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 3)

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Abstract

The paper approaches the premises, applications, technologies and the main requirements of an emergent field of the information and communications technologies (ICT), the Internet of things (IoT), as an extension of the people's need to communicate, which will bring, of course, a lot of data and unprecedented opportunities to improve life in the information society (IS) toward knowledge based society (KBS) context. The paper analysis shows that the main role of IoT is to collect data/information from life and environmental experience, helping people to optimize all Earth processes and finally add new value for a better and longer life for actual and next generations. One of the benefits of such a way to develop IoT is the „outcome economy", like an expression of the intermediate steps to optimize IS/KBS, as the products and services (at most from ICT but not exclusively) will be designed and implemented to provide specific (costumized) results. The paper identifies two main categories of IoT applications, one (A) being focused on collecting and processing data concerning the operation/existence of a „thing"/device in order to optimize that thing/device operation/existence („things" could include industrial machines, home appliances, cars, toys, animals or ... trees). The second category (B) is focussed on individual/human body, in order to collect personal data useful for that person (generally for health, but not exclusively) or for entities interested in person's behaviour. Both categories of IoT applications are further analyzed with relevant examples and revealing their main implications.

The second section of the paper analyzes the means to develop IoT on a rational base,
showing that communications, as main part of ICT, must provide the „smart" support for developing IoT and generally optimize not only the „things" existence/operation, but the IoT as „network of networks" too. An important issue on developing such IoT complex systems is that it supposes a set of requirements to be accomplished, in order to reach the optimizations goals with efficiency on long term. The main requirement is an infrastructure to connect the World IoT devices, including broadband (high speed) communications support (wireless, optical fiber, satellite, cable), optimized to the application specific traffic. Other analyzed requirements include IPv6 necessary addresses and new technologies for the energy (electric power) support. Predictive analytics will be in fact one of the main features of future IoT, intended to support optimization and added value, as generally it is not a problem to make software, but it is a huge challenge to make new performant algorithms for the optimization of the complex processes in IS/KBS. Including privacy, confidentiality and the intellectual property issues, the security requirements for IoT will be prominent and very difficult to comply, due to the complexity of interoperability conditions in a planetary network of networks. For implementing performant and complex IoT applications, the main ICT features which are required include: sensing and data collection capability; layers of local embedded processing capability;wired and/or wireless communication capability;

software to automate tasks and enable new classes of services; remote network/cloud-based embedded processing capability; full security across all data and signal path.
The paper main conclusion is that, in spite of the amazing performance of the automation/optimization processes implemented by „machines”, the risk of altering the human principles and values, by hazard or design errors, will increase and **deep analyses and research must be further performed in order to assure a consistent and secure development of IoT applications for optimizing IS/KBS on long term.**

Keywords: Internet of Things, communications and information technology, information society, knowledge based society, sensing technologies, outcome economy, nanogenerator, predictive analytics.

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

1. IoT extends communication as a core of humankind evolution and better life

Starting from „We Evolve Because We Communicate”[4], we might go further, observing that, in fact, any segment of species evolution (including humankind) is essentially a communication of the genetic „message”.

Practically, the genetic message will consist of the „parent” message but it will include the acquired genetic information, i.e. the modifications determined by life and environmental experience.

Now we can observe, from the fundamental similarity between the general case of species evolution and the actual humankind evolution, the amazing role of Internet of Things (IoT) as a medium for *collecting data/information from life and environmental experience*, **beyound the (very large) limits of usual communications of individuals.**

The significance of this role could be also expressed by the Cisco definition [4] of IoT: „*IoT is simply the point in time when more “things or objects” were connected to the Internet than people*”.

In fact this definition shows us that IoT is an extension of the people’s need to communicate, which will bring, of course, a lot of data and unprecedented opportunities to improve life and eventually the humankind genetic message itself. This essential necessity is obvious, considering IoT as critical for human progression[4]:

„*As the planet’s population continues to increase, it becomes even more important for people to become stewards of the earth and its resources*”.

The potential of IoT is already expressed [1][2][3][14][5][9][10][20] and its development is driven by a huge range of applications, but on the other hand is depending on the way the benefits and the risks will be controlled by appropriate technologies and management/politics.

