

**THE INFORMATION SOCIETY TOWARDS THE KNOWLEDGE BASED
SOCIETY DRIVEN BY THE INFORMATION AND COMMUNICATIONS
TECHNOLOGIS - FROM THE INTERNET OF THINGS TO THE INTERNET
OF ...TREES
(Part 2)**

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Abstract

The paper analyzes the Internet of things (IoT) evolution, in the context of the information and communications technologies (ICT) exponential development, as the main factor of the information society (IS) transformation toward knowledge based society (KBS).

For starting the analysis of the IoT evolution a life example was taken, where, after 40 years of carrier evolution, people who benefited from a high level of knowledge, in a special class of mathematics at the high school, had also a special opportunity which also had a remarkable role in leveraging their capacity of progress/success: the connectivity provided by the teacher in the high level working atmosphere of that class. The example conclusion is that connectivity and the access to a knowledge core are the main features for IoT model and premises.

The analysis covered the definition sphere, the technological frame and the expansion consequences estimation for the IoT amazing evolution, as part of the ICT exponential development in IS/KBS. The analysis results include the evaluation of IoT, as **the most prominent wave in Internet evolution** and a global infrastructure (**network of networks**) for the information society, enabling advanced services by interconnecting practically everything by deploying „sensors” from land to water and space, from industry to home, from trees to cows and from the skin to the heart of individual. Among the IoT expansion consequences, the **IoT will provide a huge amount of data that could be turned into information and then in knowledge**.

The most complex part of the analysis led to the conclusion that only after refining information we can get new knowledge and then include it in the wisdom heritage of humankind, irrespective the application field of IoT. The refined knowledge contributes, as an added value, to the individual education as leveraging his intellectual capacity and eventually the creative potential which then is coming back to support IoT/ICT/IS/KBS development closing ... the circle. The author concludes that the analysis provided just an estimate of the visible circle, but, as we are going forward, the real circle is changing and further analysis is necessary (i.e. to be continued).

Keywords: Internet of things, communications and information technology, information society, knowledge based society, sensors networks, connectivity, industrial Internet of things, global infrastructure, cows monitoring.

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

1. A 40 years period to remember - How knowledge and connections can leverage people's progress and success

When we were writing on *Internet of ...TREES* [3] it was, of course, just a metaphor, but it was too a (first) part of a reality we are already facing.

Here we have to be more precise and specify that the reality we have mentioned is a huge evolution process, where Internet of Things (IoT) is developing with an exponential pace ... on Earth [7][8][11][13][15][17].

Without forgetting „precision”, sometimes it could be useful to consider the significance and role of metaphor in people's lives, because humankind would have not arrived to the phase of IoT if they would not had the courage to dream.

By the way, about 40 years ago somebody dreamed about connecting the people's dreams by ... **Internet**. “Vinton Cerf and Robert Kahn design TCP during 1973 and later publish it with the help of Yogen Dalal and Carl Sunshine in December of 1974 ... Most people consider these two people the inventors of the Internet” [18].

As a pure coincidence, me and other colleagues have celebrated this month (June 2015) ... 40 years since graduating (in 1975), in Calarasi, at No.2 High school, a „special class of mathematics”.

What this would have to do with IoT?

I think apparently not very much, but the point of this paper is to understand what could be, on long term, the consequences of the „little things” changing everyday around us.

It is interesting how people could generally change, over many years, with respect to many points of view.

When we have to count 40 years (i.e. averaging more than half of one long life) it is worth to see which features changed much and which less, but very relevant it would be if we would succeed to understand what and why the changes significances would be.

In a shorter form, we observed that even after a such long time, everyone of us (colleagues) is mainly the same person if we ignore much or less of the aging natural changes.

But the main observation is that, irrespective the adverse situations we all had to manage, from young engineers, economists or teachers to bussiness men, university professors or just retired, everybody succeeded to get over obstacles and reach a high or at least decent position in the actual information society (IS).

Of course we all expressed our appreciation for our former teachers, as everyone of us had a life carrier full of satisfaction and the *knowledge they gave us supported our progress and succes in life*.

More than these usual aspects, I observed something very interesting, as everyone was, more or less, beneficiary of a high level of knowledge, mainly on mathematics, due to our good professor Dumitru Petre, we all also had benefit from the „special” medium of logical, strict and consistent working atmosphere, coordinated by our teacher, every (long) day, beyond usual high school limits (including 2 years at mathematics national olympic tournaments levels).

