

Using information and communication technology advances to leverage the search of the World new balance with less resources

-Part 4-



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Abstract

The paper analyses the context of the sustainable development of information and communication technology (ICT), for supporting the Information Society (IS) on the way towards the Knowledge Based Society (KBS) and facing the unprecedented World challenges (like climate changes, Earth resources fading, geopolitical crises, social unbalances and so on). At Earth scale, ICT power of connecting people must have a huge role for leveraging and harmonizing the humankind efforts, in order to refine knowledge all over the World with proper content and speed, versus the above context challenges.

Analyzing some relevant examples of ICT trends/results led to concrete elements and even complementary issues for the above context premises. Recalling that semiconductors industry is one of the highest energy consumers on Earth, because of the involved long thermal processes and also of their products global proliferation, in the general context of ICT carbon footprint which exceeds all planes flights, referring to 2016 Paris Agreement on global warming [19], the issue must be updated with new requirements, according to the newest standards and international targets (*International Energy Agency's Net-Zero Emissions by 2050 Scenario*) as by [1]. Another analysis (a deeper approach) pointed the recent advances in the new field named carbon-aware computing (CAC) by [2] and led to the necessity of "frameworking" the complex associated activities/processes of CAC, a difficult way of research, including new approaches/models/algorithms or even change paradigms. All these could mean that **the role of ICT in IS/KBS remains prominent, but the World sustainable progress requires refining knowledge at Earth ecosystem scale, with harmonized and continuous updated efforts**. We further approached some concrete ways to analyze the contextual mechanisms where relevant information could be generated and then transformed in updated useful knowledge and eventually leading to the expected actions and results. The critical issues for refining knowledge could be generated by using the proper data and the associated processes as inputs for the ICT mentioned advances, as the analysis of the relevant field of organizations productivity from [4] proved, but requiring a comprehensive approach, including some actual data needs, where the management ones are paramount and must reflect data-as-a-product, which needs a much wider base for optimization factors, including humans (data consumers) at the end of the line.

We concluded that, now, any improvement/solution should include a **more** comprehensive/holistic approach, which inherently will consider in model/equation **more** complicate and changing "actors"/factors, but unfortunately **more** of them contain **more** uncertainty – a crucial feature of actuality and future. Analysing and eventually mitigating (part of) uncertainty, including ICT advances help, where AI has an increasing role, it is also approached in [5], where the known problems of uncertainty are transferred at the level of AI/ML, but, for facing ML concrete limitations, a principle solution for the AI/ML model confidence improvement is to add reference data in order to calibrate the uncertainty, as, in a deeper domain/approach (a deeper learning), we have to choose/identify those added reference data, among the alternate or closed probabilities of events (contingencies).

Finally, **finding the most probable scenarios/events, in every ICT/AI/ML application case or system, is not only a complex problem of modelling, but, since the human nature and human decisions are largely implied, we consider that harmonizing and synchronizing all relevant data/actions is paramount for the best results at Earth scale and we have to notice the importance of every little step on such long and winding road, which could be reached by timely analyses and combining ICT/AI with human intelligence/values.**

Keywords: net-zero carbon emissions, carbon-aware computing, data-as-a-product, data transformation, calibrated uncertainty, artificial intelligence, machine learning, refining knowledge

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

1. ICT between keeping trends and stringent market requirements

When the whole World seems to be troubled by aggressive changes and incertitude, looking for best ways to face crises and forecast development solutions is perhaps a frequent and complicated preoccupation of people and incumbents, although at different levels and areas.

Still, sooner or later, some ideas could be convergent and useful for all areas, as the major planetary problems should be ubiquitously recognized/identified and understood, in order to maximize the chances to harmonize the humankind efforts against actual and emergent unprecedented World challenges, like climate changes, Earth resources fading, geopolitical crises, social unbalances and so on.

Facing such complex and dynamic challenges, at Earth scale, knowing the usual potential of the people and organizations it is clear that *information and communication technology (ICT)* must have a crucial role for leveraging and harmonizing the mentioned humankind efforts, in order to refine knowledge all over the World with proper content and speed, versus the context challenges we have already approached [3][11].

