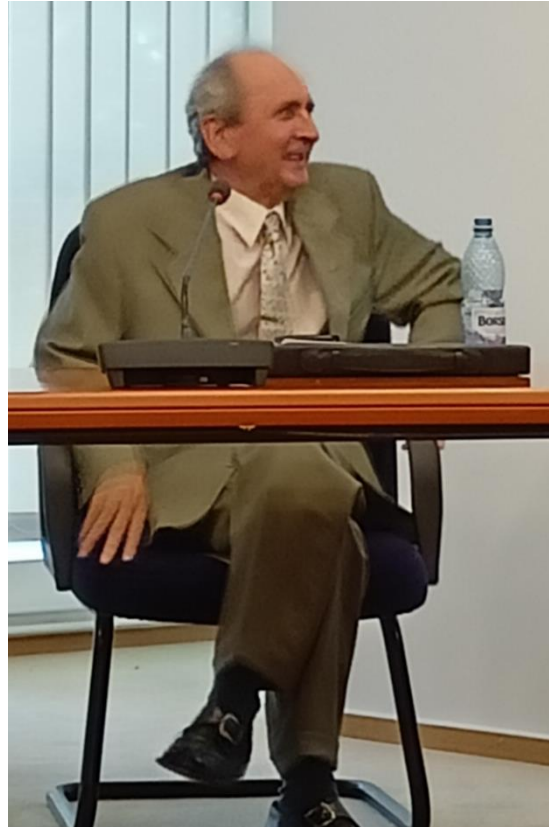


Developing Information and Communications Technology to Provide More Intelligence and Leverage More Wisdom for a Dramatically Changing World

-Part 2-



Prof. Eng. Ph.D. Victor GREU

Abstract

The paper analyses the exponential development of information and communication technology (ICT) in the emergent World dramatical changes context (WDCC), for which we have to be prepared for new rules of development or even... no rules. The link of these tendencies with the information and communications technology (ICT) is due to the fact that ICT, generally by complex and expanding ways, for decades, is already influencing the humankind and our planet evolutions, here counting mostly the benefic influences which generate the World progress, but we have to also consider, more and more, for optimal global results, all the consequences of the exponential pace ICT would/could induce to life and Earth ecosystem. The reasons to timely try to analyse all the consequences of this ICT context include the need for optimal and global results, but this is not new, while the emergency of the dramatic changes of World ecosystem rise new and extremely complicate challenges for humankind and ICT. So, it is important to evaluate the potential of ICT to enable, by artificial intelligence (AI), Big Data, Cloud, Internet of things (IoT) or other essential and powerful advances, the expected solutions for these challenges or other unexpected problems World will have to face rather sooner than later. An important feature of ICT development, which we consider necessary to be further improved for facing the dynamic and even unexpected challenges, in order to support the Information Society (IS) on the way towards the Knowledge Based Society (KBS) in the new dramatic context, is to optimally combine AI with human/crowd intelligence, when refining knowledge by the fast-changing criteria of the World ecosystem and this way leveraging the expected wisdom/sustainable based actions/evolutions.

A high ICT potential means to realistically develop its resources and that is why we have analysed some relevant issues which could at least create a short image of the results and challenges involved in the general goal of ICT optimized development, in the conditions of the emergent World dramatical changes context (WDCC). Our World dynamic context begin to look like a struggle toward unprecedented performances, in all domains,

exceeding this way the prominent case of ICT, while the actual dramatical trends/crises send us toward the prospective of surviving against such menaces for the Earth ecosystem (climate changes, Earth resources fading, social unbalances, or potential crises - like the emergent energy/food/materials or geopolitical ones). Unfortunately, unprecedented dramatical crises began to be generated by the Russia - Ukraine war, where the consequences are difficult to estimate on long term, but the food, industry and supply chains turbulences could bring crucial changes to global economy and for all balance of Earth ecosystem. This way, the need for adequate but complicate solutions will affect ICT too, which, in the same time, is expected to provide support for all human activity fields, using its huge potential of fast innovation and development.

The crucial role of technological processes by which processors, memories and other semiconductor chips are made is more than obvious for either ICT and World progress in general, but the concrete actual difficulties of such advanced processes express even more about the mentioned struggle. For example, the introduction of a 2-nanometer (nm) node chip by IBM is analysed, as the new chip will improve performance by 45 percent, versus the actual 7 nm-based chips. To reach such impressing target, a new nanosheet technology and an innovative is used, along with extreme-ultraviolet lithography (EUV).

Beyond the impressive sophistication of the 2-nm processes, we have to notice that behind the industry is the economy and the competition (IBM is ahead other companies, which reached 3-nm), but the actual World crises and dramatical changes bring even more, as beyond the competition we could perceive the geopolitical context. Still, the scientific and technological problems are yet prominent and have to be first addressed in order to step forward, considering the apogee level where we are, also from the performances point of view. Another challenge of this "era" of chips is to further improve the connections between transistors, as here the difficulty is also high, close to reaching the physical limits of the actual processes. Here we notice, along with the inherent difficulty of further improving the connections, the new kind of challenges which arise when we are on the top, even after reaching the main target, but we could encounter unprecedented problems with something that initially could appear secondary, just because the "logic" that led to the main desired solution does not apply to all parts or phases of a technical or life problem and such phenomena could be sources of the uncertainty WDCC is featuring. This way we have revealed another important feature of ICT advances, where many other fields of activity could benefit from a certain ICT result/logic beyond the direct use of ICT product/application, simply by importing the "idea", the logic or the "learned lesson", although this is not a general, but rather desired situation, as even ICT itself has to solve a lot of problems which appear along with reaching new advances or performances.

As ICT systems, products, services and applications generally became more complex or complicate, although in many cases users can see only some nice boxes or gadgets, most of them, without considering the large networks and equipments, contain electronic components and chips with a high level of integration and sophistication, growing along with the ICT advances.

