

The Information Society Towards the Knowledge Based Society Driven by the Information and Communications Technologies - From the Internet of Things to the Internet of ...Trees (Part 1)

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Abstract

The paper approaches an emergent field of the information and communications technologies (ICT), the Internet of things (IoT). ICT development optimization, as the driving force of the information society (IS) toward knowledge based society (KBS), due to IoT expansion consequences, is analyzed.

The paper analyses are focused on the emergence and challenges of the Internet of Things. Consequently, IoT is associated with the Internet World, in fact our today World, where everything is going to be connected with everything, by the information flood, IoT being a combination of practically infinite informational (usually wireless) links and things (from books to cars, from electrical appliances to food).

This paper estimation is confirmed and detailed through further definitions and analyses, based on references as EU and ITU reports, as a natural approach of the emergence and challenges of the Internet of Things.

Paper analyses also presents the implications of the ever-changing issues of IS/KBS, which have to be analyzed, but more exactly continuously re-considered, on an updated/ regularly basis and with adequate instruments, criteria and resources. This way the paper shows that, the real complications, a „challenge” for the necessary new models and algorithms, come in the complex phases of processing data to extract information and then analyze information to refine knowledge finally used to take ... decisions at ... Earth scale!

Starting from a Harvard University pilot project of tracking the global warming consequences on university green (trees) ecosystem by a local area network of sensors, the paper proposes to further analyze what should we must do in order to extend and generalize the pilot objectives to IS/KBS at Earth scale, but more than this, to identify which would be the equivalent of trees, then forest and then ... Internet!

The paper main conclusion is that the solution of the above challenges could be given by considering the fundamental issues of refining knowledge, i.e. to dynamically analyze (on a check and act basis) all the data, in the data deluge of ICT/IoT, but such an approach will not efficiently work, because too much data will block our control systems of decisions, unless adequate criteria for systemic analyze and knowledge refining will be identified.

Keywords: *Internet of things, communications and information technology, information society, knowledge based society, radio frequency identification, smart city.*

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

1. An introduction to the Emergence and Challenges of the Internet of Things

The information and communications technologies (ICT) development optimization is the driving force of the information society (IS) way toward knowledge based society (KBS) [3], as the most complex process of humankind evolution on Earth.

Perhaps any actual approach of the information and communications technologies is inherently not only incomplete but especially an act of courage or volunteer jump in ... the “Ocean” of ever-changing *things*!

Although we assume the risk of relativity, it must be added that the above picture would be really incomplete without including the **living things**! Here the **humankind** is first considered, but far of being the only, as we will later observe (among *trees*, butterflies and so on).

The image of *that Ocean* could be, in a way, associated with the Internet World, in fact **our today World**, where *everything* is going to be connected with *everything*, by the information flood.

Now we have just arrived very close to the **Internet of Things** (IoT), but *before* approaching a kind of definition of the IoT, we must observe, from the beginning, the huge dimension and complexity of the IoT context (*that Ocean*), given especially by the practically infinite *informational links* and *things*.

As we already presented [5], one of the less obvious aspects of ICT impact on IS/KBS, but with enormous importance, is generated, in addition to ICT products and services, by the transformation processes induced in our everyday life, here including education, refining knowledge and creative potential of humankind.

In order to be fair, we have considered here *only the positive transformations*, as the *negative aspects* [7], like global warming or Earth resources fading, would be later approached.

These “soft” sophisticated processes are generating the most difficult to define and control *informational links* we have above mentioned, as complex premises of ICT development optimization - the driving force of the evolution of IS toward KBS.

One of the most relevant approaches of IoT/ICT context and definitions is presented in the frame of the European Union (EU) by a milestone document [1]:

„The growth of the Internet is an ongoing process: only twenty-five years ago it was connecting about a thousand hosts and has grown ever since to link billions people through computers and mobile devices. One major next step in this development is to progressively evolve from a network of interconnected computers to a network of interconnected objects, from books to cars, from electrical appliances to food, and thus create an ‘Internet of things’ (IoT)”

As we have above mentioned, IoT is a complex concept expressing a growing and huge reality: **our connected World**.

Starting with the EU document [1], our personal estimation will be confirmed and detailed through further definitions and analyses, as a natural approach of the **emergence and challenges of the Internet of Things**.

More than this, we have to mention here that our paper approach is assumed from the beginning to be *only an introduction (to be further continued)*, as we have just remarked the huge context and complexity of the issue (IoT).

Analyzing the above EU document, in order to evaluate the dimension of IoT „phenomenon”, we must observe the astonishing expression which (partially) presents the

domains which could be covered by IoT: *from books to cars, from electrical appliances to food.*

Far from starting a detailed (text) analysis or exhaustive references presentation, we consider very relevant to add here that one of the *industrial* applications of IoT for food includes the tracking of food processing, in order to control the time, identity, quality or other information/parameter which could be associated to food in a diversity of process phases.

