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FROM THE INTERNET OF THINGS (IOT) TO SMART CITIES (SC)

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Abstract. IoT represents a network of Internet-enabled, real-world objects, such as nanotechnology, consumer electronics, home appliances, sensors of all kinds, embedded systems, and personal mobile devices. It includes enabling network and communication technologies, such as IPv6, web services, RFID, and 4G networks. We are already applying IoT solutions in practical ways by using mobile devices. A key aspect of SC is the efficient management of utilities, enabled by smart metering of the residential consumption of electricity, water or gas.

Keywords: *Internet of Things, IoT markets & applications, changes introduced by IoT, Smart Cities, standards.*

Introduction

From a historical perspective, the first object (an electric toaster bread) was connected to the Internet by company engineers Epilogue using SNMP protocol. And as new technological possibilities have arisen, Internet connection cases are multiplied almost every day.

Although the term Internet of Things "IoT" was coined in 1999 by Briton Kevin Ashton [1], IoT technologies such as sensor networks have existed since 1990. Due to advances in sensors and cloud technology (Cloud), processing and storage capability, and sensor cost of production is down, and sensor deployment has increased significantly over the past five years. The European Commission predicted that by 2020 there will be 50 to 100 billion devices connected to the Internet. As can be seen from Figure 1, the number of objects connected to the Internet exceeded the earth's population in 2008.

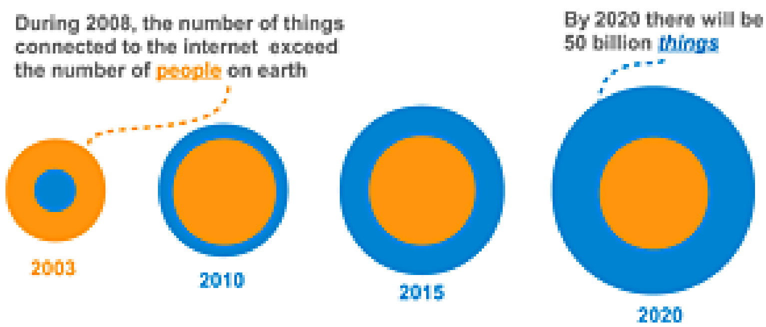

Figure 1. Increase the number of objects connected to the Internet [3].

An international definition is given in the *Présentation générale de l'Internet des objets* (UIT-T Y.2060, juin 2012, § 3.2.2). The Internet of Things is a global information society infrastructure that allows for evolving services that interconnect objects (physical or virtual) thanks to existing or evolving interoperable information and communication technologies. For ITU, the exploitation of identification, data capture, processing and communication capabilities, IoT can provide services for all kinds of applications while ensuring that security and privacy requirements are met. In a broader perspective, IoT can be considered a concept that has repercussions on technologies and society.

The Internet of Things is not a single technology, it is a concept in which the newest things are connected and activated, such as street lighting (on the network) and objects (such as built-in sensors, image recognition functions, augmented reality and communication in the near field) are integrated into decision-making support, asset management and news service. They bring many business opportunities and add to the IT complexity [2].

Thus, IoT is a network of networks (Figure 2) which enables - with the help of standardized and unified electronic identification systems and wireless mobile devices - to identify directly and without ambiguities, numerical entities and physical objects, thus recovering, store, transfer and process, without discontinuity between physical and virtual worlds, correlation data. It is thus possible to identify in a unified way elements of numerical information (addresses) and physical elements (a palette in a warehouse or an animal in a herd of cattle). So we have to deal with objects with virtual identities and personalities, working in intelligent spaces and using intelligent interfaces to connect and communicate.