Analysing some of the features of complex systems (CS) theory, we have pointed that the parameters and performances of such systems are often difficult to identify/define, just because a lot of criteria could be considered, especially for the custom-designed complex systems, where standardization provide only a part of the specifications. Also, another feature of such CS, including our Earth ecosystem subsystems in the WDCC, is the need for stability and reliability, which are naturally menaced by the incertitude of structurally changes. The reliability was always a performance indicator which is more difficult to define, compute or measure, as the system complexity increase, so it is easier to understand why, in most ICT cases, the reliability could be difficult to control, especially when, beyond intrinsic complexity, other factors should be considered, including the use conditions and sometimes the "consumption policy" - which many years considered that too high reliability or repair would be not "appropriate".

The actual tendency of Earth resources fading and the emergency of different crises, to consider just some of the mentioned challenges of WDCC, should determine us to reconsider issues like the above "consumption policy" and generally the position and content of reliability among the performances of ICT systems, products, services and applications. In some special cases, like critical infrastructures, the main reason to reconsider the reliability performances should be the security relevance in the applications context, which could be very high not only for critical infrastructures, but also generally for Earth ecosystem and people's life.

Analysing the technical issues of reliability in ICT, in a simplified electronic model, beyond other detailed deterministic causes/factors (which usually are considered and acceptably controlled), we notice that there is a hazard factor (probability of some unexpected phenomena or circumstances), which is almost impossible to precisely control. We consider that the issue of hazard could be, perhaps, linked, but in a complicate analysis that is not the paper aim, with David Hume (1739–1740) and with inspired by him No free lunch theorem, which is also useful in AI-machine learning [19][15]. In a poor design or modest system management, often the lack of controlling the usual/technical factors of reliability is claimed as the result of "hazard" and this discussion is a real challenge as the complexity of the system is increasing, i.e., just the actual and emergent complex systems, which include ICT, but in general the analysis could not be reduced to the electronic components.

The practical conclusion is that, irrespective the weight of ICT parts in a CS (for example, industrial one), in the actual stage of science and technology, ICT advances (mainly by AI and IoT, but not exclusively) could essentially contribute to the control of reliability and reducing the hazard, i.e., a very desired support for WDCC.

Based on the above general analysis, we have concluded that, along with other performance challenges, the role of reliability/hazard in WDCC will perhaps become more and more important, as it is confirmed by the analysis of a relevant example – a mobile communications network. The analysed scenario (revealing ICT negative issues) is just another face of our emergent World, versus the one (with only positive issues) we presented in the beginning of this series of papers, [3], as ICT, like the whole Earth ecosystem, could be seen as a wonder of humankind creation, but also as becoming a possible nightmare for the next generations of humans if we do not act with wisdom.

Another crucial feature of ICT is also confirmed by an example (from Australia), as the communications/connectivity ubiquity determined not only essential practical support for all activities, but also habits and even addiction for humans, which naturally will be frustrated by their sudden interruption/failing. We have to notice that this image is very relevant for the coming WDCC, where the crises and frustration could become not accidents, but frequent incidents, if ICT development will not adapt to these changes (by policies, software and hardware improvements), i.e., by refining “intelligence” with “wisdom”. From the same example, it is obvious that stop “thinking in those terms” confirms our opinion to refine knowledge addressing the new dynamic conditions and proving this way the optimal (wisdom) approach. Although the issue is only about communications networks, these are still very relevant as mobile broadband networks are becoming the universal backbone infrastructure and their global role in IS/KBS will be crucial in the WDCC, as the above proved negative consequences of low reliability.

Still, the paper considered also a larger view, as starting from the benefits ICT advances brought in the first years of Covid 19 pandemic, by enabling on line activities and other information sharing and connectivity applications, which in fact were available even before 2020. The relevant issue we could foresee is the potential of ICT to offer fast solutions or alternatives in cases of dramatical events/crises, but in the same time the essential need that such solutions to be very reliable, considering just the emergency fields they should support and imagining the damages which globally could be encountered (we have just to imagine the connectivity of future self-driving cars!). More than these, the extended proliferation and impact of ICT support in the IS/KBS, in the coming changing context, will request reliability as first performance indicator for critical infrastructure applications (power grid, governance, defence/safety, transportation etc.). Such high level of requirements will be very difficult to harmonize with the complicate premises of inherent hazard, resources fading and other factors of incertitude (yet to come), which are already prominent challenges for advanced ICT fields like AI, Big Data or IOT, where the line between intelligence and human wisdom is still a crucial bottleneck, just like the above example that should be seen in the prominent general case of connectivity (Internet/communications).

From the SCT example analysis, it is important to notice the overwhelming number of benefic ICT results and applications, at planetary scale, which prove without doubt its capacity of further supporting the IS/KBS evolution, although the need of improvement is inherently a condition of progress, especially in the WDCC. Here we can observe the impact of the SCT in the WDCC, because the pandemic challenges also generated premises of opportunities for innovation, new business models and generally refining knowledge.

Also, the crowd intelligence/wisdom is here confirmed and we consider that the coming World new challenges will request a continuous dialog between AI and human/crowd intelligence (HI), in addition to the generous channels of connectivity offered by ICT advances like IoT, Big Data, context aware communications and so on, even if the reliability of all technical systems is expected to increase, but also the uncertainty and adversity of the WDCC. The mature and globally viewed understanding for a project of development, including the ICT ones, could enable transparency, perception/view and sharing information on a certain issue/project, with reduced costs (time, energy) but greater accuracy provided by multimedia and connectivity applications. Among the benefits of refining SCT and management, in the WDCC, here the economical and social advantages are also pointed and even explicitly demonstrated, with concrete data. It is worth to notice here one of the most difficult problems of further exponential development of ICT, especially considering the WDCC, which could affect the countries and World economy increase, by the shortening of life spans of ICT systems, products, services and applications. In addition, changing the policies and management of implementing SCT could leverage local and regional economical/social benefits. As a prominent field of ICT intelligence, SCT is very relevant for the approach of critical or difficult new situations in WDCC, when lack of resources will be often the main cause of crises, but it also offers useful innovation ideas for other challenges, like converting/enabling intelligence for mature/wisdom decisions, transparency, unemployment or other social unbalances.