In order to first evaluate the applications/benefits range, we have to identify the main fields/categories of applications which will influence the humankind evolution and better life.

Unfortunately it is not an easy job to analyze this influence, first because there is no common opinion about the „evolution” and even about „better life” there is more to discuss.

Here we have to recall the main challenges of the information and communications technologies (ICT) prominent role in the development of the information society (IS) toward knowledge based society (KBS)[17].

As a consequence, the faster and higher is the ICT development, the harder is the decision on what is positive or negative in the ICT influence on IS/KBS. To be more precise, the above „higher” includes, as an iceberg, a huge amount of influence on Earth, with vertical and horizontal extentions, in all humankind activity fields, in all life on Earth issues, in all environment resources and features.

Although one could consider „too much" the effect of ICT on „all", there are many studies [1][2][3][18][7][12] that provide amazing figures for these global extentions and effects (only for IoT - estimated benefits of USD trillions order in 2025), but it is worth to emphase that this is only what we can quantify as the visible part of iceberg.

When we above have mentioned genetic message evolution, or even part of „better life", we refered to the qualitative aspects, including life quality, intelectual capacity/creative potential and eventually the behaviour profile of humankind – versus ***the changes in the Earth environment support for life on long term***!

Speaking (so generally) about intelectual capacity and behaviour profile, perhaps a very relevant and surprising example is that people will have to learn, as a natural skill, to use everyday (after sophisticated smartphones) new *augmented-reality technology* devices.

All this context must be carefully considered, as *IoT expansion will cover everything on Earth and ... more* [5].

With other words, our analysis started by evaluating the complex and dynamic context where and how this extension is happening, in order to have a rational approach of the applications range, extent and features, with the purpose to avoid a possible unconscionable exponential development and consequences, as ICT and generally industry sometimes produced [17] – climate changes being the most relevant and simple example.

Speaking of industry, anyway we have to point that, as was the case of all prominent technologies, most of IoT applications investments, benefits and consequences will be linked with industry.

That is why the most detailed and documented studies on IoT perspectives are focused on industry, although it is very difficult to cover all connections and implications of industry on all other humankind activity fields, including health, education and environment [1][2].

As a matter of fact, the industry has a trend in this direction, to offer not only products and services, but outcomes for customers, either organizations and individuals, so we will assist to a „***convergence on the outcome economy***" [12].

Our opinion is that such huge „project" (IoT at World scale) must be developed by a systemic approach and the first essential issue is of course: ***what we mainly expect from IoT on long term*?**

The answer will consider the practical fact that initially IoT applications will cover the natural extensions involving the existing devices connected to Internet, but step by step more devices will be connected, not necessary to Internet but in networks that will be eventually connected to Internet, as by some definitions ***IoT is a „network of networks***".

Now we have just arrived to the context we have mentioned above and this way it easy to conclude that IoT systemic purpose is to *collect data/information from life and environmental experience*, i.e. to help humankind to ***optimize all Earth processes and finally add new value for a better and longer life for actual and next generations***!

This way we can observe that the ***IoT applications range is practically unlimited, with the above condition: to be part of an optimization process at planetary scale of IS/KBS***.

Because we have already approched the complex problem of ICT prominent role for IS/KBS optimization [13][15][19], now we may agree and point that any optimization sub-system (sub-criteria) have to be step by step integrated in a huge planetary optimization system/process that is IS/KBS itself, ***following with strictenes a check-act-balance strategy***.

Of course, it is difficult to imagine a such huge optimization process, but practically it will be built, initially, simply by adopting some common goals, rules and standards when implementing IoT applications.

For example, the main rule is to **obtain added value** by processing the collected data, for goals like energy (power, fuel etc.) consumption reduction, health improvement and almost always ... money/resources savings.

In order to ***obtain added value***, IoT devices/applications must be „smart", this way providing the specific difference versus existent electrical/automation devices.

Without entering in technological details (as it will be presented in the paper next section), *for being smart a device must have a processing unit and communications features* to provide internal/external soft/data use for optimization processes.