The main consequence of that atmosphere was the creation of the **high level connections between us** (then we have met every 5 years since 1975) **and with the scientific/technical core of knowledge!**

Now just change **us** with **things** in the above sentence and we will get close to one of the definitions (main features) of tomorrow IoT!

This is also the explanation that not only the leaders of the class highly succeeded, but also others, because they benefited from that „drain”, from that connections with the class „core”!

Therefore, from this example we can now better understand which could be the role and the consequences of the IoT development, but these premises would not be precisely presented if we do not observe a dramatic difference in the comparison we suggest: the huge amount of data and the amazing speed and potential of the IoT connections.

An other fair mention is to be done, due to the crucial fact that IoT is not going to be an alternative to the people’s communications and potential, but a complex extension which will include humankind, body and „soul”, as it **IoT will have „sensors” from land to water and space , from industry to home, from trees to cows and from the skin to the heart of individual!**

Perhaps „potential” is the IoT feature where we have to first extend the analysis, as it is supposed to bring so much from a diversity of points of view.

The reality is that the IoT potential is a such huge developing sphere, as it will rapidly cover practically all the Earth, focussing of course on all humankind activity but exceeding it for reasons we have already analyzed [14], as Earth and humankind surviving are facing dramatic challenges as climate changes, resources fading or social balance.

Before enlarging the IoT sphere analysis we have to also recall the technological context, i.e. the main factor of this enlargement.

It could be surprising, but behind the IoT development, besides the information and communications technologies (ICT) prominent role, we have to observe the whole context of the information society (IS) toward knowledge based society (KBS), where ICT is the driving force but their expansion consequences must more deeply analyzed [12][14].

As a matter of fact, the evolution of IS/KBS is strongly influenced by the way ICT products and services are implementing the actual performances of ICT and on the other hand are generating premises for higher levels of performance and new technologies [10] [12].

Here we just arrived in **the complex circle of ICT development**, where, as we already have mentioned [14], refined criteria and knowledge must be identified for a stable development of IS/KBS and Earth evolution balance.

With other words, the expansion of IoT is tight linked with the exponential development of ICT in IS/KBS (including Internet), but the point is given by the amazing level of performance, complexity and dissemination of the IoT starting phase, which could determine an unpredictable chain of consequences, either *good or bad*!

It could appear that our approach is a little too pessimistic, but when something is going to flood **all around and inside us**, from body to the entire environment, it is wiser to analyze all potential implications, starting with the *good* but asking what is *the rest* and ***especially think twice about what is ... „good”!***

A more optimistic approach of the same dilemma could sound like this: lets ***deeply and slowly analyze, then realistically design all the „good” that could be too fast offered by IoT/ICT!***

2. Watching the exponentially rising wave of Internet of Things, as ... Even Cows Will Have Sensors

In order to present and analyze, obviously in a short form, the main aspects of the IoT evolution processes, eventually including its estimated consequences, it is worth to identify the IoT roots.

As it is pointed in [2], the Massachusetts Institute of Technology (MIT) initiated in 1999 a working group for networked radio frequency identification (RFID) and emerging sensing technologies, involving seven research universities located across four continents selected then to design the architecture for IoT.

As Cisco is one of the prominent architects of Internet [2], we consider, for the chronological approach, among other IoT definitions, what Cisco Internet Business Solutions Group (IBSG) expressed: *IoT is simply the point in time when more “things or objects” were connected to the Internet than people. Cisco IBSG estimates IoT was “born” sometime between 2008 and 2009.*

Remembering the essential fact that IoT is a process and considering other opinions too, IoT is developing, according with most of definitions, after 2010.

On the other hand, most of definitions [17][11] point the connecting feature of IoT, while [4] expressed: *„IoT is generally thought of as connecting things to the Internet and using that connection to provide some kind of useful remote monitoring or control of those things.*

We think that, technically, the essence of IoT is given by its connectivity, but as a functional and global effect on IS/KBS, IoT is a revolutionary new phase of Internet providing new ICT services for IS/KBS optimization.