Our opinion is that refining the criteria of efficiency/efficacy/optimization for ICT and generally for all human activity fields is now mandatory more than ever.

As main conclusion, we consider that, everywhere, the global impact of ICT intelligence along with wisdom of decisions/solutions should be considered and improved, although, in the same time, we have to agree

that such goal, at planetary scale, is more and more complex, complicate and difficult, but this does not mean to ignore/avoid it, as it is necessary, on contrary, to further analyse all the ways to identify the solutions to reach it at appropriate time and extent (until it is not too late).

Keywords: *artificial intelligence, refining knowledge, knowledge based society, 2-nm technology, reliability, complex systems, smart-city technology*

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

*The only true wisdom is in knowing you know nothing
- Socrates*

1. Advancing ICT resources for the coming challenges

Human's habit to learn is perhaps one of the essential keys of our incredible evolution, but this seems to be necessary, but deeper, from the early childhood to the mature ages.

Recently, a young nephew also confirmed this, in a surprisingly manner, when his grandad was telling him to not say that he knows everything, because "We all have to learn as long as we live". The 5 years boy simply said: "It means that everyone knows nothing!".

It is less probable that the young man did know what Socrates said, but this could explain why so many (especially young) people believe that life and our World are going linearly, while, in fact, nonlinearity is the case and more than these, the probabilistic approach could better estimate the future, as we also have already presented [15].

It is sure that such opinions and the differences between generations are not new in history and they are also far from being rules, but we have to watch over the evolution of Earth and humankind, in order to understand, until it is not too late, to react to the essential and dramatic changes we have to face sooner or later at planetary scale.

In our more and more complex World, but more and more based on technology exponential progress, sometimes life is teaching us to be prepared for new rules of development or even... no rules. As such changes are naturally associated with complex and complicate systems, we consider that the actual relevant news is about the fact that "sometimes" tends to become "often" and "unpredictable".

Still, it is very important to point again which is the link of this tendance with the information and communications technology (ICT) [3].

It is a matter of evidence how ICT, generally by complex and expanding ways, for decades, is already influencing the humankind and our planet evolutions, here counting mostly the benefic influences which generate the World progress, but we have to also consider, more and more, for optimal global results, **all the consequences** of the exponential pace ICT would/could induce to life and Earth ecosystem.

The reasons to timely try to analyse **all the consequences** of this ICT context include the need for optimal and global results, but this is not new, while the emergency of the dramatic changes of World ecosystem rise new and extremely complicate challenges for humankind and ICT, as we have recently begun to detail them [3].

Here the point is that just the potential of ICT to enable, by artificial intelligence (AI), Big Data, Cloud, Internet of things (IoT) or other essential and powerful advances, the expected solutions for these challenges or other unexpected problems World will have to face rather sooner than later!

An important feature of ICT development, which we consider necessary to be further improved for facing the dynamic and even unexpected challenges, in order to support the Information Society (IS) on the way towards the Knowledge Based Society (KBS) in the new dramatic context, is to optimally combine AI with human/crowd intelligence, when refining knowledge by the fast changing criteria of the World ecosystem and this way leveraging the expected wisdom/sustainable based actions/evolutions [10][9][12].

For keeping high the mentioned potential, ICT must also to realistically develop its resources and that is why we will further analyse some relevant issues which could at least create a short image of the results and challenges involved in the general goal of ICT optimized development, in the conditions of the emergent World dramatical changes context (WDCC).

Before any concrete details, we have to observe that our World dynamic context begin to look like a struggle toward unprecedented performances, in all domains, exceeding this way the prominent case of ICT, while the actual dramatical trends/crises send us toward the prospective of surviving against such menaces for the Earth ecosystem (climate changes, Earth resources fading, social unbalances, or potential crises - like the emergent energy/food/materials or geopolitical ones). Unfortunately, unprecedented dramatical crises began to be generated by the Russia - Ukraine war, where the consequences are difficult to estimate on long term, but the food, industry and supply chains turbulences could bring crucial changes to global economy and for all balance of Earth ecosystem.

This way, the need for adequate but complicate solutions will affect ICT too, which, in the same time, is expected to provide support for all human activity fields, using its huge potential of fast innovation and development.

We also presented as possible such dramatical context changes/evolution, when analysing the fast pace of ICT development and its influence in all domains, against the humankind and Earth general resources to sustainably adapt in the optimal time [6].

Beginning with performance challenges, the crucial role of technological processes by which processors, memories and other semiconductor chips are made, it is more than obvious, for either ICT and World progress in general, but the concrete actual difficulties of such advanced processes express even more about the mentioned struggle, as it is also presented in [1]:

“IBM has become the first in the world to introduce a 2-nanometer (nm) node chip. IBM claims this new chip will improve performance by 45 percent using the same amount of power, or use 75 percent less energy while maintaining the same performance level, as today's 7 nm-based chips. To give some sense of scale, with 2-nm technology, IBM could put 50 billion transistors onto a chip the size of a fingernail.

The foundation of the chip is nanosheet technology in which each transistor is made up of three stacked horizontal sheets of silicon, each only a few nanometers thick and completely surrounded by a gate. Nanosheet technology is poised to replace so-called FinFet technology named for the fin-like ridges of current-carrying silicon that project from the chip's surface. The life expectancy of FinFet has been more or less set at the 7-nm node. If it were to go any

smaller, transistors would become difficult to switch off: Electrons would leak out, even with the three-sided gates.”

