

Improving Information and Communication Technology to Innovate the Paradigms of World Progress

- Part 1-



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Abstract

The paper approaches the premises of evaluating “**right tracks of development**” and innovate the progress, in the actual dynamic World context, facing unprecedented levels of concern or danger for Earth and humankind evolution, considering that the information and communication technology (ICT) became the main driving factor of the human society by the complex consequences of its services, products and applications, when supporting the Information Society (IS) on the way towards the Knowledge Based Society (KBS) and that the average development is the result of global tendencies/innovations, including knowledge refining.

We approached the ICT role in this connected World and considered Maslow pyramid as reflecting the essential needs of humankind, and this way it resulted that the energy is among the primary needs of progress and the research in this domain is perhaps the most important, but also difficult, as World is facing at least 3 combined sources of crises, including global warming (climate changes), Earth resources fading and consumption. As an average dependence, the global warming was (and is) mostly influenced by the way we generate and use the energy for the global processes, resulting that the lack of having on Earth plenty of fossil resources for World amazing industry progress, including the exponential pace given by ICT, is now the main factor (from the above 3), we have to reconsider/mitigate.

As a starting point, when analyzing the actual Earth ecosystem and its premises of development, we used some relevant examples. In the case of Thorium nuclear energy, we considered the role of ICT to leverage the data extraction from uranium experience/processes and the necessary knowledge refining for thorium use. At Blockchain, one of the advanced ICT applications, as it is severely complicated/limited by energy factors, we pointed the benefits of hash-puzzle solving power metric.

The basics of ICT industry, first including telecommunications and computers, should also be radically improved to meet the high requirements of carbon-aware, but, eventually, **among the most important challenges for ICT context development, along with direct energy consumption (power), we could include the complex relations between performances (capacity, speed, memory and so on) and power, the extension of the 5G(6G) networks, IoT or energy costs increase.** Analyzing the impact of energy on data centers [4], we observed that all the prior expertise is used to optimize the relation performance/power or memory/time, but actually it is necessary

to rethink the models, for both device and network scale, including carbon-aware software engineering. **The difficulty of finding solutions for the actual crises lies also on the high/apogee levels of performances and progress we are in. This way we have to agree that the old improvement solutions have already reached their maximal potential benefits and new computing paradigms are necessary, based on some holistic principles, for all the ecosystem (including education and further knowledge refining).**

More than only improving ICT software, **the business processes could benefit in efficiency and efficacy by improving the thinking of organization/processes strategies and data tools, still involving ICT, but with updated approaches of using resources, including humans and technology. The practical consequences of such changes of paradigm will provide a higher flexibility in development and a faster updating the business to the emergent World challenges, targeting the new progress solutions.** Such modern approaches of business processes could use the concept of data products, as detailed in [5]. This approach also reflects the increasing value of using data/information in the Data Deluge era, with the green ICT trend, which eventually also provides an optimal development/use of ICT instruments. **Our conclusion is that we have to treat data products with special attention, as a new type of product, but with features and impact on industry and beyond, as they are linked, in more and more complex ways, with the advanced ICT products, systems and services, at Earth scale.** As a consequence, **we would propose that data products and similar new concept provided by ICT for IS toward KBS to be used like other sensible products (food, vegetables and so on), considering the appropriate environmental variable conditions, but in this case the known “time sensitivity” has to determine a more large/complex family of consequences/measures, because of the fast changes ICT and IS/KBS generate under the processes of knowledge refining we already mentioned in [11][17][13][19].**

As a final conclusion, we have just observed **some subtle ways the ICT could leverage the World progress by innovating its tools, but not in the same fast and sophisticated ways, as they have to find simpler and more business-oriented solutions/tools/advances.** There is no doubt that **these partial approaches, versus the complexity of World changes and uncertainty require further and continuously analyses to be done, at Earth scale and with appropriate knowledge refining.**

Keywords: Thorium nuclear energy, Blockchain, hash-puzzle solving power, carbon-aware software engineering, data products, developer, knowledge refining

JEL Classification: L63; L86; M15; O31; O33

1. Searching energy challenges of World progress

When life problems seem to overwhelm us, sometimes we used to rediscover the hope and the ways to go on, against all odds and eventually changing some paradigms of what we long time considered normality.