This approach is also confirmed, at least as pointing the technological support, by [4]: *„IoT creates an intelligent, invisible network fabric that can be sensed, controlled and programmed”* and more than this [2]: *„IoT represents the next evolution of the Internet, taking a hability to gather, analyze, and **distribute data that we can turn into information and, ultimately, wisdom. In this context, IoT becomes immensely important**”.*

Sometimes, to be more expressive when speaking about the importance of ICT products and services for the IS/KBS, I show my smartphone to the students and say: here is implemented most of the humanity scientific and technical progress. In a similar approach, I was glad to see the essence of Internet in [2] as: *„the Internet is one of the most important creations in all of human history”*. Then, coming back to IoT, but on the same high level of analysis as we have mentioned in Section 1(**all around and inside us**): *„IoT will change everything—including ourselves”*.

Now while the IoT definitions and premises are more than clear, we know for sure what we are talking about!

The main point is still standing: if now we are seeing just the tip of the aisberg?

This is a very difficult question to be answered, but it is worth to try an estimate by a systemic approach.

One of the most qualified systemic and complete evaluation is made by European Union (EU) specialists [1], starting from identifying and classifying the main IoT development resources as:

Enabling technologies for the Internet of Things, such as sensor networks, RFID, M2M (machine to machine), mobile Internet, semantic data integration, semantic search, IPv6, etc. are considered in [5] and can be grouped into three categories: (i) technologies that enable “things” to acquire contextual information, (ii) technologies that enable “things” to process contextual information and (iii) technologies to improve security and privacy. The first two categories can jointly be understood as functional building blocks of required building “intelligence” into “things”, which are indeed the features that differentiate the IoT from the usual Internet. The third category is not a functional but rather de facto requirement, without which the penetration of the IoT would be severely reduced.

Recalling the conclusion from the Section 1 and integrating the above 3 main groups of technologies, *it is essential to add the connectivity technologies enabling the forwarding of the acquired data mainly to or through Internet, but not exclusively, finally IoT being a **network of networks**.*

The next step in estimating the IoT is identifying a standardization and technical frame, as the International Telecommunications Union (ITU) is qualified to provide [1], *“considering the wide background and required technologies, from sensing device, communication subsystem, data aggregation and pre-processing to the object instantiation and finally service provision”*. ITU-T Study Group 13, which leads the work of the ITU on standards for next generation networks (NGN) and future networks, formulated the following frame for IoT [6]: *“IoT: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.*

This way we just arrived to the technical dimension of the “airbag” and the confirmation of our above role of IoT in IS/KBS processes - a global infrastructure for the information society (**network of networks**).

How much this infrastructure could be developed as applications area is another difficult question, but this time, surprisingly, we have got an easier job because, as a traveler on top of Everest, any way we choose will get us at a lower energy potential, but not necessarily safer!

This is true in our case too, because we theoretically could deploy IoT at a global scale anywhere, but it is not sure that this approach will provide safe (mature) solutions in every concrete application, unless we ... ***deeply and slowly analyze, then realistically design all the „good” that could be too fast offered by IoT/ITC*** - as above mentioned!

In a simpler expression, from this step further, every new IoT application (category) is limited only by human imagination ... but not exclusively!

Thereby, we have to implement IoT whenever and wherever it is necessary and effective, carefully taking into account the corresponding criteria.

It is obvious that selecting criteria is entering in a relative area, but there is something that we clearly must recall. As IoT is a “global” infrastructure, it is mandatory to develop every of its steps using *global level criteria* of selection, meaning not only group interest/profit criteria, but IS/KBS refined knowledge and strategy criteria.

Coming back to concrete applications fields, there is a large agreement [2][4][6][7][8] that these include environment, cities, buildings, vehicles, clothing, human body (health or other purposes), food, plants, animals, portable devices and other objects that could associate

more and more information with them, but could also have the ability to sense, communicate, network and produce **new information**.

Speaking of animals, perhaps an example will spread a possible doubt, as there IoT will be a usual application [2]:

In the world of IoT, even cows will be connected. A special report in The Economist titled “Augmented Business” described how cows will be monitored. Sparked, a Dutch start-up company, implants sensors in the ears of cattle. This allows farmers to monitor cows’ health and track their movements, ensuring a healthier, more plentiful supply of meat for people to consume. On average, each cow generates about 200 megabytes of information a year.

It is no doubt that one of the most dramatic influences will be produced by IoT in the industrial field of applications, considering the industry global importance for IS/KBS.

