

CONTEXT-AWARE COMMUNICATIONS AND IT – A NEW PARADIGM FOR THE OPTIMIZATION OF THE INFORMATION SOCIETY TOWARDS THE KNOWLEDGE BASED SOCIETY (Part 1)

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Abstract

The paper approaches an emergent field of the information and communications technologies (ICT), the context-aware communications and information technology (CACIT).

The way CACIT generates a new paradigm for the ICT development optimization, the driving force of the information society (IS) toward knowledge based society (KBS), due to CACIT features and influence factors, is analyzed.

The analysis reveals that CACIT has a huge potential, as it is based on the incommensurable expansion force of digital space (DS), which is generated by the digital technologies (DT) associated mainly with ICT.

In order to identify the development mechanisms of CACIT, the paper first identifies the DS features and driving factors, where human imagination plays a prominent role, as DS covers practically all humankind activity fields and this way the applications are limited only by the Earth resources and DT limits, which is not the case of imagination.

An important result of the analysis is the identification of the CACIT main evolution steps, starting from the early human context-aware communications based on the five senses, which are still driving the actual principal development directions of the applications.

On the other hand, although the paper space does not allow a detailed analysis of the CACIT main classes of applications and developing principles, some relevant examples of

such CACIT classes are presented, where healthcare is a zero priority (largely analyzed) which turns back the benefit of CACIT to its main inspiration source represented by the people.

Other analyzed relevant classes of CACIT include the GPS applications and the management of moving objects or living things (cars, trucks, cows etc.) based on GPS and wireless communications.

The paper main conclusion is that CACIT will essential contribute on large scale to the optimization of IS/KBS by a multitude of criteria, including time, Earth resources, healthcare and ... the creative potential – which then will also leverage...human imagination.

Keywords: context-aware communications and information technology, digital space, healthcare, information society, knowledge based society, supercomputing, brain diagram.

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

1. The incommensurable expansion force of digital space

We almost got used with the terms of **information age** or **information space**, as people can see everyday and everywhere around the products and services applications the information and communications technologies (ICT) provide. All these applications in fact give to people the access at more and more data, information and progressively to refined knowledge, becoming the indispensable support of the actual information society (IS) toward knowledge based society (KBS) [2].

Perhaps the amazing speed of ICT development, we may perceive in our everyday life, is the cause of the fact that we sometimes cannot perceive and memorize, as it should, every main step/side of this development.

This way we may observe that the term “digital” is on the way to be a little “forgotten” or at least inadvertently “noticed”, as its place is taken by the most frequent “information”, “IT”, smartphone etc.

The fact is that, not long time ago, we were seeing and hearing everywhere “digital” clock, digital communications, digital TV etc.

Due to all these surrounding “digital” applications/features, which are mainly based on semiconductor technologies (but not exclusively!), we were tempted to feel that we live in a “**digital space**”.

As ICT pace provided more information-based applications, we may feel that we are living in an **information space**, at the **information age**! What about the **digital space**?

In order to better understand the new more and more sophisticated applications of ICT, but especially to be sure that we perceive all the consequences and optimize the ICT development as the main driving factor of IS toward KBS, we have to properly **notice every ICT step!**

Here we have just arrived to the point: let’s see what we may find in the **digital space (DS)**!

From the beginning we have to notice that it is not the paper aim (nor space) to make an extended analysis of the digital technologies (DT), but we intend to point some relevant features of the DT development, in order to understand DS role in the general development of ICT and for the context-aware communications and information technology (IT) in particular.

On the other hand it is important to mention that the DS role and generally the ICT processes are very complex and multi-factor driven, thus they are very difficult to optimize in the context of IS/KBS, but it is worth to identify some relevant features of DT/DS in these processes.

As a starting point, we have to recall a generally understood feature of the DT, irrespective the applications field, but essential for ICT, consisting in the revolutionary change the digital processing of electrical signals made over the analogue processing, which is similar with the revolution transistor made after the vacuum tube.

This feature is in fact the base of information technology and it provides the amazing capacity to reproduce and *multiply* a device, action and generally a process in a very precise, efficient and predictable manner, anytime and anywhere.

At this point we just reached the premises of another feature of DT, which provides the fundamental driving force of ICT: the ability to design and implement, by multiplying and combining a diversity of modular devices or processes, *any desired function*.

One of the main technical driving factors of ICT amazing recent pace is just the fact that, among the mentioned elements, the modular processes became much important than the “modular devices”, as they are mainly “software modules” which are driving the applications processes in the concrete considered domain and could be easily customized.