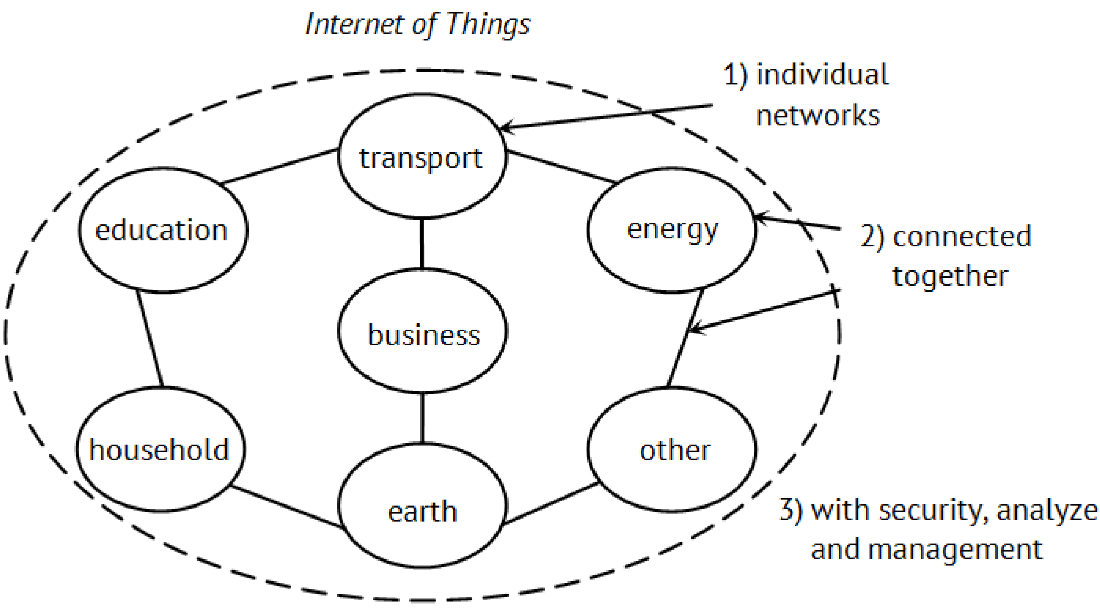

Figure 2. IoT is a network of networks.

By definition, IoT ideally allows people and things to be connected anytime, anywhere, with anyone and anyone (Figure 3), using any path / network and any service [4]. As can be seen, IoT is determined - mainly - by technological advances, not by applications or user needs.

IoT is the extension of the Internet to things and places in the physical world. While the Internet is about the world of the world, IoT is the exchange of information and data from real-world devices to the Internet.

The Internet of Things is, therefore, a network of networks that allows - through standardized and wireless electronic identification systems - numerical identification and communication with physical objects to measure and exchange data between physical and virtual worlds.

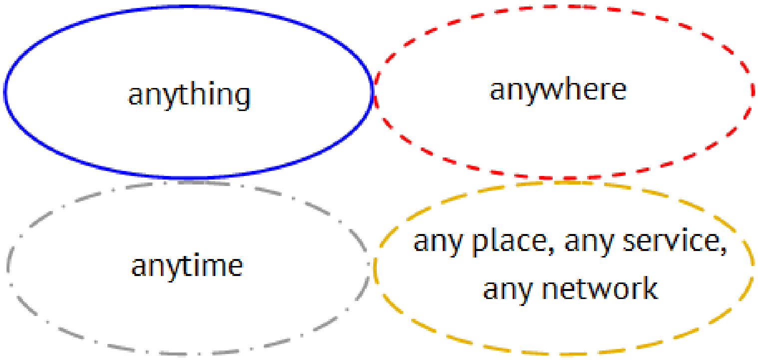

Figure 3. Connectivity with the Internet of Objects.

As these systems continue to improve and develop, the role of human beings will be assured, first of all, by cars, while men will act as protective guardians. This will disrupt the process of work and challenge scholarships in terms of personnel skills worldwide, with advancements in the field of artificial intelligence (AI).

IoT has emerged within the framework of the tendency of mechanization and standardization, applied to the automation of the processing of documents and information on material support, and then name. IoT first appeared in the U.S. and spread rapidly due to globalization. Gradually, the objects have been modified (with RFID1 chips), for example, to connect to the IP protocol, thus becoming connected objects to the centralized servers capable of communicating with each other and / or with server networks in a manner less and less centralized.