More than these contextual premises, *the complex consequences of ICT services, products, systems and applications which are supporting the Information Society (IS) on the way towards the Knowledge Based Society (KBS)* are generally known but should be timely analyzed for leading to development optimal/sustainable solutions, versus the actual and emergent World challenges, in all humankind areas of activity [7][8][12][17][18][22].

This way, the ICT development needs to be analyzed on multi-criterial optimization bases, considering also the usual(high) pace of the last decades and the fundamental World/market requirements for a sustainable-only progress in all domains of human activity. We have to recall the relevance of the recent exponential pace of ICT, as, beyond the sustainable implications of the climate changes and Earth resources fading at least, the high speed induced in many other industries/domains could generate, along with benefic consequences, new challenges in the actual and emergent unprecedented World crises context.

We also have observed that one of the most complex implications of the mentioned high speed consists in the limitation of time required to identify, analyze and properly react to all the consequences of such model of development, at Earth scale, which is perhaps one of the less visible/considered causes of some of the actual World crises [24][13].

Analyzing some relevant examples of ICT trends/results could add concrete elements and even complementary issues for the above context premises of approaching the actual and emergent World complex challenges, involving both Earth ecosystem and humankind evolution.

It is a matter of fact that, generally, ICT development and products are mainly depending on what is usually called semiconductors, although this family includes a variety of technologies and is in a continuous change for improvements, but, in the same time, their strategic role in World economy is recognized, as it is also confirmed, in the actual context, by [1]:

“Growing demand for semiconductors means industry emissions are likely to increase. Semiconductor companies are making sustainability commitments, but more is needed to achieve net zero. For the past few years, semiconductor companies have focused on

addressing the chip shortage and directed their energies into increasing supply. But another customer imperative, as well as the health of the planet, now requires increasing attention: the need for greater sustainability. Many end customers are already asking their suppliers, including semiconductor companies, to step up their efforts to reduce greenhousegas (GHG) emissions to achieve net-zero carbon emissions along their entire supply chain ...Suppliers are taking heed of these requests, both to retain business and to join in the fight against global warming.”

Here we have to point, from the beginning, the indirect reality that semiconductor industry is one of the highest energy consumers on Earth, because of the involved long thermal processes and also of their products global proliferation, in the general context of ICT carbon footprint which exceeds all planes flights, as we analyzed too, referring to 2016 Paris Agreement on global warming [19], but here the issue is clearly updated with new requirements:

“The urgent need to increase sustainability efforts comes just as semiconductor production ramps up to meet growing demand and more sophisticated chip designs are required for leading-edge mobility, computing, and connectivity applications. As production increases, however, so do emissions. Even with major semiconductor companies’ latest commitments, which are more stringent than past measures, the industry is not on track to limit emissions to the extent required under the 2016 Paris Agreement, which aims to restrict the mean rise in global temperature to 1.5°C from preindustrial levels. Some semiconductor companies have recently set more aspirational emissions-reductions targets, but getting the industry to net zero will require more comprehensive action... wide road map that could be considered by semiconductor device makers seeking to achieve a 1.5°C trajectory by 2030 and net-zero emissions by 2050.”

As we also often observed and similar to other challenges of ICT too, along with the existing development trends, the needed efforts of improvement are harder as we advance on a growing scale of performances, requiring considerably investments on innovation, according to the newest standards and international targets:

„In addition to describing how companies can apply existing levers to reduce emissions, the road map highlights the importance of developing new or improved carbonization technologies—a lengthy process—and increasing the supply of renewable energy...In line with the Science Based Targets Initiative’s Corporate Net-Zero Standard ...

To determine how much emissions would need to decrease by 2050, we followed the International Energy Agency’s Net-Zero Emissions by 2050 Scenario, in which energy and industrial-process CO₂ emissions fall by 95 percent between 2020 and 2050...Even with major semiconductor companies’ latest commitments, the industry is not on track to limit emissions to the extent required under the 2016 Paris Agreement...”

This way we have just arrived to the critical points in the core of these ICT challenges, which, on the other side, have the advantage to be useful, if properly and soon solved, for other similar (non-ICT) industrial processes:

“Emissions from semiconductor device makers fall into different categories:

-Scope 1 emissions arise directly from fabs, primarily from process gases with

high global warming potential (GWP) that are used during wafer etching, chamber cleaning, and other tasks; they can also come from high-GWP heat transfer fluids that may leak into the atmosphere when fabs use them in chillers.