Now we can observe that the miracle of exponential development of ICT is done by the leveraging effect of the DT/software capacity to adapt very fast and efficiently to any new application design (desired function), as it could use an already available set (hardware) of “modular devices” (as integrated circuits etc.).

The above observation is pointing another feature/trend of the DT/ICT, called “software-defined” X, where we easy may recognize X in actual concepts like software-defined radio, software-defined instruments or (soon) “software-defined network”.

In this context it is now obvious how the DS is **expanding** around or inside our everyday lives. We have just arrived to the concept of **digital space expansion**, but there is one more step to the **DS expansion force**.

After the above features presentation it is easier to reveal that the capacity of DS to expand, with an amazing pace in time and an impressive volume in a diversity of applications fields space, is clearly based on the leveraging effect of the DT/software and further on the feature of multiplying and combining a diversity of modular devices or processes in order to generate, very fast and with the highest efficiency, *any desired function in the surrounding space*.

The last mechanism is just the impressive way the **DS expansion force** is acting in order to generate any desired application.

Probably we all have met the expression “sky is the limit”, when someone tried to express that a particular process could be developed “without limits”.

In our case, we have to evaluate how **DS expansion force** could evolve, starting from the previously mentioned features as premises.

Obviously, the main factors of the expansion are the above revealed features, best expressed by the multiplying and combining capacity when applied to hardware modules, but especially to software modules.

As we already have mentioned, these are very complex processes and we inherently revealed just a part of the involved factors.

It is fair to underline that at least one driving factor was deliberately missed, but the exact expression is that we have mentioned only the most important factors and features that could lead to the desired topic.

In order to complete the topic of this paper chapter, we have to analyze what is missing in order to have an expansion without limits of the DS.

Of course there are many factors which could determine the DS limits and they include:

- human intelligence;
- human imagination;
- social command;

- industry politics;
- Earth resources etc.

It is also evident that the above factors are not total independent, intelligence and imagination being a good example, but they could be mainly analyzed in order to reveal their contribution.

With a good approximation we may conclude that, by far, the imagination has an unlimited potential to extend the DS, in a given context.

First we have to mention that the context is given, considering a multi-variables optimization mathematical model, by the other above factors.

As a consequence, it is straightforward to deduce that the expansion force limit for the DS is ... the human **imagination** – a huge resource which practically has no limits.

Remembering the above quotation, we may say without doubt that, **for the DS expansion force “imagination is the limit”**.

One could still be cautious and ask: Is it just like that?

Yes, the question is good and meaning that the humankind could imagine a lot, but not anything could be done!

Further we may continue the analysis and it is easy to observe that the implementation of what imagination generates is practically limited exactly by the other mentioned factors – where we must recall first the Earth resources.

More than these, we already prevented this question, when mathematically have fixed the context with the condition: **in a given context**.

Anyway, we have just arrived to the chapter point, as we have supposed that **the DS expansion force is incommensurable**.

As a matter of fact we may observe that we did not suppose that DS has **no limits**, but we intended to suggest that DS expansion force is very high and could not be **measurable**.

Here it is important to notice that the human imagination is really **incommensurable**.

We think that the most interesting aspect of this result is the fact that we have revealed a direct relationship between DS expansion force and the human imagination, but we have recognized in the same time that this force (link) **is not measurable**!

With other words, we admit that DS expansion force is very high due to the human imagination direct influence, but in the same time, this influence, the imagination and the DS expansion force are not measurable!

All we could surely say is that the imagination and the DS expansion force are **qualitatively** very high and perhaps the essential is just the fact that such a huge phenomenon like the DS expansion in the IS/KBS is related with such a huge human resource like the imagination, in the critical context of Earth resource fading [4].

Alongside the main point of this chapter, somewhere in the background a question is still pending: Which is the relationship between DS and the context-aware communications and information technology?

The above presented features of DS, including the conclusions, give relevant elements for observing that DS expansion force represents by DT a crucial premise for the context-aware communications and information technology, from technological point of view but also regarding other implications of these features, as will be further detailed.

2. From context-aware people to context-aware devices and ...BACK

The evolution of ICT, where DT have a central place, is a very complex process, as it is the main driving factor of IS/KBS and includes practically most of the scientific and technical knowledge the humankind created. For example, *almost all humankind „history” in data*

volume is now replicated in the last 2 years! Every day we create 2.5 quintillion (10^{18}) bytes (2.5 exabytes) of data, actually referred as „big data” process [5], [6].