The Growth of the IoT Market

A recent study of the Polytechnic of Zurich (ETHZ) states that, thanks to smartphones and the number of connected objects, which are constantly increasing, in 2025 over 150 billion objects will be connected to each other, to the Internet and to several billion people. As such, information will need to be more and more filtered with complex algorithms - which has generated the fear of lower personal data protection, and the increasing danger of manipulating government decisions.

The growth of the IoT market will accelerate in the years to come; from US$ 655.8 billion in 2014 will reach US$ 1700 billion in 2020, with an average annual growth rate of 16.9%.

Changes introduced by IoT

Over the coming years, IoT will completely change our way of working; this will happen when the cost of the captors will be quite cheap to penetrate in all areas. Universal connectivity began and is in full swing, forming the basis for the construction of future transformations. There is still a need to really connect the whole set of data and to have a general analytical framework that can make sense of it. In the coming years, we will head to woven networks that will add to the data connectivity of the Internet by routing packets of data. This will reduce the cost of connectivity and create more flexible connections between systems.

It is anticipated that in the next 5 to 10 years, "classical" data analysis techniques - which give value from this information - will fail. They will be replaced by a specific artificial intelligence (AI) that will be developed for this purpose and will receive years of apprenticeship. There will be specialized apprenticeship systems in the health, manufacturing and other fields that will ask questions from data and the environment, faster than we could imagine, and even more quickly because we can respond. These specific Artificial Intelligence systems will still be far from a global artificial intelligence, but they will transform our way of working.

New paradigms have emerged - such as the low-power Low Power Wide Area Networks (LPWAN) designed by Sigfox - or the LoRa alliance, all tailored to IoT communication (such as combining IoT with Cloud technologies Things-as-a-Service (TaaS) platforms, Sensors-as-a-Service (S2aaS), IoT-as-a-Service.

The increase in IoT technology is related to M2M (machine-to-machine) communication where, for example, a temperature sensor indicates dangerously high temperatures in a control room so that the cooling system automatically switches on. How will the role of people evolve in an environment where cars can increasingly solve problems themselves?

At the control level, machines can solve themselves rudimentary problems (such fault management in redundant systems). They can also alert early on exploitation problems. At this stage, the role of people is (still) in making decisions and providing an intuitive direction, starting from data analysis. Generally, these systems are distinct and cannot work (yet!) together effectively.

IoT applications

The major objectives of IoT are the creation of intelligent environments / spaces and self-aware things (e.g. intelligent transport, products, cities, buildings, intelligent rural areas, energy, health, smart living, etc.) for climate, energy, mobility, society and numerical applications related to health. The concept is illustrated in Figure 4. Developments in intelligent entities will also encourage the development of new technologies needed to address the emerging challenges of public health, aging populations, environmental protection and climate change, energy conservation and resource-rich materials, improvements reliability and safety in operation, security applications in the field of IoT, continuation and increase of economic prosperity. These challenges will be addressed through:

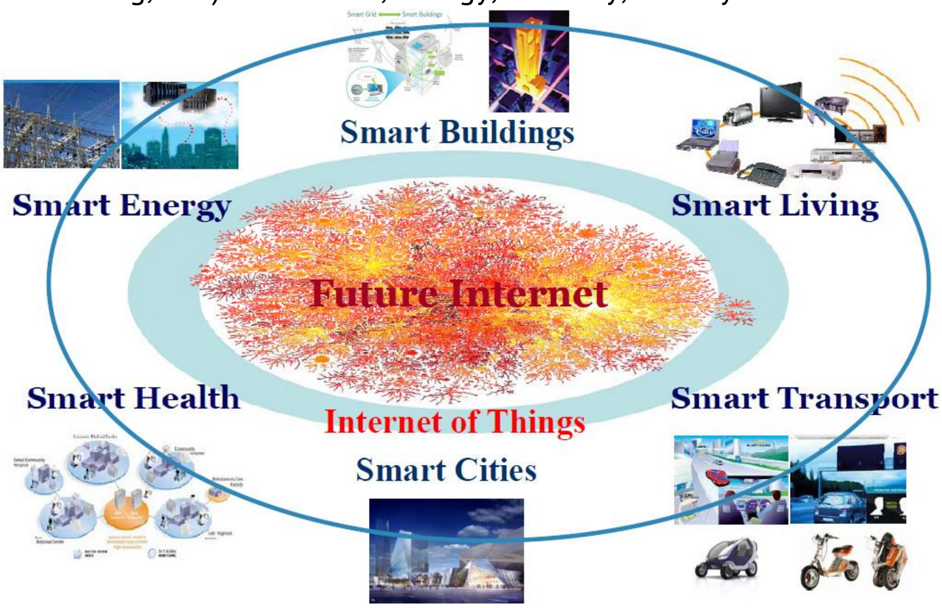

Figure 4 IoT and the creation of intelligent environments.

• Provide reliable, intelligent, self-managed, conscious and adaptive network technology, network discovery, and network management.

• Refine the interaction between hardware, software, algorithms as well as the development of intelligent interfaces (intelligent machine-to-machine, object-to-object interfaces) and intelligent human-machine interfaces / object interfaces, enabling intelligent and mobile software.

• Incorporating intelligent functionality through further developments in nanoelectronics, sensors, actuators, antennas, storage, power sources, integrated systems and sensor networks.

• Developing multiple disciplines to address multi-functional communications, multi-domain communications, information processing and signal processing technology, identification technology, as well as search and discovery of engine technologies.

• Developing new techniques and concepts to improve security, privacy, security and business privacy technologies, in order to adapt to new technological and social challenges.

• Strengthen standardization, interoperability, validation and modularisation of technologies and IoT solutions.

• Define new governance principles to address the evolution of technology to enable business development, and free access to knowledge - in line with global needs - while maintaining respect for privacy, security and safety.

Standards

Open standards are key elements for the success of wireless communications technologies (such as RFID or GSM) and, in general, for any machine-to-machine (M2M) communication.

Without global recognition, standards (such as TCP.IP or GSM / UMTS / LTE), extending the RFID and M2M solutions to the Internet of Things will not be able to reach a global, global scale. The need to establish interoperable standards more quickly has been recognized as an important element for the implementation of IoT applications. Clarifications are required on the requirements for a unique global identification. The lack of convergence of