To be more concrete we recall that one of the first applications of barcode system was (and still is) referring to the food products, among other.

On the other hand, we have to mention that the main reason we considered [1] as most relevant exceeds the government/political implications of Commission of the European Communities, but is given by the fact that, for the (*new*) term of IoT, [1], considering IoT ***the umbrella for a new paradigm***, is referring to the most prestigious international organization in the field: ITU.

This way, the concept of IoT is presented by the ITU 2005 Report (*Internet of Things*) [2] as:

„Today, developments are rapidly under way to take this phenomenon an important step further, by embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves.

*A new dimension has been added to the world of information and communication technologies (ICTs): **from anytime, any place** connectivity for **anyone**, we will now have connectivity for **anything***

Connections will multiply and create an entirely new dynamic network of networks – an Internet of Things.

The Internet of Things is neither science fiction nor industry hype, but is based on solid technological advances and visions of network ubiquity that are zealously being realized”.

Although this ITU description of IoT is very comprehensive and precise, it is difficult to not add any comment, at least observing the „negative mirroring” definition: *The Internet of Things is neither science fiction nor industry hype, but is based on solid technological advances and visions of network ubiquity.*

After such *image* ITU presented, we consider the IoT is not only clearly defined but, most important, it is precisely defined as time, space and consequences, i.e. in the context of ICT, humankind (IS/KBS) and ... Earth.

The fact that ITU gave an impressive definition of IoT does not mean that any other further approach/definition would be redundant, especially taking into account the amazing pace of ICT development but also the necessity, generated just by this evolution, to find new models/concepts to optimize it.

We recently recalled our 30 years ago estimation [9] on Earth data resolution humankind, by ICT, could get: „to know every cm³ of Earth” (on land or water, in air or underwater), including non-military purposes.

Now we have to observe that the time is to have, by IoT, a new perspective on the same issue, as [6] expressed it:

*„Nowadays, we are witnessing formation of a new technological marvel: Internet of Things. This construction is able to combine in a particular operational entity **all the bits and pieces of the world around us**. Thus, **why could not this unique establishment present the long-sought essence in the Nature of Things ?**”*

Similarly, it is worth to observe, as [6] impressing IoT image combined so wonderful what we have above mentioned, as elementary parts of Our World, „infinite *informational links and things*”.

We also have to remark, in the above mentioned progressive detailing of **emergence and challenges of the Internet of Things**, the interesting proposal of [6] referring to the **long-sought essence in the Nature of Things**, which opens by our opinion, an *information vision on Univers* or at least on the *ICT impact on Earth*.

Apparently contradictory, the impact of ICT and their products tends to be given by elements which are less and less „visible”, but *not only* because of the products miniaturization.

In order to observe the intimate and relevant ways of the IoT **emergence**, let's come back to ITU report [2]:

„Over a decade ago [our note: in 1995] the late Mark Weiser developed a seminal vision of future technological ubiquity – one in which the increasing “availability” of processing power would be accompanied by its decreasing “visibility”.

As he observed, “the most profound technologies are those that disappear...they weave themselves into the fabric of everyday life until they are indistinguishable from it”.

Early forms of ubiquitous information and communication networks are evident in the widespread use of mobile phones: the number of mobile phones worldwide surpassed 2 billion in mid-2005. These little gadgets have become an integral and intimate part of everyday life for many millions of people, even more so than the internet”.

Coming back in our days, it is obvious and dramatic how IoT evolution exceeds any imagination, as in 2013 forecast studies [10] estimated that, from about 10 billion of devices connected to Internet, in 2020 their number could rise to about 30 billion.

Now most of the forecasts predict for 2020 more than 50 billion devices in IoT, but it is easy to understand that all these figures would be soon re-considered.

All these estimations do not mean much, but the real significance comes from the speed they change and we may observe that IoT have all the chances to be a „phenomenon” much impressing that the „usual” ICT Moore Law. One could ask „How that?”, because Moore Law lays behind ICT/IoT.

Again we have to recall that the IoT complexity and dimension come from „infinite informational links and things”, but the point is on links, because in a complex system, for a given number of nodes, the number of links could exponentially encrease.

It is the case of IoT, where connections come from thing-thing, thing-human and service-service, thus their number are unpredictable and same the number of things is.

Keeping in mind the above mention, that any ICT approach is only partial, for IoT emergency the situation is similar, but a relevant image of their evolution is given in [4] as:

„Whereas in the first run Internet of Things referred to the advent of barcodes and Radio-frequency identification (FID), helping to automate inventory, tracking and basic identification, the second current wave of IoT sees a strong verve for connecting sensors, objects, devices, data and applications.