-Scope 2 emissions arise directly from purchased electricity, steam, heating, and cooling equipment; the major sources include production tools and facilities/utilities.

-Scope 3 emissions include all other indirect emissions in a company's value chain; upstream emissions are those generated by suppliers or their products, while downstream emissions are related to the usage of products containing semiconductors."

Finally, a relevant and useful picture of the stage we are in is presented based on integrating the specific industry actors' actual results, in order to reveal the relevance of production processes and eventually lead the efforts/investments priorities:

„By aggregating emissions data from key semiconductor device makers, the percentage of emissions classified as Scope 1, 2, or 3 upstream can be determined ... Our research revealed that 35 percent of emissions at a typical semiconductor fab fall into the Scope 1 category, compared with 45 percent for Scope 2, and 20 percent for Scope 3 upstream. This breakdown can vary by fab, however, based on various factors, including the amount of renewable energy used and the extent to which process-gas-abatement systems have been implemented."

Naturally, the analysis may be continued with critical technical, economic and decisions details, from case to case, but here it is clear that commitment and emergency are World priorities in these ICT directions [14][15].

The next example will reveal a deeper approach, where the ways ICT significant energy consumers could benefit from the recent advances in the new field named carbon-aware computing are presented [2]:

“Computing economics is partially a function of energy availability and energy costs. Human factor issues, clearly, must also be considered. However, here, we argue for the need to create a framework(s) for how to view the problem solely from energy considerations. The energy consumption costs of computing activities such as blockchain, data centers, supercomputing, and cryptographic applications have recently come to increased public and media attention. Nations, states, and cities are beginning to mandate energy-efficient computing in public works, and meanwhile, corporations, investors, and others are demanding the same from the private sector.”

We have to observe the global relevance of this approach, not only due to the ubiquitous applications of computing, but also by confirming the huge actual interest and importance of optimizing the energy consumption in this prominent area of ICT, either for both public and private entities, which lead to the necessity of “frameworking” the complex associated activities/processes:

“We term any activity in response to these demands and mandates as carbon-aware computing, although we can also say “power-aware computing” or “energy-efficient computing” because the reduction of power consumption is an important problem regardless of the origin of the power. The focus on carbon-aware computing presents challenges and opportunities. A successful response to these opportunities and challenges should theoretically result in a reduced carbon footprint of major computing activities and could lead to the

discovery of new ways to optimize computing. However, these outcomes would need to be supported by a priori and posteriori research.”

It is clear that the concrete solutions for reaching those targets could come on a long way of research, but here we point the importance of structuring and identifying mile-stones on this long and winding way:

“Carbon-aware computing includes hardware, software, and systems. Addressing the energy concerns of these three could provide government and industry with new sustainable solutions and business opportunities. For example, integration of wireless charging, energy harvesting, or “greener clouds” (cloud computing services that are competitively advantaged due to reduced energy consumption). Enablers for carbon-aware computing include retooling of existing optimization techniques for time and memory trade-offs that can be adapted for energy efficiency.”

Last, but not least, as we also presented in many cases [6][9], when developing ICT and aiming higher performances, especially under unprecedented challenges, it is important to look for new/better approaches/models/algorithms or even change paradigms:

„Algorithm efficiency is also important. Inhibitors to carbon-aware computing stem from the traditional computing paradigm, which evolved largely without regard to the costs of energy consumption (an exception is embedded computing systems). There is also a historical precedent for energy-aware computing in embedded systems that we shouldn’t forget.”

Such analyses/examples show one more time that the search for improvements in ICT development is more and more difficult, the optimization is more complicate, as the World context is more complex/unpredictable and the start level of performances/benefits are higher.

With other words, our World are in a stage of high level of consumption/development which is extremely difficult to rise or even maintain in sustainable ways, facing the emergent and dramatical consequences of climate changes, Earth resources fading, geopolitical crises or social unbalances.

All these could mean that the role of ICT in IS/KBS remains prominent, but the World sustainable progress requires refining knowledge at Earth ecosystem scale, with harmonized and continuous updated efforts.