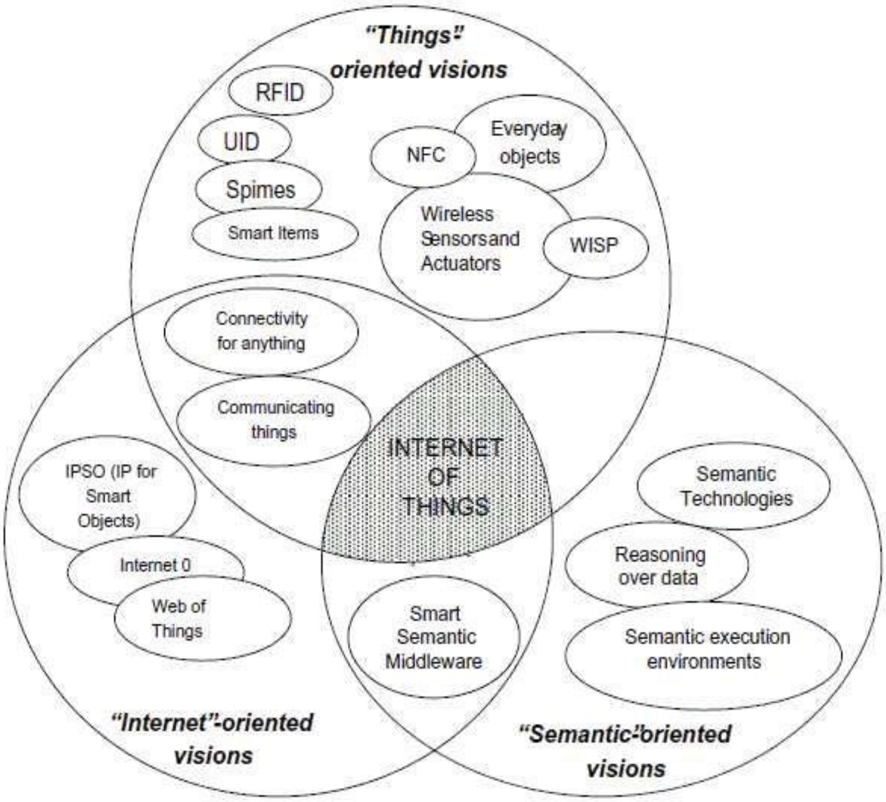

Figure 5. Convergence of different visions of SOs [9].

the definition of the common reference models, the reference architecture for future networks, the future of the Internet and IoT as well as the integration of inherited systems and networks are challenges that need to be addressed in the future.
Figure 5 lists the main concepts, technologies and standards with reference to the three possible views of IO.
The picture clearly shows the future convergence of the three visions.

Modeling and design

Designing large-scale IoT systems is a challenge, due to the large number of heterogeneous components involved and the complex iterations between devices introduced through cooperative and distributed approaches. To tackle this problem, innovative models and design rules must be developed; for example, inspired by co-simulation methods for large systems and *hardware-in-the-loop* approaches.

As for the dimensions of the intelligent object (figure 6), we distinguish three types of canonical objects: conscious activity, conscious policies and conscious processes. Intelligent objects can cooperate to form an "intelligent object Internet."

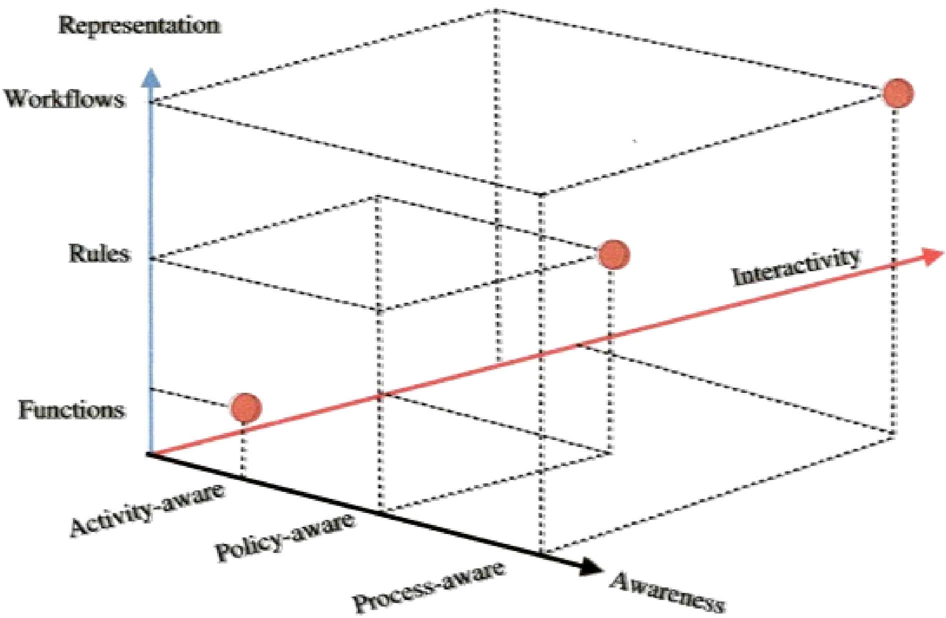

Figure 6. The dimensions of the smart object [8].

Manufacturing

The challenges of manufacturing must be convincingly resolved. Costs must be reduced to less than one centimeter on passive label and output must reach extremely high volumes, while the whole production process will have a very limited impact on the environment, be based on strategies for reuse and recycling, taking into account the overall life cycle of digital devices and other products that could be labeled or activated by a sensor.