The next wave could be called a “cognitive IoT”, facilitating object and data reuse across application domains, leveraging on hyper-connectivity, interoperability solutions and semantic enriched information distribution, incorporating intelligence at different levels, in the objects, devices, network(s), systems and in the applications for evidence-based decision making and priority setting.

Economically , it could generate billions of Euros that easily translate into growth and employment, provided it ensures trust and security for the European citizens and businesses. At the same time, the IoT will bring hyper-connectivity to a global society, using augmented and rich interfaces. This global society will also be characterised by higher semi-autonomous system behaviour than today”.

We have finally chose this description especially because, in addition to the perspective of “*cognitive IoT*”, it brings the premises of some of **IoT challenges**, as „*global society will also be characterised by higher semi-autonomous system behaviour than today*”.

This way, even in a short (**introduction**) form, we have to approach some of the IoT today visible **challenges**.

From the beginning we have to admit, this time very sure, that in ICT and also in IoT, today only some (visible) challenges could be considred. In a simpler manner ICT/IoT development is such a complex and huge combination of processes at Earth scale, as it is nearly impossible to forecast all their consequences.

Perhaps the most important here, as we already have estimated [7], is to notice that the consequences are either **positive and negative** for the humankind/Earth, but the point is that some times **it is very difficult to separe them!**

Anyway, in this paper space we have to consider the largest agreed opinion, i.e. **the positive consequences are prevailing**.

It is natural to consider that one of the main challenges for the IoT development is represented by the espetations to be covered at systemic level.

Again we consider EU Digital Agenda for a relevant reference, where these main espetations fields are expressed [4] as:

„Smart cities are an obvious application of IoT as a horizontal enabler, covering sustainable smart grids, smart mobility and smart health.

Advances in integration and miniaturisation of ultra-low power components and micro systems and increased autonomy and flexibility of service robots is accelerating the diffusion of embedded ICT in all types of physical objects and artefacts ranging from clothes and even bodies to homes, cars and transport systems, as well as all public spaces and cities.”

After a systemic image of the „horizontal” image of IoT, we can observe a comprehensive palette of the developing domains for IoT in IS/KBS: *all types of physical objects and artefacts ranging from clothes and even bodies to homes, cars and transport systems, as well as all public spaces and cities.*

With other words, IoT applications and presence will cover all humankind activity fields, but some of them will be more prominent, as smart cities, smart robots, smart energy grids, smart mobility, smart health, industrial or commercial smart devices and services etc.

Still, it is more than obvious the fact that even at the actual level of development /disemination of ICT/IoT it will be very difficult to cover all „*all types of physical objects and artefacts*” **anytime and anywhere**.

The difficulties of IoT development are increasing if we consider only some other **challenges which are not independent** of the above presented.

We already mentioned [5] [7] that generally the ICT development, especially as amazing pace, could bring negative consequences too.

An old military rule says that *any communication could lead to information leakage*, so what should we expect when *all types of physical objects and artefacts* will be implied in a diversity of data (wireless) exchanges?

The question is much more than it seems to be, because, along with the ethical and legal implications, we have to consider many other connected issues as the data deluge/exa data [5], the spectrum limits, the electromagnetic compatibility etc.

There are also other main challenges for IoT, as the health, commercial, environment, energy or information management consequences associated with the IoT products and services.

Perhaps an relevant example could express the huge volume of challenges/ consequences we have just suggested.

Lets imagine what consequences will have the proliferation of IoT in the emergent area of drones and robots, from the point of view of legal conformity, physical security, personal data/intimacy, social/ethical issues, identity/recognition inventory, environment protection, education, labour market, transportation or ... data deluge! All these diverse and complex issues and much more need to be further and detailed analyzed, taking into account the larger context of IS/KBS.

2. IS/KBS - like a long road where ... we have to watch the *forest ... by the trees*

Apparently, the above analysis of IoT did not pointed much of their influence on IS road to KBS, but we have to recall that the ICT products and services evolution lately showed that *the increasing "availability" of processing power would be accompanied by its decreasing "visibility"*.

In a simpler expression, we have to observe that, in fact „that influence” became so much ubiquitous over Earth and humankind life, as we would hardly observe their „flood”, in „that Ocean” we have suggested at the beginning.

This impression does not have to „slow” our watching over ICT development and its huge consequences on IS complex transformations toward KBS.

The watch we suggest is more and more necessary as ICT/IoT consequences, either positive and negatives, are flooding us every day, but the real dangers comes from the exponential pace of ICT development.

We have already mentioned [7] the main risks of that exponential pace of ICT, first including the fact that their consequences are so complex and at large scale on Earth, that people really could not have the time and resources to properly react to them.