Beyond the philosophical relativity of the above thinking, it is sure that the actual World crises and challenges represent unprecedented levels of concern for most people and incumbents, just considering the consequences of global warming (climate changes), Earth resources fading, social unbalances or geopolitical/security crises, consumption or changes in human behaviour/values [7][8][10][21][11][19].

Under such negative premises, the expectations for World progress are naturally an important but very complicate issue, which must be deeply analyzed in order to eventually foresee the ways of improvements [12][18][20][17].

In fact, for a more precise evaluation of the premises and actual World's context, we should consider with more care even the used terms, as “concern for most people and incumbents” includes at least 3 sources of uncertainty/approximation, as “concern” is not an objective measure of reality, which then could be affected by the diversity/statistics which the level of democracy generates among “people and incumbents”.

Such general and non-technical consideration could seem inappropriate for evaluating **“right tracks of development”**, but we have to recall that we live in a highly connected World, where the democracy is prevailing (at least till now!) and average development is the result of global tendencies/innovations, including knowledge refining.

With other words, the democracy and the market economy generate, either good and bads, development tendencies, as reflecting “most people and incumbents” options and eventually ...their knowledge - which should be refined in the actual dynamic World context.

On the other hand, actually, a basic premise for any progress should consider the information and communication technology (ICT) crucial role, as ICT became the main driving factor of the human society by the complex consequences of its products, applications and services, when supporting the Information Society (IS) on the way towards the Knowledge Based Society (KBS), as we already approached in [15][13].

It is sure that the real World context, processes and evolutions are much more complex and complicated than the above suggested generic model, but this is the reason to consider it as a starting point, when analyzing the actual Earth ecosystem and its premises of development, using some relevant examples [1][2][4][5][14][23][24].

Starting from ICT role in this connected World and considering Maslow pyramid as reflecting the essential needs of humankind, which must be a base for reducing uncertainty/approximation in the above mentioned “options”, we expect to find some reasons/ways which could lead to the “**right tracks of development**” when facing the mentioned unprecedented levels of concern or danger for Earth and humankind evolution.

This way it is natural to consider the energy among primary needs of progress and the research in this domain is perhaps the most important, but also difficult, as World is facing at least 3 combined sources of crises, considering global warming (climate changes), Earth resources fading and consumption.

In fact, as an average dependence, the global warming was (and is) mostly influenced by the way we generate and use the energy for the global processes, resulting that the lack of having on Earth plenty of fossil resources for World amazing industry progress, including the exponential pace given by ICT, is now the main factor (from the above 3), we have to reconsider/mitigate.

In concrete/practical approaches, we could recall the research for alternative (non fossils) sources of energy, revolutionary battery technology (pointing the future electrical cars and even aircrafts) and so on.

Even the nuclear energy technology, by its already spread use and potential, is the target of many research centres, one being presented by the next example in [1]:

“...China announced the completion of its first experimental thorium-based nuclear reactor. Built in the middle of the Gobi Desert in the country’s north, the reactor over the next few years will undergo testing. If the experiment proves successful, Beijing plans to construct another reactor potentially capable of generating electricity for more than 100 000 homes. China is not alone in its intentions to reap thorium’s unique properties. In the past, India, Japan, the United Kingdom, the United States of America and other countries have demonstrated enthusiasm for research into the possible application of thorium in nuclear power. The appeal of this metal is its potential to be a more abundant and efficient substitute for uranium, the dominant nuclear fuel.”

The nuclear research made by different countries is still monetarized by the specialized international agency (IAEA) specialists, who have a balanced opinion on the sustainability of Thorium:

<<“Many countries consider thorium as both a viable and very attractive option for generating power and meeting their growing energy needs,” said Kailash Agarwal, a Nuclear Fuel Cycle Facilities Specialist at the IAEA and one of the authors of the report. “Our research project helped share valuable knowledge and experience among national laboratories and research institutions in the use of thorium, culminating in this publication.”