This opinion is confirmed by the prestigious Davos Forum, where World Economic Forum’s IT Governors agreed that [9]:

“Industrial Internet (of Things), this latest wave of technological change will bring unprecedented opportunities, along with new risks, to business and society. It will combine the global reach of the Internet with a new ability to directly control the physical world, including the machines, factories and infrastructure that define the modern landscape. However, like the Internet was in the late 1990s, the Industrial Internet is currently in its early stages. Many important questions remain, including how it will impact existing industries, value chains, business models and workforces, and what actions business and government leaders need to take now to ensure long-term success”.

The above text clearly express both “good and bad” of IoT from industry point of view, where its impact will probably be the strongest, by material and financial criteria (but not exclusively, by our opinion).

As a bright side, we have to mention that, in this case, as we also consider fair, some proposals for solving the dilemma are added:

“All stakeholders need to work together in three important areas. Industries, governments and academia need to collaborate on long-term R&D to solve fundamental technology challenges related to security, interoperability and management of systemic risks. They need to conduct joint lighthouse projects to demonstrate the real benefits and raise the profile of the Industrial Internet among the general public”.

We also consider [16] [14] that this is the way for the general approach of such complex processes associated with the ICT exponential development, in order to optimize IS/KBS evolution.

That is the way our actual paper is oriented too, as step by step we have arrived to the last, but most important phase of the IoT development analysis, aiming the “global” meaning of the above mentioned “**new information**”.

Here it is also the adequate level where we can detail the analysis of the **complex circle of ICT development** we have pointed in the first section of the paper.

Although we have already approached this difficult analysis [12], the new context of IoT is rising new challenges by the data deluge it will generate at planetary scale.

The essence of this approach is how to best manage the huge amount of data IoT will provide and use the results in order to control both vertical and horizontal development of IoT applications.

Naturally, from above we step to the next difficult question: what means “best manage”?

Now we have to face the most difficult part of the “circle” and deeper analyze the logical segment from the resulted data to ICT/IS/KBS development.

Starting from the above [4] evaluation (**data that we can turn into information and, ultimately, wisdom. In this context, IoT becomes immensely important**) and recalling our previous analysis [10][12], it is important to observe and add that only after refining information we can get **new knowledge** and then include it in the wisdom heritage of humankind, irrespective the application field.

Perhaps the most subtle phase of these complex processes, where the IS/KBS really get a huge progress, is the benefit that refined knowledge contributes with, as an added value, to the individual education while leveraging his intellectual capacity and eventually the creative potential which then is coming back to support IoT/ICT/IS/KBS development closing ... **the circle!**

Before closing the (actual) analysis, we have to fairly recognize that we were touching just an estimate of the visible **circle**, but, as a Morgana illusion, as we are going forward, **the real circle is changing and further analysis is necessary (to be continued)!**

Thinking at **changing circles**, we have to re-think for future IoT what will mean, at the optimization criteria level, for example, the **new energy and carbon dioxide circle** or the **privacy-security circle**, when we will have to manage over 50 billion **Internet** connections/devices just in 2025! These are issues which need of course other analysis.

3. Conclusions

In order to analyze the IoT evolution we have started from a life example, where, after 40 years of carrier evolution, people who benefited from a high level of knowledge (in special class of mathematics at the high school) had also a special opportunity which also had a remarkable role in leveraging their capacity of progress/success: the connectivity provided by the teacher in the high level working atmosphere of that class.

The conclusion was that connectivity and the access to a knowledge core are the main features for IoT model and premises.

The paper analyzed the definition sphere, the technological frame and the expansion consequences estimation for the IoT amazing evolution, as part of the ICT exponential development in IS/KBS.

The analysis results include the evaluation of IoT, as the *most prominent wave in Internet evolution* and a global infrastructure (**network of networks**) for the information society, enabling advanced services by interconnecting practically everything by deploying „sensors” from land to water and space, from industry to home, from trees to cows and from the skin to the heart of individual.

Regarding the IoT expansion consequences, the *IoT will provide a huge amount of data that we can turn into information and then in knowledge.*

The most complex part of the analysis led to the conclusion that only after refining information we can get **new knowledge** and then include it in the wisdom heritage of humankind, irrespective the application field of IoT.

More than this, the refined knowledge contributes, as an added value to the individual education while leveraging his intellectual capacity and eventually the creative potential which then is coming back to support IoT/ICT/IS/KBS development closing ... **the circle!**

In the same time, the analysis provided just an estimate of the visible **circle**, but, as we are going forward, **the real circle is changing and further analysis is necessary (to be continued)!**

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