Beyond the impressive sophistication of the 2-nm processes, we have to notice that behind the industry is the economy and the competition, but the actual World crises and dramatical changes bring even more, as beyond the competition we could perceive the geopolitical context, as it is further suggested:

“One can’t help but sense a bit of one-upmanship in IBM’s development after Taiwan Semiconductor Manufacturing Co. (TSMC) decided to stay with FinFETs for its next generation process, the 3-nanometer node. While IBM’s manufacturing partner, Samsung, does plan to use nanosheet technology for its 3-nm node chips, IBM outdid them both by using nanosheets and going down another step to a 2-nm node.”

Still, we consider that the scientific and technological problems are yet prominent and have to be first addressed in order to step forward, considering the apogee level where we are, also from the performances point of view. Here we can recall that, in a university book, in 1988, we have estimated this point of inflexion/saturation when reaching the physical limits of CMOS channel (now 2nm is practically zero) [18].

This way we can understand now the incredible performance realized by IBM, using the highest instruments and technological processes:

“To further enable the chip beyond nanosheets, IBM has used bottom dielectric isolation (BDI) to produce 12-nm gate lengths, a feature representing a first in the industry. BDI involves the introduction of a dielectric layer underneath both the source and drain gate regions. The benefits of implementing a full BDI scheme is to reduce sub-channel leakage, immunity to process variation and power-performance improvement.

Another first for these chips was IBM’s application of extreme-ultraviolet lithography (EUV) patterning to the front-end-of-line (FEOL) where the individual devices (transistors, capacitors, resistors, etc.) are patterned in the semiconductor. After a decade of hand-wringing over whether EUV would ever deliver on its promises, it has in the last few years become a keystone for enabling 7-nm chips. Now, in this latest step in its evolution, EUV patterning has made it possible for IBM to produce variable nanosheet widths from 15 nm to 70 nm.

IBM has also developed a multi-threshold-voltage (Multi-VT) scheme for both system-on-a-chip (SoC) and high-performance computing (HPC) applications. Threshold voltages—also known as gate voltages—are the minimum voltage differential needed between a gate and the source to create a conducting path between the source and drain terminals. Multi-VT schemes leverage gates with different thresholds to optimize for power, timing, and area constraints.”

Of course, there is a lot to comment on such amazing and sophisticated technological processes, but at least the confirmation of the mature stage for EUV technique is remarkable, as one of the last milestone innovations asked by the mentioned point of inflexion/saturation, which is just a part of the struggle ICT is passing through [6][7][8][14].

Another challenge of this “era” of chips is to further improve the connections between transistors, as here the difficulty is also high, close to reaching the physical limits of the actual processes:

<<While these all represent breakthrough developments in enabling 2-nm node chips, it does raise the question of interconnect crowding. In a press conference this week, Mukesh

Khare, vice president of Hybrid Cloud at IBM Research in Albany, NY, addressed this question by explaining that this latest announcement is focused primarily on the transistor. According to Khare, the transistor is critical to address questions of scale, especially in scaling the gate length and the power and performance. However, he was quick to acknowledge the importance of interconnect issues.

“Interconnect scaling is equally important as the transistor,” said Khare. “We are continuing to drive the correct scaling for the interconnects as well. That’s part of our full 2-nm technology features.”>>

Here we have to observe, along with the inherent difficulty of further improving the connections, the new kind of challenges which arise when we are on the top, even after reaching the main target, but we could encounter unprecedented problems with something that initially could appear secondary, just because the “logic” that led to the main desired solution does not apply to all parts or ...phases of a technical or ... life problem and such phenomena could be sources of the uncertainty WDCC is featuring.

This way we have arrived to another important feature of ICT advances, where many other fields of activity could benefit from a certain ICT result/logic beyond the direct use of ICT product/application, simply by importing the “idea”, the logic or the “learned lesson”.

Unfortunately, the last observation is not a general, but rather desired situation, as even ICT itself has to solve a lot of problems which appear along with reaching new advances or performances.

It is obvious that, in this complex ICT/IS/KBS context, there is a diversity of challenges/problems, but our paper point is just in the specific area generated by the ICT exponential development/proliferation and linked with World dramatical changes, where not only more intelligence, but especially more wisdom everywhere is needed.

2. Looking for wisdom in a more and more intelligent but changing World

As ICT systems, products, services and applications generally became more complex or complicate, although in many cases users can see only some nice boxes or gadgets, most of them, without considering the huge networks and equipments, contain electronic components and chips with a high level of integration and sophistication, growing along with the ICT advances.

Recalling some of the features of complex systems (CS) theory, it is well known that the parameters and performances of such systems are often difficult to identify/define, just because a lot of criteria could be considered, especially for the custom-designed complex systems, where standardization provide only a part of the specifications.

Another feature of such CS, including our Earth ecosystem subsystems in the WDCC, is the need for stability and reliability, which are naturally menaced by the incertitude of structurally changes [5][11].

Anyway, with simple words, the reliability was always a performance indicator which is more difficult to define, compute or measure, as the system complexity increase.

Now it is easier to understand why, in most ICT cases, the reliability could be difficult to control, especially when, beyond intrinsic complexity, other factors should be considered,

including the use conditions and sometimes the “consumption policy”, which many years considered that too high reliability or repair would be not “appropriate”.

Here we have just arrived at the point where the actual tendency of Earth resources fading and the emergency of different crises, to consider just some of the mentioned challenges of WDCC, should determine us to reconsider issues like the above “consumption policy” and generally the position and content of reliability among the performances of ICT systems, products, services and applications.

In fact, in some special cases, like critical infrastructures, the main reason to reconsider the reliability performances should be the security relevance in the applications context, which could be very high not only for critical infrastructures, but also generally for Earth ecosystem and people’s life.