Internet of everything (IoE)

The other abbreviation (*Internet of Everything* IoE) recently introduced by Cisco includes not only the *Internet of Things*, but also data, processes, and people (via their smartphones and their social networks) [7].

Enterprises strategic decisions

Informatics increasingly integrates the product itself and these intelligent and connected products require a new technology infrastructure for enterprises, making possible four new functional categories: supervision, control, optimization and automation. In terms of differentiation, they are operational effectiveness and customer experience.

To take advantage of these advantages, businesses are exposed to new strategic decisions, such as, for example, *(1)* which set of functionalities of a smart and connected product should privilege the enterprise? *(2)* how should the enterprise possess the property and rights of access to product data? *(3)* Should the enterprise change its model of job?

Smart Cities (SC)

As a result of rural migration and suburban concentration towards cities, urban life has become an important challenge both for citizens and for the governance of the city. Waste, traffic, energy, water, education, unemployment, health and crime management are just some of the critical issues [5].

Smart Cities smart cities - with their travel, consumption, pollution reduction, etc. applications. - and "Smart Grid" - with connected meters and the management of intermittent power networks and sources, mobility, tablets, smartphones, drone, home automation and remote control of all domestic appliances and equipment, and even their collaboration. All these new uses will increasingly use artificial intelligence and semantic analysis to manage objects and cross the produced data.

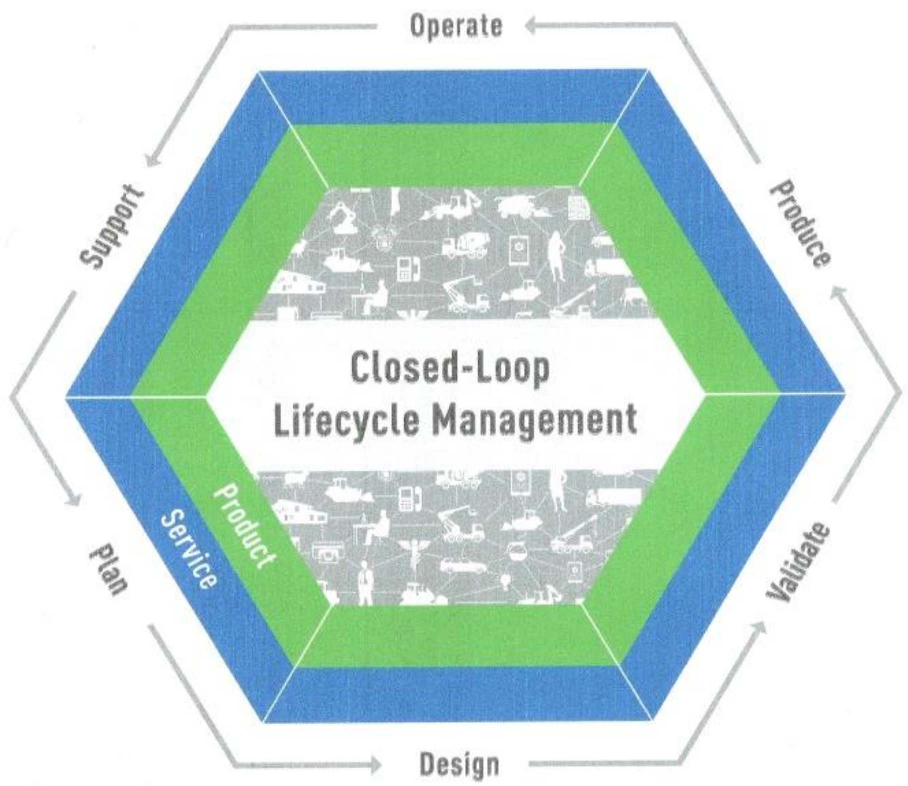

Figure 7. Closed Loop of Life Cycle Management [10].

By definition, SC have six main features: intelligent economy, intelligent people, intelligent governance, smart mobility, intelligent environment and intelligent life [6].