Thorium is a silvery, slightly radioactive metal commonly found in igneous rocks and heavy mineral sands. It was named after Thor, the god of thunder in Norse mythology. It is three to

four times more abundant in nature than uranium but historically has found little use in industry or power generation. This is partly because thorium in itself is not a nuclear fuel, but it can be used to create one. Thorium-232, the only naturally occurring isotope of thorium, is a fissionable material but not a fissile one, meaning that it needs high-energy neutrons to undergo fission — the splitting of atomic nuclei which releases energy that is used for electricity generation. However, when irradiated, thorium-232 undergoes a series of nuclear reactions, eventually forming uranium-233, a fissile material that can be burned up as fuel in nuclear reactors.>>

Although is an “abundant and efficient substitute for uranium”, Thorium has also some technical challenges to be considered and eventually solved before becoming a practical solution for the energy of future:

<<However, there are several economic and technical obstacles making the deployment of thorium challenging. Despite its abundance, the metal is currently expensive to extract. “The mineral monazite, which is a major source of rare earth elements, is also a primary source of thorium,” said Mark Mihalasky, a Uranium Resources Specialist at the IAEA. “Without the current demand for rare earth elements, monazite would not be mined for its thorium content alone. Thorium is a by-product, and extraction of thorium requires methods that are costlier than for uranium. So, as it stands, the amount of thorium that can be pulled out of the ground in a cost-effective manner is not as great as for uranium. This, however, could change if there was a higher demand for thorium and its application in nuclear power.”>>

Last but not the least, the research costs for thorium industrial use are also considerable, because of the novelty of such industry processes, which need, again, innovations.

We also suppose that, in this new context, the role of ICT, to leverage the data extraction from uranium experience/processes and the necessary knowledge refining for thorium use, could be benefic and significant:

<<Equally expensive are research, development and testing of thorium-powered nuclear installations due to a lack of significant experience with thorium and uranium's historical pre-eminence in nuclear power. “Another hurdle for thorium is that it can be difficult to handle,” said Anzhelika Khaperskaia, Technical Lead on Fuel Engineering and Fuel Cycle Facilities at the IAEA. Being a fertile and not fissile material, it needs a driver, such as uranium or plutonium, to trigger and maintain a chain reaction. >>

Still, the prevailing conclusion is that thorium is an important/potential resource for the future energy industry, while the research of this field will continue in a sustainable way:

“To meet growing energy demand and achieve global climate objectives, the world is looking for alternative sustainable and reliable energy technologies. Thorium may become one of those,” concluded Clément Hill, Section Head at the IAEA. “We will continue our research to deliver credible and science-based results for those interested in working with thorium.”

Looking for the relevant links of ICT development with World general progress versus actual challenges, including the energy crises, we have to recall the huge energy consumption of ICT planetary products and services [19][11].

On the other side, it is known that the race of ICT towards new performances (capacity, speed, memory, miniaturization etc.) has been more and more linked and even limited by the energy/power consumption, where Cloud, AI or Blockchain are relevant cases.

The next example reveals how Blockchain, one of the advanced ICT applications, are severely complicated/limited by energy factors to be considered [2]:

“Clearly, Bitcoin’s challenge is to create an ecosystem of mostly honest pseudonymous miners. More specifically, the challenge is to 1) incentivize as many computer owners as possible to participate in this distributed process as nodes, thereby motivating a large plurality of unrelated nodes and 2) discourage nodes from creating crony nodes that might affect the

outcome of the distributed agreement. After all, the more nodes that decline an invalid mined block, that is, a block with modifications (of transactions or entire blocks), double spending, or omissions, the lower the chance that the whole network will accept it in their blockchain view.”

Because blockchain is a concept and a technology which include very complex processes, in order to address the above challenges, at least their short description should be approach:

“A node is chosen at random from all working nodes within the ecosystem. This random node selection is not done by a governing authority; rather, it is done by having all nodes try to solve a hash puzzle. As hash puzzles are randomized, the only way a node can solve the problem is by repeatedly tossing a coin and trying a new candidate solution. Being energy costly with almost no reward (rejected blocks are not rewarded even though a miner solved the hash puzzle), this process addresses the aforementioned challenge number 2). In contrast, the lucky nodes that solve the hash puzzle receive an incentive [thereby addressing the aforementioned challenge number 1)] in the form of 0.625 bitcoins (in 2021), delivered as a special Bitcoin transaction; miners will continue mining as long as this incentive off sets their expenses.”

In simpler words, one of the main mechanisms of blockchain, which provide essential features of randomization and integrity, is in the same time a big consumer of energy, as large as it takes the process of mining (solve hash puzzle).