Coming down to the technical issues of reliability in ICT, in a simplified electronic model, beyond other detailed deterministic causes/factors (which usually are considered and acceptably controlled), there is a hazard factor (probability of some unexpected phenomena or circumstances), which is almost impossible to precisely control.

We consider that the issue of hazard could be, perhaps, linked, but in a complicate analysis that is not the paper aim, with David Hume (1739–1740) and with inspired by him *No free lunch theorem*, which is also useful in AI-machine learning [19][15].

Still, it is important to notice that, in a poor design or modest system management, often the lack of controlling the usual/technical factors of reliability is claimed as the result of “hazard” and this discussion is a real challenge as the complexity of the system is increasing, i.e., just the actual and emergent complex systems, which include ICT, but in general the analysis could not be reduced to the electronic components.

The practical conclusion is that, irrespective the weight of ICT parts in a CS (for example, industrial one), in the actual stage of science and technology, ICT advances (mainly by AI and IoT, but not exclusively) could essentially contribute to the control of reliability and reducing the hazard, i.e., a very desired support for WDCC.

Based on the above general analysis, we could understand why, along with other performance challenges, the role of reliability/hazard in WDCC will perhaps become more and more important, as it is confirmed in [2]:

“QR (Quick Response) codes have undergone something of a renaissance during the pandemic: Where I live in Australia, we use them to check in at a restaurant or cinema or classroom. They anchor the digital record of our comings and goings to better assist contact tracers. It’s annoying to have to check into such venues this way—and even more annoying when it doesn’t work. Not long ago, I went to a local café, only to have the check-in process fail. I thought the problem might be my smartphone, so my companion gave it a go, using a different phone, OS, and carrier. No luck. We later learned the entire check-in infrastructure for our state had gone down. Millions of people were similarly vexed—I would argue completely needlessly. Nearly all the apps on our smartphones—and on our desktop computers—rest on networked foundations.”

The analysed scenario (revealing ICT negative issues) is just another face of our emergent World, versus the one (with only positive issues) we presented in the beginning of this series of papers, [3], as ICT, like the whole Earth ecosystem, could be seen as a

wonder of humankind creation, but also as becoming a possible nightmare for the next generations of humans if we do not act with wisdom.

The reality is that ICT must be seen in a continuous evolution, as its processes are among most complexes in the World and the consequences are strongly influenced by the speed and amplitude of the impact on people's life, like it is further detailed:

“Over the last generation, network access has become ubiquitous, useful, cheap, and stable. While such connectivity has obvious benefits, it seems to have simultaneously encouraged a form of shortsightedness among app developers, who find it hard to imagine that our phones might ever be disconnected. Before the arrival of the smartphone, we encountered connected devices only rarely. Now they number in the tens of billions—each designed around a persistently available network. Cut off from the network, these devices usually fail completely, as the contact-tracing app did for a time for so many Australians.”

Here, the crucial feature of ICT is also confirmed, as communications/connectivity ubiquity determined not only essential practical support for all activities, but also habits and even addiction for humans, which naturally will be frustrated by their sudden interruption/failing.

Again, we have to notice that this image is very relevant for the coming WDCC, where the crises and frustration could become not accidents, but frequent incidents, if ICT development will not adapt to these changes (by policies, software and hardware improvements), i.e., by refining “intelligence” with “wisdom”, or generally recalling Stephen Hawking's *Intelligence is the ability to adapt to change* and further concretely recommended:

“People who develop firmware or apps for connected devices tend to write code for two eventualities: One assumes perfect connectivity; the other assumes no connectivity at all. Yet our devices nearly always reside in a gray zone. Sometimes things work perfectly, sometimes they don't work at all, and sometimes they only work intermittently. It's that third situation we need to keep front of mind. I could have checked into my café, only to have the data documenting my visit uploaded later (after some panicked IT administrator had located and rebooted the failed server). But the developers of this system weren't thinking in those terms. They should have taken better care to design an app that could fail gracefully, retaining as much utility as possible, while patiently waiting for a network connection to be reestablished.”

It is obvious that stop “*thinking in those terms*” confirms our opinion to refine knowledge addressing the new dynamic conditions and proving this way the optimal (wisdom) approach.

We have to notice again that, along with the technical options/solutions, ICT is based on development policies which, in turn, depend on economical or other criteria, but user experience and other social factors eventually should determine a continuous refine of the knowledge in ICT/IS/KBS processes, where engineers and leaders should cooperate:

“As engineers, we need to remember that wireless networking is seldom perfect and design for the shadowy world of the sometimes connected. Our aim should be to build devices that do as well as they possibly can, connected or not.”

Although the issue is only about communications networks, these are still very relevant as mobile broadband networks are becoming the universal backbone infrastructure and their global role in IS/KBS will be crucial in the WDCC, as the above proved negative consequences of low reliability, like it is further confirmed:

“Like fish in water, we now swim in a sea of our own connectivity. We can’t see it, except in those moments when the water suddenly recedes, leaving us flapping around on the bottom, gasping for breath. Typically, such episodes are not much more than a temporary annoyance, but there are times when they become much more serious—such as when a smartwatch detects atrial fibrillation or a sudden fall and needs to signal that the wearer is in distress. In a life-or death situation, an app needs to provide defense in depth to get its message out by every conceivable path: Bluetooth, mesh network—even an audio alarm.”

Here, we might observe also a larger view, as starting from the benefits ICT advances brought in the first years of Covid 19 pandemic, by enabling on line activities and other information sharing and connectivity applications, which in fact were available even before 2020.

The relevant issue we could foresee is the potential of ICT to offer fast solutions or alternatives in cases of dramatical events/crises, but in the same time the essential need that such solutions to be very reliable, considering just the emergency fields they should support and imagining the damages which globally could be encountered (we have just to imagine the connectivity of future self-driving cars!).