2. Knowledge refining, data transformations and uncertainty

As refining knowledge is a general and complex target, especially in the huge Earth ecosystem, it is realistic to approach concrete ways to analyze the contextual mechanisms where relevant information could be generated and further transformed in updated useful knowledge and eventually leading to the expected actions and results [6].

For example, time proved that, in complicate and global challenges, irrespective the individual efforts which have been, the best results at planetary scale could be obtain only by united/harmonized extended actions/contributions of the worldwide people and organizations.

Also confirming and explaining our initial assertion about convergent thinking and actions, using the leveraging role of ICT in IS/KBS and its advances, including (artificial intelligence)AI, (Internet of Things)IoT or Cloud, in specific applications for cooperation and real time synchronization, we could improve the chances, efficacy and efficiency of any

approach/action of fighting the actual and emergent unprecedented World challenges, where climate changes, Earth resources fading, geopolitical crises or social unbalances are prominent and among most difficult to mitigate.

Recalling again this huge World challenges may seem redundant, but they are the reference roots of actual and future worst scenarios we should imagine in order to design the new development options/solutions, first including the ICT areas.

On the other side, such scenarios/premises should consider continuous actualized data across the Earth ecosystem context, where environmental, economic, human/health/behavioral or conceptual data in their processes and trends could be analyzed, using the ICT advances like AI, IoT, Big Data or Cloud [16][21].

Now we have just arrived at the point where the critical issues for refining knowledge could be generated by using the proper data and the associated processes as inputs for the ICT mentioned advances, with approaches like the analysis of the next example presents, aiming the relevant field of organizations productivity [4]:

“Delivering stupendous business productivity is every organization’s holy grail. We have been chasing this dream for decades. It turns out that data teams have a pivotal role to play in this. High developer productivity enables businesses to innovate faster and deliver high-quality data outcomes rapidly. Software engineering made strides, in the early 2000s, with the introduction of disciplines like product management, agile development and DevOps. The data teams are now beginning to adopt the same principles. With the advent of cloud computing, these trends have only accelerated. If the current advancements continue, the space of data applications will look very different in the next 3 - 5 years.”

Starting from the premises of software engineering improvements, the next step is adapting to the reality of Cloud computing, Big Data and AI, but understanding that refining knowledge to a higher data productivity needs a *comprehensive* approach:

“But what are the key ingredients to data team productivity? IT teams have obsessed over a technology-centric approach to modernizing data infrastructure. However, this approach has only led to an increasingly complex data ecosystem. Thus, improving data productivity must be comprehensive and include sociotechnical aspects. The modern data stack was already bursting at the seams long before generative AI became the talk of the town due to steep increase in the number of data sources, data consumers, and use cases. As the world fixates on AI-driven data outcomes, there is an immense urgency to modernize the underlying data infrastructure to meet the data needs of the business in a manner that is trustworthy, reliable, timely and, of course, accurate. In addition, there is already a rallying cry for simplification and complexity reduction. To address these needs, it is imperative to reduce data stack complexity, which further helps increase reliability of the infrastructure components.”

Because the comprehensive approach is a general concept, our main view on properly refining knowledge could be seen by some actual *data needs* (*trustworthy, reliable, timely and, of course, accurate*), but we think that the new challenge of *complexity reduction* is perhaps the most difficult to handle when speaking about large/complex ecosystems, advanced technologies infrastructures and high pace of changes:

“It is quite plausible that in a few years, the world would have pivoted towards some new invention to derive intelligence. However, a strong data transformation foundation, will allow organizations to address new technologies and advancements. It helps organizations

future proof its IT investments and respond to changes quickly. To achieve this goal, certain best practices have to be applied and to rethink the data transformation approach. This whitepaper explores the three critical business needs and provides a roadmap to handle current and future data engineering use cases.”

Adding such requirements to the data transformation processes, it leads to their practical holistic approach and emphasizes the actual relevance of the management and human issues for proper refining of knowledge (*rethink the data transformation approach*), in order to get an efficacious and efficient mitigation of the World crises:

“Data transformation processes today are fragmented and under heavy pressure to address business needs at near real-time speed. For example, let’s say the marketing team launches a new campaign. They need real-time information on campaign performance to make instant decisions. If your data engineering team is busy handling data downtime crises or is otherwise backlogged, then the marketing team won’t have the data-driven insights they need to ensure the campaign meets its goals. The modern holistic approach should consider organizational and process aspects besides the technical facets.”

