unique sequence that defines an individual [11]. This achievemenet will open a new era in medicine, in order to prevent and then precisely treat the worst diseases.

In the same field of medicine, one of the biggest challenges for ICT-CPS is to determine the wiring diagram of the human brain. In this World project the scientists try to

identify the neuron networks involved and understand the associated mechanisms of perception and cognition.

A relevant expression of the complexity of the wiring diagram of the human brain is the fact that this project is one of the few goals for the future exa-scale supercomputers, because 1mm^3 (of brain) will request about 1 petabyte (1000 terabytes), so eventually about 1000 exabytes [12], [10].

In order to help the persons with disabilities, ICT-CPS is used to realize an added wireless nervous system which will compensate the disabled functions/organs by implanting appropriate signals in critical zones of the human body, on a scale and complexity highly surpassing the already old pace-maker [13].

It is obvious that, from the genome cells to the Sun and the Milky Way, we can shortly try to imagine all our life, Earth “life” and beyond.

This giant step is a reality based approach to shorter the examples list, as some prominent project where ICT-CPS have an essential role are extended that far.

After we have almost forgot the 24 satellites composing the GPS (included as device in our cars and smartphones), we assist at a spectacular project, where the solar activity (including the storms) will be watched by a new 2 satellites system measuring the solar wind at 1.5 millions km from Sun, along with an experimental system called SUNJAMMER which will fly 1 million km closer to the Sun (i.e. at „only” 0.5 million km).

For understanding the punt of a such system (ignoring the communication link!) it is useful to remember March 1989 Quebec and south New Jersey „black out” and then to imagine the necessity of the power grid protection early warning for the next solar superstorm [14].

Also on space research, the GAIA European project is going to start a vast program to explore the Milky Way and it is easy to understand that such a daring goal is based on the unprecedented performance and processing capacity of the involved ICT-CPS.

This spatial journey could not be complete if we would not mention the stage of the spatial odyssey, where the private trip in space is already an affordable service for space traveling.

Because we have just mentioned the future exa-scale supercomputers it is worth to complete the image (and the examples list) with this „flag” of ICT-CPS, as they reflect in the same time the exponential development and the unique and essential contributions to achieve revolutionary future targets like the artificial intelligence and global climate changes forecast [10], [2].

It is important to mention that these targets, along with the wiring diagram of the human brain represent the few domains where the whole World progress is not sufficient, yet, to achieve the objectives and this progress is mainly depending on the ICT-CPS by the future of exa-scale supercomputers (over 1 billion of operations per second and 10000 of cores).

On the other hand, these targets will bring huge contributions by the refined knowledge useful for solving fundamental problems of the mankind’s every day life and destiny on Earth.

We have to remember that some decades ago the supercomputers had as main goal to simulate the nuclear explosions or experiments. In our days, security domains like broking cryptographic codes remain non-civilian priority applications for supercomputers.

As a matter of fact, the significant examples could continue, but, ignoring the paper space, the above presented, in a systemic approach, have clearly - although not exhaustive - covered the objectives of this paper and allow to understand the huge dimensions of the mechanisms by which the ICT exponential development leverages the generation of the refined knowledge in IS/KBS, for the people’s well and mankind progress.

4. Conclusions

The ICT exponential development, even after a short analysis, represents a phenomenon by its huge influence on actual mankind activity, irrespective the domain where we analyze it, from industry to finances, from medicine to entertainment etc.

ICT's unique exponential speed of development and the subsequent power to innovate provides unprecedented efficacy and efficiency for all they „touch”.

As a global consequence, ICT have an the essential contribution to the evolution of the human society as IS and to the transformation of IS towards the future KBS, both being very complex processes where ICT is included as a main driving factor.

Observing that the ICT's exponential pace given by the Moore Law is very difficult to be maintained, led to the conclusion that we are at the actual and dramatic points where ***the mankind has to know exactly what is at the risk to be lost and it is better to also know the value of the things we could lose before that happens, in order to efficiently react and refine the knowledge.***

The analysis concluded that the global effect of ICT development could be expressed as a 3 dimensional process and it acts as a systemic liant for these dimensions by the knowldege involved in all human activities leveraged by ICT.

Finally, the paper analyzed the most relevant systemic examples of the ways ICT development generates refined knowledge, there resulting the huge dimensions of the mechanisms by which the ICT exponential development leverages the generation of the refined knowledge in IS/KBS, for the people's well and mankind progress on Earth and beyond.

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