These premises indicate how „big” and complex is the operational „space” of the digital world we are talking about.

Starting from this reality, it is clear why the evolutions of ICT and further of IS/KBS need to be optimized, especially if we take into account all the consequences of the fact that the exponential pace ICT has a dramatical influence on all activity fields and finally on today and tomorrow’s Earth [4].

Of course, the optimization of such complicated processes, at Earth scale, is only a dream, but that does not mean there is nothing to do.

Anyway, a better understanding of DS evolution, which is a biggest part of the „pie”, is the first step for the optimization.

Here is the point where we have to show the tight link between DS and the context-aware communications and information technology (CACIT), as two sides of the ICT evolutions.

In fact, DT represents the technological base for the most of ICT applications, as very few of ICT remained „analogue”, as a consequence of the revolution we have mentioned before.

The idea and concept of CACIT have also a step by step evolution, as it seems that from the beginning people needed to have information from the context, especially as the mobile communications began to be ubiquitous.

It is essential to mention here that, already for a couple of decades, the communications and IT have „converged” and their operation and development are practically inseparable.

As a consequence, it became obvious that as the volume of information which is exchanged in context-aware communications increased, it must be processed in real time in an adequate manner, including both IT technological and application customized elements.

With other words, ***CACIT appeared from the necessity to benefit from the (mobile) communications opportunities, in order to give to the people, in real time, the information they could use to optimize their activities/lives in the changing context they live every second.***

By this achievement, **CACIT will essential contribute on large scale to the optimization of IS/KBS from a multitude of criteria, including time, Earth resources, healthcare and ... the creative potential – which then will improve...human imagination.**

An other necessary mention, also in order to be actual, must refer to the amazing reality that the service of communication and besides the information processing (i.e. IT) are no longer intended to serve (only) „people” (persons), but „devices” too!

Maybe would be interesting to recall here that the number of devices which are connected to the Internet is higher than the number of connected persons and the CISCO study „Internet of things” estimated that in 2020 will be 50 billion devices connected to Internet. Here the „devices” do not include the mobile phones held by persons.

For example, the GPRS wireless communicator is used in a security/alarm system to transmit specific information, in real time, from a remote site to the monitoring unit.

Now became clear why the DS and CACIT tend to be so complex processes, including the huge number of connected devices and their operational needs.

By the way, referring to the needs, one could ask: From where did the CACIT start?

Perhaps we all remember the Maslow pyramid of humankind needs, where, after eating, communication is one of the important need. To be more exact, here the need is on being „context-aware”, not on communication anyway!

As a consequence, we have to notice that for the first time **humankind was aware of its contextual environment** in the early stages of his evolution, when „communication” was performed by the five human senses!

It is a matter of fact and very interesting that the actual design and concept of CACIT is still based and originated on the five human senses [8].

This way we have just entered into the complex process of analyzing how the CACIT is developing/generated.

It is necessary to recall the fact we above concluded about the essential role of imagination in extending the DS and now it is clear that CACIT has the same feature, as it is implemented by DS elements and **the main driving factor in generating CACIT applications is given by the humankind needs and ... imagination!**

In order to be consequent, we have to mention that here the **humankind needs include all the devices needs!**

In a such diverse „space”, a systemic analysis should start with the obvious need of classification, as the above reference to the five human senses already suggested.

On the other hand, the fundamental role of (free) imagination in developing CACIT must to be considered on a realistic basis, which also leads to feasibility/efficiency criteria and inherent classifications.

Although such a systemic approach of CACIT could be eventually considered for an other paper, now it is important to remark that CACIT applications are impressively extending, in an „**incommensurable**” space, just like their base – the DS.

After these formal considerations, an approach of some concrete examples will get inside CACIT, from simple to complex applications, this way sketching the evolution tendencies too.

Remembering that we have mentioned above the priority of communications in the implementation of CACIT, one of the most relevant and perhaps still largest system is GPS (Global Positioning System).

GPS was realized by the USA (Department Of Defence), between 1973 and 1995, as a constellation of 24 geostationary satellites, intended to offer precise location data (coordinates, speed and other) in every place on Earth which has a direct line of sight with 4 satellites, for military purposes like rockets, submarines etc.

Among the remarkable features of GPS were the private access and antijamming provided by the use of spread-spectrum systems (SSS) principles (being one of the first large applications of SSS in satellites communications) [3].

Now GPS is in a modernization stage (GPS III) and before 1995 a less precise version (without privacy code) was offered World wide for civilian applications. One remarkable moment in this offer was the GPS Navigation Conference (1995) organized by the USA in Bled-Slovenia, where we represented Romania – in the frame of Partnership for NATO.