Among the main principles we should generally consider for a practical holistic approach, the organizational/management ones are paramount and must reflect *data-as-a-product*:

“We spent the past decade amassing more data, but the current decade is more concerned with ensuring we have the right data. This is the decade where new options of delivering data, such as data mesh, data products, data sharing, exchanges, and marketplaces are starting to become mainstream. Data mesh introduced four principles, two of which are domain-driven data ownership and data-as-a-product. These two principles are being utilized in increasing numbers whether an organization is interested in the overall data mesh concepts or not. The reason for an uptick in building data products is because of the urgent need to accelerate time to value from data assets.”

Here we have to underline that, beyond the crucial paradigm of considering the data a business product, it is important to go further, in the actual context of IS/KBS and World crises (*accelerate time to value from data assets*), these assets (data) are more than business relevant, being the main ingredient of refining knowledge for the Earth ecosystem, which needs a much wider base for optimization factors, where humans (*data consumers*) must be seen at the end of the line:

“Data products turn the data-as-a-product principle into an actionable and consumer-driven asset that uses product management principles. It helps data producers and data consumers be accountable and responsible for data’s quality, availability and reliability. Prior to this decentralized approach, data stewards and governance teams were introduced into the mix. However, the people who best understand the context of data are the data producers. Data governance and data quality are inextricably mixed. You can’t have one without the other.”

It is now **more** obvious that, in the actual World complex context/crises, any improvement/solution should include a **more** comprehensive/holistic approach, which inherently will consider in model/equation **more** complicate and changing “actors”/factors, but unfortunately **more** of them contain **more** uncertainty – a crucial feature of actuality and future.

We repeatedly expressed our opinion, [22][24], that the road toward the mentioned solutions is through refining knowledge for the Earth ecosystem, while analysing and

eventually mitigating (part of) uncertainty, including ICT advances help, where AI has an increasing role, as it is also approached in the next example [5]:

“Modern AI systems commonly use machine learning (ML) models to make important, domain-relevant inferences about their environment. However, these models are often used in the presence of uncertainty. This can cause inaccurate results in scenarios where humans would reasonably expect high accuracy. Also, some commonly-used ML models do not accurately estimate uncertainty. This can cause their predictions to be wrong. Worse, these inaccurate estimates of uncertainty make it difficult to predict when a model’s predictions will be wrong. AI system components and humans who use the model’s output are then forced to reason with incorrect inferences that they think are correct.”

Although, generally, the problems of uncertainty are long time known, their solutions became much difficult as their sources and consequences became more complicate as the IS/KBS, World crises and the Earth ecosystem have increased in complexity, a reality that is transferred also at the level of AI/ML:

“Modern neural networks often make predictions with high confidence regardless of their accuracy. In other words, they are overconfident. For example, finding a car in aerial imagery is a common analysis task. Since neural networks are very good at detecting objects in images, a human intelligence analyst might use a neural network-based tool to find a car in overhead photos. The upper part of the example figure shows two possible matches for the car in question. The neural network is very confident in its prediction! It computed a raw confidence of 0.9773 (or 97.73%) that the car on the left is a match and a raw confidence of 0.9834 (or 98.34%) that the car on the right is a match. There is just one problem: the car can only be in one place at a time! Both cars cannot be matches, despite their high confidence scores. How can our intelligence analyst tell which one is correct? The raw confidence score is unrelated to whether the neural network correctly identified the car.”

Starting from such concrete limitations, it seems that a principle solution for the AI/ML model confidence improvement is to add reference data in order to calibrate the uncertainty:

“Calibrated uncertainty is more useful to our intelligence analyst than raw uncertainty. It factors in the likelihood that a model will make correct predictions. The calibrated confidence scores in the lower half of the example figure show a much higher confidence for the car on the right (0.9834, or 98.34%) than the car on the left (0.2463, or 24.63%). This tells our intelligence analyst to focus attention on the car on the right. Calibrating the uncertainty in a neural network’s prediction led to a better outcome.”