The aim of „outcome economy", like an expression of the intermediate steps to optimize IS/KBS, as the products and services, at most from ICT but not exclusively, will be designed and implemented to provide specific (costumized) results.

After analyzing the context and rules for developing IoT huge number of applications, we can better approach/identify the main categories of applications, starting from a simple obervation.

It is obvious that most of possible IoT applications (A) are focused on collecting and processing data concerning the operation/existence of a „thing"/device in order to optimize that thing/device operation/existence. Such „things" could include industrial machines, home appliances, cars, toys, animals or ... trees[3][18].

An other category (B) is focussed on individual/human body, in order to collect personal data useful for that person (generally for health, but not exclusively) or for entities interested in person's behaviour.

Of course, these two categories (A;B) do not cover all possible scenarios and are not totally independent (orthogonal), but similar classificatios are confirmed [8].

For example, this way we agree (with formal regret) that „cow"[4][21] is a „thing" and people's blood pressure monitoring is in the same category with the monitoring of person's behaviour refering to the shops she/he is often visiting.

With other words B is human-centric and A is „non-human"-centric, although, for example, when we collect data about electric power home consumption we indirectly reflect people's behaviour, but the application focus is oriented to optimize the cost/resources.

An other practical and important observation is that B applications are generally more complex and such applications will have initially a reduced pace but an explosive development on long term, as commercial and social applications/entities, based mainly on soft defined infrastructures, will be wide-spread in IS/KBS. On the other hand, B applications development will have complex challenges regarding legislation, privacy and security.

A similar classification could be done as a function of user [3]: IoT for individual; IoT for community (group of citizens); IoT for entreprise.

The above premises explain the amazing development of IoT (mainly A type) and the diversity of applications areas, which could be aproximatelly detailed in some main fields, as it is often expressed [3][1][2][6][11][16][8].

Table 1. „A" IoT applications fields

Field/areas	Field/areas
Industry M2M Applications Indoor Air Quality Temperature Monitoring Ozone Presence Indoor Location (ZigBee;UWB;RFID;NFC) Vehicle alarm/diagnosis	***Retail*** Supply Chain Control NFC Payment (for public transport, gyms, theme parks etc.) Smart Product Management in Warehouses
Energy Smart Grid Smart Grid Tank level Photovoltaic Installations	***Logistics*** Quality of Shipment/Container Conditions (vibrations, strokes, temperature etc.) Item Location

Water Flow Silos Stock Calculation	Storage Incompatibility Detection Fleet Tracking
Agriculture Wine/Soil Quality Enhancing Green Houses (micro-climate conditions) Selective irrigation in dry zones Meteorological/Forecast Station Network Compost (Control of humidity and temperature levels) Animal Farming Offspring Care Animal Tracking Toxic Gas Levels	***Vehicles including cars/trucks/ ships/ aircraft/ trains*** Condition based maintenance Usage-based design Pre-sales analytics ***Mining, oil and gas, construction*** Operating efficiencies Predictive maintenance Health and safety
Community Smart Parking Structural health of constructions Noise Urban Maps Traffic Congestion Smart Lighting Waste Management Intelligent Transportation Systems	***Environment*** Forest Fire Detection Air Pollution Landslide and Avalanche Prevention Earthquake Early Detection ***Water*** Water Quality Water Leakages River Floods
Security Perimeter Access Control Liquid Presence Radiation Levels Explosive and Hazardous Gases	***Home*** Energy and Water Use Remote Control Appliances Intrusion Detection Systems Art and Goods Preservation

Table 2. „B" IoT applications fields

Field/areas	Field/areas
eHealth Person Fall Detection Patients Surveillance Ultraviolet Radiation Medical Freezers conditions Sportsmen Care	***People's behaviour*** Smart and Customized Commerce/ Services/ Entertainment *Social management*

Obviously, Table 1 and Table 2 are far from being complete and on the other hand every area/field could be detailed and surely new technologies will be added to ZigBee, UWB(Ultra Wide Band), RFID(RF Identification), NFC(Near Field Communications) and GPS, as mobile communications 4G and even future 5G are planned to be implied in IoT long term development.