The inclusion of GPS in CACIT is based on the fact that, instead of being a usual communications system intended for communication between two persons, GPS is providing positioning data for a nomadic person.

It is important to notice that although this nomadic person is using a receiver to get the data, GPS could not be considered a *broadcasting system* (like usual radio and TV), but a **context-aware communications system**, due to the fact that the GPS receiver will receive different useful information in different places, as it is moving on Earth at least a few meters!

The GPS example is presenting exactly the concept and the principle of CACIT, but it is worth to underline that more than this, GPS is a very large CACIT system, taking into account both the planetary covering and the huge number of potential users.

By the way, now every smartphone has a GPS receiver, but here a new story starts, as the data provided by GPS could be used in a large number of applications in addition to other

data or features and this way new, this time fully CACIT applications (but not necessary systems!) could be operational.

In order to emphasize the essential role of communications, another example of CACIT, on the above line of GPS, is the management of moving objects or living things (MOMOOLT).

If the concept of MOMOOLT seems unclear or too general, it is so just because it also covers a huge number of users/applications, by simply adding to the GPS receiver a radio (transmitter + receiver). This way, MOMOOLT could monitor the position of precious cars, boats, trucks or yachts, but also of any horse, cow, elephant or ... dolphin!

A last but not least class of applications example is healthcare CACIT, as a part of the actual concept of “ubiquitous healthcare” [1].

As we recently mentioned [10], BAN (body area network) is an emergent field of ICT, which have a tremendous importance for people’s life.

By our opinion, healthcare ICT (HICT) represents the most useful direction of ICT development, as it provides fundamental advances in life protection (**coming ... BACK to the people!**) and zero priority of the social command – one of the main factors, we have mentioned above, which determine the DS/CACIT expansion.

In order to illustrate the role of the social command, we believe that the entertainment ICT industry is not an useful direction of the same importance as HICT, but, as we all can see, games and other applications determine impressive ICT products and services World wide.

Coming back to BAN, this is only a part (to be fair, the most difficult to implement) of healthcare CACIT (HCACIT), which adds to other components, like a diversity of nanosensors [6] and processing, in order to provide and transmit in real time contextual information (position, type of activity etc.) useful for monitoring and processing data for vital signs and generally healthcare.

An indication on the complexity of future HCACIT we recall the „brain diagram” World program [6] and one of its the most prominent projects, Brain Research Through Advancing Innovative Neurotechnologies (known as **BRAIN Initiative**), which was supported in 2013 by the USA Government with 110 millions USD, as Barack Obama announced in april 2013 [11].

The required technological level of the program target could be expressed by the actual state-of-the-art neurological activity recording applied for the zebra fish involving 80000 neurons (a mouse has 75 million neurons and a human has... **about 86 billion neurons**). More than these, there are 150 trillion estimated connections linking the neurons in the human brain. A rough estimation of the computing power for the above program (**BRAIN Initiative**) would require over 10^{17} bytes memory(storage) [11].

This last example also confirms that, as the CACIT complexity increases, the necessary processing power and sophisticated algorithms increase too.

Anyway, the real dimension, complexity and performance of HCACIT is fast increasing, as the premises created by Moore’s Law [9], [6].

Recalling the imagination leveraging role in generating CACIT, a huge number of applications have been developed or are emerging and they could be approached in an other paper.

Just think what if we would learn on our way (no matter if walking or driving), about general contextual (environmental, actual or emergent) weather, bussiness/commercials, social events or personal stage of approaching one of our travel objectives, financial transactions etc.

Now the importance, complexity, diversity and expansion potential of CACIT at least have been just suggested, but it is obvious that a detailed approach need further analysis and presentation.

3. Conclusions

The analysis of DS development identified the main factors of influence, where the **human imagination plays an overwhelming role**, as a huge and unlimited resource in the context of other factors which have material or formal limits. This fact confirmed that DS and then CACIT (which is technological based on DS) has an **incommensurable expansion force**, as applications potential.

Extending CACIT applications in most of the humankind activity context is a necessity to benefit from the (mobile) communications opportunities, in order to give to the people, in real time, the information they could use to **optimize their activities/lives in the changing context they live every second**.

As a consequence, **CACIT will essential contribute on large scale to the optimization of IS/KBS from a multitude of criteria, including time, Earth resources, healthcare and ... the creative potential – which then will also leverage...human imagination.**

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