Beyond the generic example, the real problem is now transferred in a deeper domain/approach (a deeper learning), where we have to choose/identify those added reference data, among the alternate or closed probabilities of events (contingencies):

“To solve the problems caused by uncertainty in machine learning (ML), we need to find out when our ML systems do not know things. We can manage uncertainty by quantifying it, examining its sources, and fixing its causes. From an AI Engineering perspective, many AI systems incorporate ML models as system components. Calibrating uncertainty informs downstream AI system components that a model’s inferences may not be correct and they should therefore use contingencies. Detecting and rectifying uncertainty stand as best practices for iterating on ML models. This makes the process of maintaining ML models more rigorous, which in turn leads to more reliable and accurate AI applications.”

Further, **finding the most probable scenarios/events, in every ICT/AI/ML application case or system, is not only a complex problem of modelling, but, since the human nature and human decisions are largely implied, we consider that harmonizing and synchronizing all relevant data/actions is paramount for the best results at Earth scale.**

From such ICT/AI principle approaches towards useful help for solving the main real problems in the Earth ecosystem, or even some at the World crises level, it is sure a never-ending road, but we have to notice the importance of every little step on such long and winding road, which could be reached by timely analyses and harmonizing all implied factors, first including ICT/AI with human intelligence/values.

3. Conclusions

Facing aggressive changes and incertitude, while looking for best ways to mitigate crises and forecast development solutions, became major issues for people and incumbents, although at different levels and areas, as the planetary problems should be ubiquitously recognized/identified and understood, in order to maximize the chances to harmonize the humankind efforts against actual and emergent unprecedented World challenges, like climate changes, Earth resources fading, geopolitical crises, social unbalances and so on.

At Earth scale, ICT power of connecting people must have a crucial role for leveraging and harmonizing these humankind efforts, in order to refine knowledge all over the World with proper content and speed, versus the above context challenges we have already approached [3][11]. The complex consequences of ICT services, products, systems and applications which are supporting the IS/KBS are generally known but should be timely analyzed for leading to development optimal/sustainable solutions, versus the actual and emergent World challenges, in all humankind areas of activity.

We have to notice the relevance of the recent exponential pace of ICT, as, beyond the sustainable implications of the climate changes and Earth resources fading at least, the high speed induced in many other industries/domains could generate, along with benefic consequences, new challenges in the actual and emergent unprecedented World crises context. One of the most complex implications of this high speed consists in the limitation of time required to identify, analyze and properly react to all the consequences of such model of development, at Earth scale, which is perhaps one of the less visible/considered causes of some of the actual World crises [24][13].

Analyzing some relevant examples of ICT trends/results led to concrete elements and even complementary issues for the above context premises of approaching the actual and emergent World complex challenges, involving both Earth ecosystem and humankind evolution.

Recalling that semiconductors industry is one of the highest energy consumers on Earth, because of the involved long thermal processes and also of their products global proliferation, in the general context of ICT carbon footprint, which exceeds all planes flights, referring to 2016 Paris Agreement on global warming [19], the issue must be updated with new requirements.

ICT development and products are mainly depending on semiconductors and their strategic role in World economy is also confirmed, in the actual context, as we analyzed [1], where *net-zero emissions* possibilities for 2050 are pointed, according to the newest standards and international targets (*International Energy Agency's Net-Zero Emissions by 2050 Scenario*). As we also often observed and similar to other challenges of ICT too, along with the existing development trends, the needed efforts of improvement are harder as we advance on a growing scale of performances, requiring considerably investments on innovation. A relevant and useful picture of the stage we are in is presented based on integrating the specific industry actors actual results, in order to reveal the relevance of ICT production processes and eventually lead the efforts/investments solutions, but it is clear that commitment and emergency are World priorities in these ICT directions.

We further analysed a deeper approach, where the ways ICT significant energy consumers could benefit from the recent advances in the new field named *carbon-aware computing (CAC)*, presented by [2]. The ubiquitous applications of computing and the huge actual interest and importance of optimizing the energy consumption in this prominent area of ICT, either for both public and private entities, led to the necessity of “*frameworking*” the complex associated activities/processes of CAC, a difficult way of research. Here we pointed the importance of structuring and identifying mile-stones on this long and winding way, because, while developing ICT and aiming higher performances, especially under unprecedented challenges, it is important to look for new approaches/models/algorithms or even change paradigms.