That is why we consider that facing this new major „challenge” of ICT, we call now IoT, is an even more difficult job we have to do.

On the road of IS to KBS the main issue is the evolution of knowledge and especially the way we will succeed to refine this knowledge in the optimization complex and complicate process, taking into account the corresponding criteria – which in their turn are ... dynamically changing as a consequences of ICT evolutions!

The future context will be progressively complicated by the „data deluge”, where IoT will contribute more and more by their „infinite” number of sensors, spread from human body to the tip of mountains or deep „Ocean”.

The real complications, a „challenge” for the necessary new models and algorithms, come in the complex phases of processing data to extract information and then analyze information to refine knowledge finally used to take ... decisions at ... Earth scale!

Having all this in mind we consider that „the Internet of trees” [8] is only a very inspired metaphor we can further develop.

In order to understand the confirmed importance of a such „preoccupation”, we recall the above presented EU point of view [4] as: „... *the IoT will bring hyper-connectivity to a global society, using augmented and rich interfaces. This global society will also be characterised by **higher semi-autonomous system behaviour than today***”.

What should we expect from a global society with **higher semi-autonomous system behaviour than today**? **How to manage/control such an IS/KBS development in a efficacious and efficient manner?**

By our opinion this will bring a lot of challenges, part of them shortly suggested above, but „globally” it is clear that we have to carefully watch that „behaviour”, more than we do today, if we want to avoid „unexpected” consequences.

This way we have just arrived to the point where, starting from the Harvard pilot project [8] of tracking the global warming consequences on university green (**trees**) ecosystem by a local area network (LAN) of sensors, we have to further imagine what should we must do in order to extend and **generalize** their objectives to IS/KBS at Earth scale, but more than this, to identify which would be the equivalent of **trees**, then **forest** and then ... **Internet!**

Our opinion is that generalizing is only a first approximation, as in fact we have to come back to same fundamental issues of refining knowledge, i.e. to dynamically analyze (on a check and act basis) all the data (in the data deluge).

It is obvious that such an approach will not efficiently work, because too much data will block our control systems of decisions unless adequate criteria for systemic analyze and knowledge refining will be identified.

With other words this means to carefully identify our World **trees/priorities**, keeping in mind our unique Earth ecosystem, where humankind life, for the next generations too, must be the main concern.

Carefully watch the corresponding **forest** could mean to wisely choose our future models, for humankind and especially IS/KBS, taking into account the actual Earth resources, trends and status.

Last but not least, **watching the forest without losing it because of trees** could mean that all our analyses must consider the present but not neglecting the long term future, as we already face some consequences of global warming, Earth resources fading or social movements.

The sad part is that all those complex analyses need more and more time, as the global society (IS/KBS) becomes more complex, but with an increasing speed – given by the ICT/IoT pace!

That is why these ever-changing issues of IS/KBS have to be further analyzed, but more exactly continuously re-considered, on an updated/regularly basis and with adequate instruments, criteria and resources.

3. Conclusions

Analyzing IoT we have realized and pointed their impressive development in the global context of ICT exponential pace – as a driving factor of IS evolution toward KBS.

IoT applications and presence will cover all humankind activity fields, but some of them will be more prominent, as smart cities, smart robots, smart energy grids, smart mobility, smart health, industrial or commercial smart devices and services etc.

The complexity of IoT expanding, *in every bit and peace on Earth*, could generate, along with the obvious benefic consequences for humankind and IS/KBS, some important challenges for IoT.

Some challenges will be at the technical level, as by the development/disemination of ICT/IoT it will be very difficult to cover all „*all types of physical objects and artefacts*” **anytime and anywhere**.

The main challenges for IoT will still arise in the areas of their applications, as the health, commercial, environment, energy or information management consequences associated with the IoT products and services.

Observing the IoT perspective [4] to *bring hyper-connectivity to a global society, as this global society could be characterised by higher semi-autonomous system behaviour than today*, **the paper analyzed the ways to manage/control such an IS/KBS development in a efficacious and efficient manner.**

The paper proposed solution would be, as a first approximation, to come back to same fundamental issues of refining knowledge, i.e. to dynamically analyze (on a check and act basis) all the data, in the data deluge of ICT/IoT, but such an approach will not efficiently work, because too much data will block our control systems of decisions, unless adequate criteria for systemic analyze and knowledge refining will be identified.

An other conclusion is that all those complex analyses on IoT need more and more time, as the global society (IS/KBS) becomes more complex, but with an increasing speed – given by the ICT/IoT pace. That is why these ever-changing issues of IS/KBS have to be further analyzed, but more exactly continuously re-considered, on an updated/regularly basis and with adequate instruments, criteria and resources.

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