Further we have to shortly analyze some premises, design rules and technologies useful to implement the above IoT development/applications.

2. Using information and communications new technologies to develop IoT, for optimizing complex processes of IS/KBS

From the first section we already have some contextual elements to further see which are the means to develop IoT on a rational base, having in mind the essential conditions we have just mentioned ***to be part of an optimization process*** and ***lead to added value*** in IS/KBS.

Again communications, as main part of ICT, must provide the „smart" support for developing IoT and generally optimize not only the „things" existence/operation but the above mentioned „network of networks" too.

Developing such IoT complex systems supposes a set of requirements to be accomplished, in order to reach the optimizations goals with efficiency on long term.

The necessary infrastructure to connect the World IoT devices includes broadband (high speed) communications support (wireless, optical fiber, satellite, cable), optimized to the application specific traffic.

As a „network of networks", at network level IoT will have very complex challenges, as potentially billions of new sensors will require unique IP addresses.

Adressing these challenges, the extension of IPv6 (replacing IPv4) will provide practically unlimited number of adresses and make the management of networks easier due to auto configuration capabilities, offering too improved security features [4][1][8][2].

An other systemic challenge for IoT is naturally the energy support, considering the diversity of the applications and the fact that more and more they will include „areas" of sensors – not one or a couple.

Lets imagine some environment applications, where large areas (forest, sea coasts etc.) must be monitored, so how could be changed the batteries for each sensor?

Consequently, researchers are looking for finding sensors to generate the necessary electricity from environmental elements such as vibrations, light or airflow.

On this topic the good news are already coming [4]:

„Scientists announced a commercially viable nanogenerator—a flexible chip that uses body movements such as the pinch of a finger to generate electricity ...This development [the nanogenerator] represents a milestone toward producing portable electronics that can be powered by body movements without the use of batteries or electrical outlets. Our nanogenerators are poised to change lives in the future. Their potential is only limited by one's imagination".

This result and similar achievements simply express the above mentioned „iceberg" and our estimation is confirmed by authorities like Gatner [4]:

„Analyst firm Gartner recently declared that the Internet of Things (IoT) was the most hyped technology in 2014".

Generally is agreed that IoT development on long term will be more and more based on „soft defined applications" and sophisticated software that can process/analyze more data than has ever been analyzed in order use the huge potential of IoT.

Recalling the „data deluge" we already analyzed [13][15], we must point here that IoT will rise at unprecedented level the critical necessity for new performant algorithms for processing and especially for analytics associate with what is called Big Data, Exa Data etc.

Predictive analytics will be in fact one of the main features of future IoT intended to provide the core of the above mentioned optimization and added value, as generally it is not a problem to make software, but it is a huge challenge to make new performant algorithms for the optimization of the complex processes in IS/KBS.

Such a firm appreciation could be justified by simple considering only two of the main goals (criteria) of the IoT optimization role on Earth: providing a better life and assist people to prevent/anticipate the changes (at individual, community and Earth levels).

Now it could appear easier to fulfill another essentiall requirement for the IoT development technologies: to provide IoT devices/applications more and more complex as purposes/functions, but very simple to operate/understand by users.

Of course it could be a topic for an other paper (although we have mentioned above about genetic message changes and humankind evolution just for this reason), but the fact that the users must learn, step by step, to work and communicate with the new „smart machines", leads us to the conclusion that „simple to operate/understand" will be a dynamic term.

Coming back to the ICT requirements necessary to develop IoT, most of the specialists include [8]:

- ✓ Sensing and data collection capability (sensing nodes)
- ✓ Layers of local embedded processing capability (local embedded processing nodes)
- ✓ Wired and/or wireless communication capability (connectivity nodes)
- ✓ Software to automate tasks and enable new classes of services
- ✓ Remote network/cloud-based embedded processing capability (remote embedded processing nodes)
- ✓ Full security across all data and signal path

For example only the hard components of those requirements will have to provide a diversity of functions/devices like: Sensing (presence, gases etc.); Accelerometer; Magnetometer; Gyroscope; Pressure; Altimeter; Temperature; MCU (micro controller unit); MPU (micro processor unit); Hybrid MCU/MPU; Network Processor etc.