Further, an essential leveraging way to evaluate the system efficiency is to introduce and use an associated metric (hash rate) for hash-puzzle solving power:

“Note that most, if not all, fully operational nodes in the Bitcoin ecosystem participate in the mining proof-of-work operation, namely, they all try to solve the hash puzzle. Hash-puzzle solving power is measured using a metric called hash rate, which measures hashes computed per second (H/s). A personal laptop has a hash rate of a few millions of hashes per second; because the hash-puzzle target T_a has become so small over the years, the probability of solving it within 10 min on a personal laptop has become negligible. Therefore, serious miners must invest in expensive hardware to perform mining and hardware capable of computing a large amount of hash candidates, albeit with a high energy cost; specialized hardware can achieve close to 100 trillion hashes computed per second (TH/s).”

It is important to notice that the network development requires not only energy but also performant hardware able to compete in hash-puzzle generation.

On the other hand, even for a such complex and complicate ICT application/system, the above metric and the corresponding figures could be used to improve the energy consumption, while studying the system operation general cost:

“The hardware’s fixed cost is several thousand U.S. dollars. Miners most often use racks consisting of a plurality of such hardware devices, thereby increasing energy consumption even more. As energy hungry as each mining operation is, multiply that by the number of mining nodes in the network (estimated to be more than one million nodes) to understand how the total electrical power consumption reached 135 TW/h in 2021. According to Digiconomist, a single Bitcoin transaction has an average carbon footprint of approximately 500 kg CO₂, the equivalent of roughly 90,000 h of watching YouTube.”

Still, the final estimations/results show huge energy consumption, versus other global ICT applications, putting in a realistic picture the challenges ICT has to face at Earth scale, especially for complex products, applications and services where energy is a main ingredient for providing high performances, **needing further timely analyses and even new approaching models in order to optimize the development and provide sustainable progress.**

2. Innovate while using efficient ICT and refining the knowledge everywhere

The complex and complicate premises of approaching the innovation of World progress are much beyond from only considering the generation and consumption of energy, especially in the context of optimally developing the huge domain of ICT as global impact at Earth scale.

From energy basic factors, to the improved right tracks of progress, there is a long and winding road for ICT to lead the World toward mitigating the consequences of emergent crises.

In fact, even the basics of ICT industry, first including telecommunications and computers, should be radically improved to meet the high requirements of *carbon-aware*, as we already pointed [3][19].

Among the most important challenges for ICT context development, along with direct energy consumption (power), eventually, we could include the complex relations between performances (capacity, speed, memory and so on) and power, the extension of the 5G(6G) networks, IoT or ...energy costs increase [23][24].

A prominent importance has the impact of energy on data centers, as they became, in the Cloud applications proliferation context, the highest power consumers. Their needs for power are difficult to be reduced while their capacity/performances would increase, although more and more research is continuously done, on all implied factors.

The research directions for improving the development of green or *carbon-aware* ICT include extensions of earlier phases of battery savings type, but it is clear that the new crises era, we entered in, requires radical steps forward, for both hardware and software of the equipments and systems, as it is also detailed presented by [4]:

“From the dawn of computing through the mid-1980s, machines were severely limited in memory capacity and computation speed. The early devices were physically large in comparison to today and required substantial energy, so much so that cooling for data centers received significant research attention. In the latter part of the early computing era, embedded systems, with limited memory capability (for example, the Space Shuttle Inertial measurement computer program resided in 64 K of random-access memory), relied on a time-space tradeoff principle. This informal principle held that, to use less memory you had to increase computation time and vice versa. In those days, all kinds of tricks were used to save time (like loop unrolling, which removed the overhead of counting the loop iterations) but at the expense of additional storage requirements. Many other approaches used in compiler optimization were employed, although these methods were specifically oriented toward real-time, embedded systems.”

Here we can observe that all the prior expertise is used to optimize the relation performance/power or memory/time, but actually it is necessary to rethink the models, for both device and network scale:

“In the early days of portable computing, researchers focused on battery-saving strategies. Various power conservation techniques were proposed that have now become commonplace, such as turning off the computer’s screen during disuse, optimizing hard drive input–output, and slowing down the CPU with clocking schemes. Process migration over networks from high power consumption to more efficient computational devices can also be used. Although most of these early hardware energy principles are still with us today, perhaps we need a new set of power-saving and “power-aware” principles for current computing paradigms”.