More than these, the extended proliferation and impact of ICT support in the IS/KBS, in the coming changing context, will request reliability as first performance indicator for critical infrastructure applications (power grid, governance, defence/safety, transportation etc.).

Such high level of requirements will be very difficult to harmonize with the complicate premises of inherent hazard, resources fading and other factors of incertitude (yet to come), which are already prominent challenges for advanced ICT fields like AI, Big Data or IOT, where the line between intelligence and human wisdom is still a crucial bottleneck, just like the above example that should be seen in the prominent general case of connectivity (Internet/communications) [17].

On the other side, it is important to notice the overwhelming number of benefic ICT results and applications, at planetary scale, which prove without doubt its capacity of further supporting the IS/KBS evolution, although the need of improvement is inherently a condition of progress, especially in the WDCC.

A relevant example of the World mentioned evolution is the smart-city technology (SCT) and applications, which could reveal the huge potential of SCT/ICT, as it is presented by [4]:

“Smartcities, like many things, took a beating in 2020. Alphabet, Google’s parent company, pulled its Sidewalk Labs subsidiary out of a smart-city project in Toronto. Cisco killed its plans to sell smart-city technology. And in many places, city budgets will be affected for years to come by the pandemic’s economic shock, making it more difficult to justify smart-city expenses.

That said, the pandemic also provided municipalities around the world with reason to invest new technologies for public transportation, contact tracing, and enforcing social distancing. In a way, the present moment is an ideal time for a new understanding of smartcity infrastructure and a new way of paying for it.”

We already can observe the impact of the SCT in the WDCC, because the pandemic challenges also generated premises of opportunities for innovation, new business models and generally refining knowledge, as it is further detailed:

<<Cities need to think of their smart-city efforts as infrastructure, like roads and sewers, and as such, they need to think about investing in it, owning it, maintaining it, and controlling how it's used in the same ways as they do for other infrastructure. Smart-city deployments affect the citizenry, and citizens will have a lot to say about any implementation. The process of including that feedback and respecting citizens' rights means that cities should own the procurement process and control the implementation.>>

In some cases, citizen backlash can kill a project, such as the backlash against Sidewalk's Toronto project over who exactly had access to the data collected by the smart-city infrastructure. Even when cities do get permission from citizens for deployments, the end results are often neighborhood-size "innovation zones" that are little more than glorified test beds.>>

Observing that the crowd intelligence/wisdom is here confirmed, we consider that the coming World new challenges will request a continuous dialog between AI and human/crowd intelligence (HI), in addition to the generous channels of connectivity offered by ICT advances like IoT, Big Data, context aware communications and so on, even if the reliability of all technical systems is expected to increase, but also the uncertainty and adversity of the WDCC.

The mature and globally viewed understanding for a project of development, including the ICT ones, could enable transparency, perception/view and sharing information on a certain issue/project, with reduced costs (time, energy) but greater accuracy provided by multimedia and connectivity applications:

"A truly smart city needs a master plan, citizen accountability, and a means of funding that grants the city ownership. One way to do this would be for cities to create public authorities, just like they do when investing in public transportation or even health care. These authorities should have publicly appointed commissioners who manage and operate the sensors and services included in smartcity projects..."

Among the benefits of refining SMT and management, in the WDCC, here the economical and social advantages are also pointed and even explicitly demonstrated by concrete examples:

"For example, consider a public safety project that requires sensors at intersections to reduce collisions. The project might use the gathered data to meet its own safety goals, but the insights derived from analyzing traffic patterns could also be sold to taxi companies or logistics providers. These sales will underpin the repayment on bonds issued to pay for the technology's deployment and management. While some municipal bonds mature in 10- to 30-year time frames, there are also bonds with 3- to 5-year terms that would be better suited to the shorter life spans of technologies like traffic-light sensors."

It is worth to notice here one of the most difficult problems of further exponential development of ICT, especially considering the WDCC, which could affect the countries and World economy increase, by the shortening of life spans of ICT systems, products, services and applications.

In addition, changing the policies and management of implementing SCT could leverage local and regional economical/social benefits:

“Smart-city contracts could employ local contractors and act not just as a source of revenue for cities but also as an economic development tool that can create jobs ...

For decades, cities have invested in their infrastructure using public debt. If cities invest in smart-city technologies the same way, they could give their citizens a bigger stake in the process, create new streams of revenue for the city, and improve quality of life. After all, people deserve to live in smarter cities, rather than innovation zones.”

This field of ICT intelligence (smart-city technologies) is very relevant for the approach of critical or difficult new situations in WDCC, when lack of resources will be often the main cause of crises, but it also offers useful innovation ideas for other challenges, like converting/enabling intelligence for mature/wisdom decisions, transparency, unemployment or other social unbalances.

Our opinion is that refining the criteria of efficiency/efficacy/optimization for ICT and generally for all human activity fields is now mandatory more than ever.

In fact, everywhere, the global impact of ICT intelligence along with wisdom of decisions/solutions should be considered and improved, although, in the same time, we have to agree that such goal, at planetary scale, is more and more complex, complicate and difficult, but this does not mean to ignore/avoid it, as it is necessary, on contrary, to further analyse all the ways to identify the solutions to reach it at appropriate time and extent (until it is not too late!).

3. Conclusions

As we live in a more and more complex World, but more and more based on technology exponential progress, we have to learn to be prepared for new rules of development or even... no rules.

The link of these tendances with the information and communications technology (ICT) is due to the fact that ICT, generally by complex and expanding ways, for decades, is already influencing the humankind and our planet evolutions, here counting mostly the benefic influences which generate the World progress, but we have to also consider, more and more, for optimal global results, **all the consequences** of the exponential pace ICT would/could induce to life and Earth ecosystem. The reasons to timely try to analyse all the consequences of this ICT context include the need for optimal and global results, but this is not new, while the emergency of the dramatic changes of World ecosystem rise new and extremely complicate challenges for humankind and ICT, as we have recently begun to detail them [3].