We know that ICT have an „Achile's heel" even in the most performants achievements: privacy and confidentiality. It is easy to imagine how much the risks will increase when billions of IoT devices/applications will operate on Earth and the individuals/organizations concerns about their data privacy/confidentiality/integrity are justified.

Adding here the intellectual property issues implied by generating data/information on a diversity of platforms and legal contexts, we complete the picture of security, as IoT will be a network of networks with obvious risk of attacks from Internet user and more, in spite of usual or new crypto-measures.

At a planetary scale of IoT it is essentiall to mention that security risks are not reduced at the data/information aspects. As IoT applications will cover critical infrastructures like ICT, energy, transportation, food, health and more, we have a concerning picture of what the consequnces of vulnerabilities could bring ... on Earth!

This way the security requirements for IoT will be prominent and very difficult to comply, due to the complexity of interoperability conditions in a planetary network of networks.

Of course, as we progress with the automation/optimization processes implemented by „machines", the risk of altering the human principles and values, by hazard or design errors, will increase.

As a consequence, ***deep analyses and research must be further performed in order to assure a consistent and secure development of IoT applications for optimizing IS/KBS on long term and facing all inherent challenges***.

3. Conclusions

The paper analyzed the premises of IoT emerging development, as an extension of the people's need to communicate, which will bring, of course, a lot of data and unprecedented opportunities to improve life in IS/KBS context and eventually the humankind genetic message itself. The main role of IoT is then to *collect data/information from life and environmental experience*, i.e. to help humankind to ***optimize all Earth processes and finally add new value for a better and longer life for actual and next generations***. This way the ***IoT applications range is practically unlimited, with the condition to be part of an optimization process at planetary scale of IS/KBS.***

One of the benefits of such a way to develop IoT is the „outcome economy", like an expression of the intermediate steps to optimize IS/KBS, as the products and services, at most from ICT but not exclusively, will be designed and implemented to provide specific (costumized) results.

The paper identified two main categories of IoT applications, one (A) being focused on collecting and processing data concerning the operation/existence of a „thing"/device in order to optimize that thing/device operation/existence („things" could include industrial machines, home appliances, cars, toys, animals or ... trees).

The second category (B) is focussed on individual/human body, in order to collect personal data useful for that person (generally for health, but not exclusively) or for entities interested in person's behaviour.

Both categories of IoT applications are further analyzed, with relevant examples and revealing their main implications.

The second section of the paper analyzed the means to develop IoT on a rational base,

showing that communications, as main part of ICT, must provide the „smart" support for developing IoT and generally optimize not only the „things" existence/operation but the above mentioned „network of networks" too.

An important conclusion on developing such IoT complex systems is that it supposes a set of requirements to be accomplished, in order to reach the optimizations goals with efficiency on long term.

The main requirement is an infrastructure to connect the World IoT devices including broadband (high speed) communications support (wireless, optical fiber, satellite, cable), optimized to the application specific traffic.

Other analyzed requirements include IPv6 necessary addresses and new technologies for the energy (electric power) support.

IoT development on long term will be more and more based on „soft defined applications" and sophisticated software that can process/analyze more data than has ever been analyzed („data deluge") in order use the huge potential of IoT.

Predictive analytics will be in fact one of the main features of future IoT intended to provide the core of the above mentioned optimization and added value, as generally it is not a problem to make software, but it is a huge challenge to make new performant algorithms for the optimization of the complex processes in IS/KBS.

Including privacy, confidentiality and the intellectual property issues, the security requirements for IoT will be prominent and very difficult to comply, due to the complexity of interoperability conditions in a planetary network of networks.

For implementing performant and complex IoT applications, the main ICT features which are required include: sensing and data collection capability; layers of local embedded processing capability;wired and/or wireless communication capability; software to automate tasks and enable new classes of services; remote network/cloud-based embedded processing capability; full security across the signal path.

Despite the amazing performance of the automation/optimization processes implemented by „machines", the risk of altering the human principles and values, by hazard or design errors, will increase and ***deep analysis and research must be further performed in order to assure a consistent and secure development of IoT applications for optimizing IS/KBS on long term.***

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