Far from being simpler, the software optimization problem, although more flexible and having the benefit of easy updating, at the actual critical requirements of *carbon-aware software engineering* is also dependent of the impact of the new hardware solutions/versions on environment:

“Carbon-aware software engineering involves the design and development of software with a focus on reducing the carbon footprint. Related practices include reducing energy consumption of the software during development as well as its runtime energy consumption. It also includes considering the environmental impact of the hardware used to run the software. The techniques used in carbon-aware software engineering include energy profiling, power management, and use of renewable energy sources. (A small example here is the pixel colors on a smartphone screen; not all pixel colors drain the same amount of the phone’s battery.)”

As we observed earlier [11], the difficulty of finding solutions for the actual crises lies also on the high/apogee levels of performances and progress we are in and this way we have to agree that the old improvement solutions have already reached their maximal potential benefits:

“Carbon-aware software engineering takes us back to the old days of embedded computing with 64 K executable memory stores, self-modifying code, and space/time tradeoffs. Through the 1980s, software engineers had to be aware of the underlying hardware and target devices, components even to the transistor level, which is anathema to the concept of hardware-agnostic software engineering, computer architecture (hat tip to the late, great Fred Brooks). But the new computing paradigm requires software engineers to rethink these principles.”

The realistic approach became, naturally, the necessity of new computing paradigms, as part of the larger picture we have mentioned from the beginning (**changing some paradigms of what we long time considered normality**):

“Fonseca et al.[3] proposed the following nine principles for energy-aware software engineering:

- 1. Public awareness is key for widespread adoption.*
- 2. Incentives for software stakeholders.*
- 3. Energy-aware software engineering should be a priority for every stakeholder.*
- 4. Education and professional training should cover energy-aware software by default.*
- 5. Broad adoption requires attention to usability.*
- 6. Energy awareness should be engineered throughout the lifecycle.*
- 7. Software quality should not come at the expense of energy awareness.*
- 8. Energy awareness demands dynamic adaptability.*
- 9. We value measures over beliefs (and reliable trends over precision).*

These principles appear simple and useful, but we consider that their prominent quality is to provide for all the ecosystem, (nota bene: **including education and further knowledge refining**) a holistic approach/solution to follow in a very complicate ICT context:

“All of these are self-explanatory and important. Incidentally, any of these principles could be adopted for cybersecurity. To promote awareness, perhaps software engineers should adopt some sort of carbon-aware labelling system: green, yellow, orange, and red for energy usage for typical usage or exceptional profiles. Such a system could lead to carbon-aware compilers. Input to a “carbon-aware compiler” would include a description of the hardware configuration, a set to operational profiles and their probabilities, and the output would be (in addition to the usual outputs) a power consumption profile. Of course, this approach would necessitate an accurate description of the underlying hardware configuration and power requirements under an operational profile, accurate descriptions of these operational profiles and software trace executions, and accurate knowledge of the likelihood of these profiles”.

Although these proposals could seem too general, they have remarkable practical benefits, as they respond to the complex and dynamic context of World crises, where ICT has to “heal first its own wounds”, while leveraging the expected solutions for the whole Earth ecosystem by their obvious quality to be easy applied in larger environments or domains.

More than only improving ICT software, the business processes could benefit in efficiency and efficacy by improving the thinking of organization/processes strategies and data

tools, still involving ICT, but with updated approaches of using resources, including humans and technology [6][9][22].

The practical consequences of such changes of paradigm will provide a higher flexibility in development and a faster updating of the business to the emergent World challenges, targeting the new progress solutions.

Such modern approaches of business processes could use the concept of *data products*, as detailed in [5], but we think that these also reflect the increasing value of using data/information in the Data Deluge era, with the *green* ICT trend, which eventually provides an optimal development/use of ICT instruments:

“Some companies that used to release new functionality every six months are now able to build and deploy new data outcomes in weeks...Data product owners are responsible for the overall data products value chain and to ensure its success throughout its entire lifecycle. This lifecycle is from the creation of data products to their eventual retirement. In the previous ‘project-led’ approach, there was no accountability and data assets created for the duration of the project were never purged once their utility was over.”

In a concrete expression, we have to treat data products with special attention, as a new type of product, but with features and impact on industry and beyond, as they are linked, in more and more complex ways, with the advanced ICT products, systems and services, at Earth scale.