On this line, it is important to evaluate the potential of ICT to enable, by artificial intelligence (AI), Big Data, Cloud, Internet of things (IoT) or other essential and powerful advances, the expected solutions for these challenges or other unexpected problems World will have to face rather sooner than later. An important feature of ICT development, which we consider necessary to be further improved for facing the dynamic and even unexpected challenges, in order to support the Information Society (IS) on the way towards the Knowledge Based Society (KBS) in the new dramatic context, is to optimally combine AI with human/crowd intelligence, when refining knowledge by the fast changing criteria of the World ecosystem and this way leveraging the expected wisdom/sustainable based actions/evolutions [10][9][12].

For a high potential, ICT must also to realistically develop its resources and that is why we have analysed some relevant issues which could at least create a short image of the results and challenges involved in the general goal of ICT optimized development, in the conditions of the emergent World dramatical changes context (WDCC).

We have to notice that our World dynamic context begin to look like a struggle toward unprecedented performances, in all domains, exceeding this way the prominent case of ICT, while the actual dramatical trends/crises send us toward the prospective of surviving against such menaces for the Earth ecosystem (climate changes, Earth resources fading, social unbalances, or potential crises - like the emergent energy/food/materials or geopolitical ones). Unfortunately, unprecedented dramatical crises began to be generated by the Russia - Ukraine war, where the consequences are difficult to estimate on long term, but the food, industry and supply chains turbulences could bring crucial changes to global economy and for all balance of Earth ecosystem. This way, the need for adequate but complicate solutions will affect ICT too, which, in the same time, is expected to provide support for all human activity fields, using its huge potential of fast innovation and development.

The crucial role of technological processes by which processors, memories and other semiconductor chips are made, is more than obvious for either ICT and World progress in general, but the concrete actual difficulties of such advanced processes express even more about the mentioned struggle.

The *introduction of a 2-nanometer (nm) node chip by IBM* is analysed, as *the new chip will improve performance by 45 percent, versus the actual 7 nm-based chips*. To reach such impressing target, a new nanosheet technology and an innovative is used, along with extreme-ultraviolet lithography (EUV).

Beyond the impressive sophistication of the 2-nm processes, we have to notice that behind the industry is the economy and the competition (IBM is ahead other companies, which reached 3-nm), but the actual World crises and dramatical changes bring even more, as beyond the competition we could perceive the geopolitical context.

We consider that the scientific and technological problems are yet prominent and have to be first addressed in order to step forward, considering the apogee level where we are, also from the performances point of view. Here we can recall that, in a university book, in 1988, we have estimated this point of inflexion/saturation when reaching the physical limits of CMOS channel (now 2nm is practically zero) [18]. This way we can understand now the incredible performance realized by IBM, using the highest instruments and technological processes, as EUV, which is one of the last milestone innovations asked by the mentioned point of inflexion/saturation, which is just a part of the struggle ICT is passing through [6][7][8][14].

Another challenge of this “era” of chips is to further improve the connections between transistors, as here the difficulty is also high, close to reaching the physical limits of the actual processes.

Here we notice, along with the inherent difficulty of further improving the connections, the new kind of challenges which arise when we are on the top, even after reaching the main target, but we could encounter unprecedented problems with something that initially could appear secondary, just because the “logic” that led to the main desired solution does not apply to all parts or phases of a technical or ... life problem and such phenomena could be sources of the uncertainty WDCC is featuring.

This way we have revealed another important feature of ICT advances, where many other fields of activity could benefit from a certain ICT result/logic beyond the direct use of ICT product/application, simply by importing the “idea”, the logic or the “learned lesson”, although this is not a general, but rather desired situation, as even ICT itself has to solve a lot of problems which appear along with reaching new advances or performances.

It is obvious that, in this complex ICT/IS/KBS context, there is a diversity of challenges/problems, but our paper point is just in the specific area generated by the ICT exponential development/proliferation and linked with World dramatical changes, where not only more intelligence, but especially more wisdom everywhere is needed.

As ICT systems, products, services and applications generally became more complex or complicate, although in many cases users can see only some nice boxes or gadgets, most of them, without considering the large networks and equipments, contain electronic components and chips with a high level of integration and sophistication, growing along with the ICT advances.

Analysing some of the features of complex systems (CS) theory, we have pointed that the parameters and performances of such systems are often difficult to identify/define, just because a lot of criteria could be considered, especially for the custom-designed complex systems, where standardization provide only a part of the specifications. Also, another feature of such CS, including our Earth ecosystem subsystems in the WDCC, is the need for stability and reliability, which are naturally menaced by the incertitude of structurally changes [5][11]. The reliability was always a performance indicator which is more difficult to define, compute or measure, as the system complexity increase, so it is easier to understand why, in most ICT cases, the reliability could be difficult to control, especially when, beyond intrinsic complexity, other factors should be considered, including the use conditions and sometimes the “consumption policy” - which many years considered that too high reliability or repair would be not “appropriate”.

The actual tendency of Earth resources fading and the emergency of different crises, to consider just some of the mentioned challenges of WDCC, should determine us to reconsider issues like the above “consumption policy” and generally the position and content of reliability among the performances of ICT systems, products, services and applications. In some special cases, like critical infrastructures, the main reason to reconsider the reliability performances should be the security relevance in the applications context, which could be very high not only for critical infrastructures, but also generally for Earth ecosystem and people’s life.