The analyses/examples showed one more time that the search for improvements in ICT development is more and more difficult, the optimization is more complicate, as the World context is more complex/unpredictable and the start level of performances/benefits are higher, i.e., **our World are in a stage of high level of consumption/development which is extremely difficult to rise or even maintain in sustainable ways, facing the emergent and dramatical consequences of climate changes, Earth resources fading, geopolitical crises or social unbalances.** All these could mean that **the role of ICT in IS/KBS remains prominent, but the World sustainable progress requires refining knowledge at Earth ecosystem scale, with harmonized and continuous updated efforts.**

Agreeing that refining knowledge is a general and complex target, especially in the huge Earth ecosystem, we further approached some concrete ways to analyze the contextual mechanisms where relevant information could be generated and then transformed in updated useful knowledge and eventually leading to the expected actions and results.

Fallowing our initial assertion about convergent thinking and actions, using the leveraging role of ICT in IS/KBS and its advances, including AI, IoT or Cloud, in specific applications for cooperation and real time synchronization, we could improve the chances, efficacy and efficiency of any approach/action of fighting the actual and emergent unprecedented World challenges, where climate changes, Earth resources fading, geopolitical crises or social unbalances are prominent and among most difficult to mitigate, but they are also reference roots of actual and future worst scenarios we should imagine in order to design the new development options/solutions, first including the ICT areas. Such scenarios/premises should consider continuous actualized data across the Earth ecosystem context, where

environmental, economic, human/health/behavioral or conceptual data in their processes and trends could be analyzed, using the ICT advances like AI, IoT, Big Data or Cloud.

The critical issues for refining knowledge could be generated by using the proper data and the associated processes as inputs for the ICT mentioned advances, as the analysis of the relevant field of organizations productivity from [4] proved.

Starting from the premises of *software engineering* improvements, the next step is adapting to the reality of Cloud computing, Big Data and AI, understanding that refining knowledge to a higher data productivity needs a *comprehensive* approach, including some actual *data needs (trustworthy, reliable, timely and, of course, accurate)*, but we think that the new challenge of complexity reduction is perhaps the most difficult to handle when speaking about large/complex ecosystems, advanced technologies infrastructures and high pace of changes. Such requirements and their practical holistic approach, where the organizational/management ones are paramount, must reflect *data-as-a-product*, but these assets (data) are more than business relevant, being the main ingredient of refining knowledge for the Earth ecosystem, which needs a much wider base for optimization factors, where humans (*data consumers*) must be seen at the end of the line.

We concluded that now it is **more** obvious that, in the actual World complex context/crises, any improvement/solution should include a **more** comprehensive/holistic approach, which inherently will consider in model/equation **more** complicate and changing “actors”/factors, but unfortunately **more** of them contain **more** uncertainty – a crucial feature of actuality and future.

Analysing and eventually mitigating (part of) uncertainty, including ICT advances help, where AI has an increasing role, it is also approached in [5], where the known problems of uncertainty, as their solutions became much difficult as their sources and consequences became more complicate as the IS/KBS, World crises and the Earth ecosystem have increased in complexity, are transferred at the level of AI/ML. For facing ML concrete limitations, it seems that a principle solution for the AI/ML model confidence improvement is to add reference data in order to *calibrate the uncertainty*. Consequently, the issue is now transferred in a deeper domain/approach (a deeper learning), where we have to choose/identify those added reference data, among the alternate or closed probabilities of events (*contingencies*).

Finally, **finding the most probable scenarios/events, in every ICT/AI/ML application case or system, is not only a complex problem of modelling, but, since the human nature and human decisions are largely implied, we consider that harmonizing and synchronizing all relevant data/actions is paramount for the best results at Earth scale.**

From such ICT/AI principle approaches towards useful help for solving the main real problems in the Earth ecosystem, or even some at the World crises level, it is sure a never-ending road, but we have to notice the importance of every little step on such long and winding road, which could be reached by timely analyses and harmonizing all implied factors, first including ICT/AI with human intelligence/values.

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