As a consequence, **we would propose that data products and similar new concept provided by ICT for IS toward KBS to be treated like other sensible products (food, vegetables and so on), considering the appropriate environmental variable conditions, but in this case the known “time sensitivity” has to determine a more large/complex family of consequences/measures, because of the fast changes ICT and IS/KBS generate under the processes of knowledge refining we repeatedly mentioned [11][17][13][19].**

Some examples of such approaches and measures could be similarly observed in the further analysis of *data products* consequences, first considering their developers:

“There is a higher emphasis on doing higher value-add tasks that support business imperatives, in contrast to the past when a lot of effort was spent in performing overhead tasks. Many of those tasks are now handled by the cloud provider, or are automated. The ability to focus on the business needs is enabled by an automated low-code developer platform that handles underlying infrastructure enablement tasks.”

As we have mentioned above, some complicated conditions/requirements of the business ecosystem must be changed for a new/improved progress launch, as even some definitions/paradigms should be considered:

“In the modern approach, it is imperative to increase the definition of a developer. Some developers may be SQL experts, but other ‘citizen developers’ need a visual drag-and drop platform to explore data assets. The latter want ‘self-service’ capabilities without depending upon an overburdened data engineer to deliver their requests.”

We have to notice the subtle/complicate ways ICT is involved in these apparently human resources processes, as initially it is about decreasing the engineers role, not always being necessary experts for structured query language (SQL) to manipulate data, but later we see that, in fact, it is about changing their tools, for a better efficiency:

“To speed up the delivery of data products, one of the biggest impacts is via using tools that offer business users a visual interface with no-code or low-code tooling, while automatically generating code that savvy developers can customize. This low-code platform enables citizen data engineers and citizen analysts who are not well versed in coding techniques but need to prepare data for their own initiatives to use visual drag and drop and intuitive user interfaces and quickly build pipelines, reuse existing artifacts and start analyzing

data. As organizations enhance their maturity in enabling data products, they add the ability to measure benefits, like the frequency of new releases, and the usage of data products.”

Here we have just observed **some subtle ways the ICT could leverage the World progress by innovating its tools, but not in the same fast and sophisticated ways, as they have to find simpler and more business-oriented solutions/tools/advances.**

There is no doubt that **these partial approaches, versus the complexity of World changes and uncertainty require further and continuously analyses to be done, at Earth scale and with appropriate knowledge refining.**

3. Conclusions

We consider that searching new paradigms for World progress could start by evaluating **“right tracks of development”**, in a highly connected World, where the democracy is prevailing (at least till now!) and average development is the result of global tendencies/innovations, including knowledge refining. The democracy and the market economy generate, either good and bads, development tendencies, as reflecting “most people and incumbents” options and eventually their knowledge - which should be refined in the actual dynamic World context.

A basic premise for any progress should consider the ICT crucial role, as it became the main driving factor of the human society by the complex consequences of its products, applications and services, when supporting the IS on the way towards the KBS, as we already approached in [15][13].

It is sure that the real World’s context, processes and evolutions are much more complex and complicated than the suggested generic model of democracy, but this is the reason to consider it as a starting point, when analyzing the actual Earth ecosystem and its premises of development, using some relevant examples.

Approaching the ICT role in this connected World and considering Maslow pyramid as reflecting the essential needs of humankind, which must be a base for reducing uncertainty/approximation in the above mentioned “options”, we expect to find some reasons/ways which could lead to the **“right tracks of development”** when facing the mentioned unprecedented levels of concern or danger for Earth and humankind evolution. This way it resulted that the energy is among the primary needs of progress and the research in this domain is perhaps the most important, but also difficult, as World is facing at least 3 combined sources of crises, considering global warming (climate changes), Earth resources fading and consumption.

In fact, as an average dependence, the global warming was (and is) mostly influenced by the way we generate and use the energy for the global processes, resulting that the luck of having on Earth plenty of fossil resources for World amazing industry progress, including the exponential pace given by ICT, is now the main factor (from the above 3), we have to reconsider/mitigate.

In concrete/practical approaches, we could recall the research for alternative (non fossils) sources of energy, revolutionary battery technology (pointing the future electrical cars and even aircrafts) and so on, but even the nuclear energy technology, by its already spread use and potential, is the target of many research centres, one being analysed by the example of *Thorium nuclear energy* [1]. We also concluded that, in this new context, the role of ICT, to leverage the data extraction from uranium experience/processes and the necessary knowledge refining for *thorium* use, could be benefic and significant.