Analysing the technical issues of reliability in ICT, in a simplified electronic model, beyond other detailed deterministic causes/factors (which usually are considered and acceptably controlled), we notice that there is a hazard factor (probability of some unexpected phenomena or circumstances), which is almost impossible to precisely control. We consider that the issue of hazard could be, perhaps, linked, but in a complicate analysis that is not the paper aim, with David Hume (1739–1740) and with inspired by him *No free lunch theorem*, which is also useful in AI-machine learning [19][15].

It is important that, in a poor design or modest system management, often the lack of controlling the usual/technical factors of reliability is claimed as the result of “hazard” and this discussion is a real challenge as the complexity of the system is increasing, i.e., just the actual

and emergent complex systems, which include ICT, but in general the analysis could not be reduced to the electronic components.

The practical conclusion is that, irrespective the weight of ICT parts in a CS (for example, industrial one), in the actual stage of science and technology, ICT advances (mainly by AI and IoT, but not exclusively) could essentially contribute to the control of reliability and reducing the hazard, i.e., a very desired support for WDCC.

Based on the above general analysis, we could conclude that, along with other performance challenges, the role of reliability/hazard in WDCC will perhaps become more and more important, as it is confirmed by the analysis of a relevant example – a mobile communications network.

The analysed scenario (revealing ICT negative issues) is just another face of our emergent World, versus the one (with only positive issues) we presented in the beginning of this series of papers, [3], as ICT, like the whole Earth ecosystem, could be seen as a wonder of humankind creation, but also as becoming a possible nightmare for the next generations of humans if we do not act with wisdom.

Another crucial feature of ICT is also confirmed by an example (from Australia), as the communications/connectivity ubiquity determined not only essential practical support for all activities, but also habits and even addiction for humans, which naturally will be frustrated by their sudden interruption/failing. We have to notice that this image is very relevant for the coming WDCC, where the crises and frustration could become not accidents, but frequent incidents, if ICT development will not adapt to these changes (by policies, software and hardware improvements), i.e., by refining “intelligence” with “wisdom”, or generally recalling Stephen Hawking’s *Intelligence is the ability to adapt to change*. From the same example, it is obvious that stop “*thinking in those terms*” confirms our opinion to refine knowledge addressing the new dynamic conditions and proving this way the optimal (wisdom) approach. Also, along with the technical options/solutions, ICT is based on development policies which, in turn, depend on economical or other criteria, but user experience and other social factors eventually should determine a continuous refine of the knowledge in ICT/IS/KBS processes, where engineers and leaders should cooperate. Although the issue is only about communications networks, these are still very relevant as mobile broadband networks are becoming the universal backbone infrastructure and their global role in IS/KBS will be crucial in the WDCC, as the above proved negative consequences of low reliability.

Still, we might observe also a larger view, as starting from the benefits ICT advances brought in the first years of Covid 19 pandemic, by enabling on line activities and other information sharing and connectivity applications, which in fact were available even before 2020. The relevant issue we could foresee is the potential of ICT to offer fast solutions or alternatives in cases of dramatical events/crises, but in the same time the essential need that such solutions to be very reliable, considering just the emergency fields they should support and imagining the damages which globally could be encountered (we have just to imagine the connectivity of future self-driving cars!).

More than these, the extended proliferation and impact of ICT support in the IS/KBS, in the coming changing context, will request reliability as first performance indicator for critical infrastructure applications (power grid, governance, defence/safety, transportation etc.). Such high level of requirements will be very difficult to harmonize with the complicate

premises of inherent hazard, resources fading and other factors of incertitude (yet to come), which are already prominent challenges for advanced ICT fields like AI, Big Data or IOT, where the line between intelligence and human wisdom is still a crucial bottleneck, just like the above example that should be seen in the prominent general case of connectivity (Internet/communications).

From the SCT example analysis, it is important to notice the overwhelming number of benefic ICT results and applications, at planetary scale, which prove without doubt its capacity of further supporting the IS/KBS evolution, although the need of improvement is inherently a condition of progress, especially in the WDCC. Here we can observe the impact of the SCT in the WDCC, because the pandemic challenges also generated premises of opportunities for innovation, new business models and generally refining knowledge.

Also, the crowd intelligence/wisdom is here confirmed and we consider that the coming World new challenges will request a continuous dialog between AI and human/crowd intelligence (HI), in addition to the generous channels of connectivity offered by ICT advances like IoT, Big Data, context aware communications and so on, even if the reliability of all technical systems is expected to increase, but also the uncertainty and adversity of the WDCC. The mature and globally viewed understanding for a project of development, including the ICT ones, could enable transparency, perception/view and sharing information on a certain issue/project, with reduced costs (time, energy) but greater accuracy provided by multimedia and connectivity applications. Among the benefits of refining SMT and management, in the WDCC, here the economical and social advantages are also pointed and even explicitly demonstrated, with concrete data.

It is worth to notice here one of the most difficult problems of further exponential development of ICT, especially considering the WDCC, which could affect the countries and World economy increase, by the shortening of life spans of ICT systems, products, services and applications. In addition, changing the policies and management of implementing SCT could leverage local and regional economical/social benefits.

As a prominent field of ICT intelligence, SCT is very relevant for the approach of critical or difficult new situations in WDCC, when lack of resources will be often the main cause of crises, but it also offers useful innovation ideas for other challenges, like converting/enabling intelligence for mature/wisdom decisions, transparency, unemployment or other social unbalances.

Our opinion is that refining the criteria of efficiency/efficacy/optimization for ICT and generally for all human activity fields is now mandatory more than ever.

As main conclusion, we consider that, everywhere, the global impact of ICT intelligence along with wisdom of decisions/solutions should be considered and improved, although, in the same time, we have to agree that such goal, at planetary scale, is more and more complex, complicate and difficult, but this does not mean to ignore/avoid it, as it is necessary, on contrary, to further analyse all the ways to identify the solutions to reach it at appropriate time and extent (until it is not too late!).

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