Looking for the relevant links of ICT development with World general progress versus actual challenges, including the energy crises, we have to recall the huge energy consumption of ICT planetary products and services [19][11]. On the other side, it is known that **the race of**

ICT towards new performances (capacity, speed, memory, miniaturization etc.) has been more and more linked and even limited by the energy/power consumption, where Cloud, AI or Blockchain are relevant cases.

We have analyzed an example that reveals how Blockchain, one of the advanced ICT applications, are severely complicated/limited by energy factors to be considered [2]. It is important to notice that the network development requires not only energy but also performant hardware able to compete in *hash-puzzle* generation. For a such complex and complicate ICT application/system, the *hash-puzzle solving power* metric and the corresponding figures could be used to improve the energy consumption, while studying the system operation general cost. The final estimations/results showed a huge energy consumption, versus other global ICT applications, putting in a realistic picture the challenges ICT has to face at Earth scale, especially for complex products, applications and services where energy is a main ingredient for providing high performances, **needing further timely analyses and even new approaching models in order to optimize the development and provide sustainable progress.**

The complex and complicate premises of approaching the innovation of World progress are much beyond from only considering the generation and consumption of energy, especially in the context of optimally developing the huge domain of ICT as global impact at Earth scale. Counting the energy basic factors, to the improved right tracks of progress, there is a long and winding road for ICT to lead the World toward mitigating the consequences of emergent crises.

As even the basics of ICT industry, first including telecommunications and computers, should be radically improved to meet the high requirements of *carbon-aware*, **among the most important challenges for ICT context development, along with direct energy consumption (power), eventually, we could include the complex relations between performances (capacity, speed, memory and so on) and power, the extension of the 5G(6G) networks, IoT or energy costs increase.**

This way, we have analyzed the impact of energy on data centers [4], as they became, in the Cloud applications proliferation context, the highest power consumers. Their needs for power are difficult to be reduced while their capacity/performances would increase, although more and more research is continuously done, on all implied factors, including both hardware and software of the equipments and systems. Here we observed that all the prior expertise is used to optimize the relation performance/power or memory/time, but actually it is necessary to rethink the models, for both device and network scale, including *carbon-aware software engineering*.

As we observed earlier [11], the difficulty of finding solutions for the actual crises lies also on the high/apogee levels of performances and progress we are in. This way we have to agree that the old improvement solutions have already reached their maximal potential benefits. Consequently, the necessity of *new computing paradigms* [4], as part of the larger picture we have mentioned from the beginning (**changing some paradigms of what we long time considered normality**), resulted, based on some holistic principles, for all the ecosystem (nota bene: **including education and further knowledge refining**), to follow in a very complicate ICT context. **We consider that these principles respond to the complex and dynamic context of World crises, where ICT has to “heal first its own wounds”, while leveraging the expected solutions for the whole Earth ecosystem by their obvious quality to be easy applied in larger environments or domains.**

More than only improving ICT software, the business processes could benefit in efficiency and efficacy by improving the thinking of organization/processes strategies and data tools, still involving ICT, but with updated approaches of using resources, including humans and technology [6][9][22]. The practical consequences of such changes of

paradigm will provide a higher flexibility in development and a faster updating the business to the emergent World challenges, targeting the new progress solutions. Such modern approaches of business processes could use the concept of *data products*, as detailed in [5], but we think that these also reflect the increasing value of using data/information in the Data Deluge era, with the *green* ICT trend, which eventually provides an optimal development/use of ICT instruments.

Our conclusion is that we have to treat *data products* with special attention, as a new type of product, but with features and impact on industry and beyond, as they are linked, in more and more complex ways, with the advanced ICT products, systems and services, at Earth scale. As a consequence, we would propose that data products and similar new concept provided by ICT for IS toward KBS to be used like other sensible products (food, vegetables and so on), considering the appropriate environmental variable conditions, but in this case the known “time sensitivity” has to determine a more large/complex family of consequences/measures, because of the fast changes ICT and IS/KBS generate under the processes of knowledge refining we repeatedly mentioned [11][17][13][19].

As a final conclusion, we have just observed **some subtle ways the ICT could leverage the World progress by innovating its tools, but not in the same fast and sophisticated ways, as they have to find simpler and more business-oriented solutions/tools/advances.** There is no doubt that **these partial approaches, versus the complexity of World changes and uncertainty require further and continuously analyses to be done, at Earth scale and with appropriate knowledge refining.**

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