The explosion of the number of connected objects in operation (several tens of billions in 2020) leads to an explosion of data to be processed, to a drastic limitation of energy consumption and maintenance operations, to the search for new network architectures, and ad hoc systems to model complex systems that combine heterogeneous but interoperable resource constraints with optimized electronic components (caps, sensors, MEMS, NEMS) [2].

As products evolve, they allow a new set of functions and offer opportunities to create value for customers, manufacturers and the connected ecosystem.

The capabilities of the connected smart products can be grouped into 5 categories: monitoring, control, optimization, automation and transformation.

Monitoring: Connected sensors and data sources allow complete monitoring of product performance, and the external environment generates alerts and intelligence that can be operated.

Control: Interventia produselor inteligente, conectate prin intermediul comenzilor de la distanță emise de către fabricant, utilizator sau logică și regulile integrate în produs, permit controlul și personalizarea.

Optimization: The rich information monitoring flow coupled with the capability to control allows manufacturers to improve product performance and perform remote services and repairs.

Automation: Applying software algorithms and product business logic, user preferences, and widening of the system over time allow the product to function independently.

Transformation: The closed cycle of life cycle management (Figure 7).

By listening to the product during each stage of its life cycle, you can access the information you need to transform how it creates, operates, and delivers intelligent services and connected products.

The intelligent city model

A *Smart City* is a performance city with 6 features, built on the "smart" combination of facilities and citizens' activities that carry out decisive, independent and conscious activities.

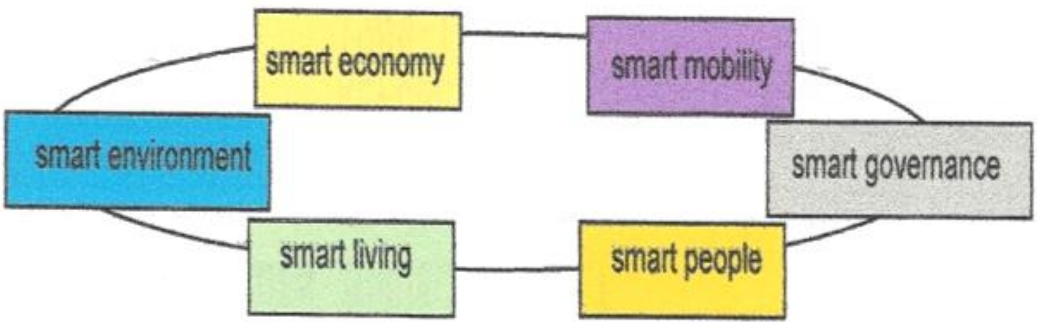

Figure 8. The 6 smart combinations of citizens' endowments and activities.

A smart city uses and introduces new IT and telecommunication technologies in its various sectors in order to optimize the use of existing infrastructures.

Whether it is transport, construction, governance or the environment, new technologies can make a full contribution to meeting today's challenges.

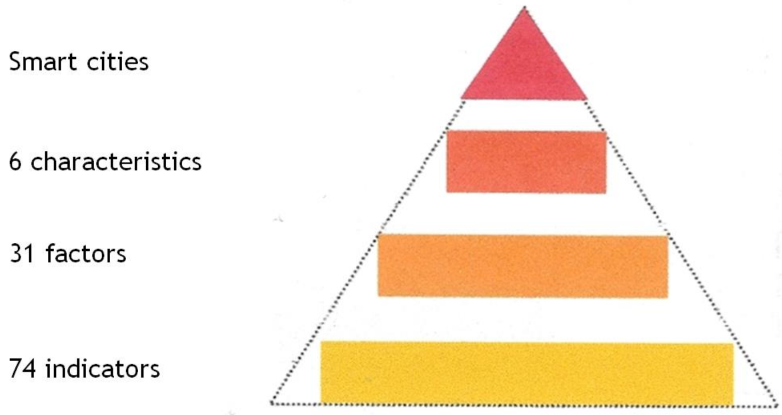

Figure 9. Elements describing a smart city (based on which the chart in figure 10 is set).

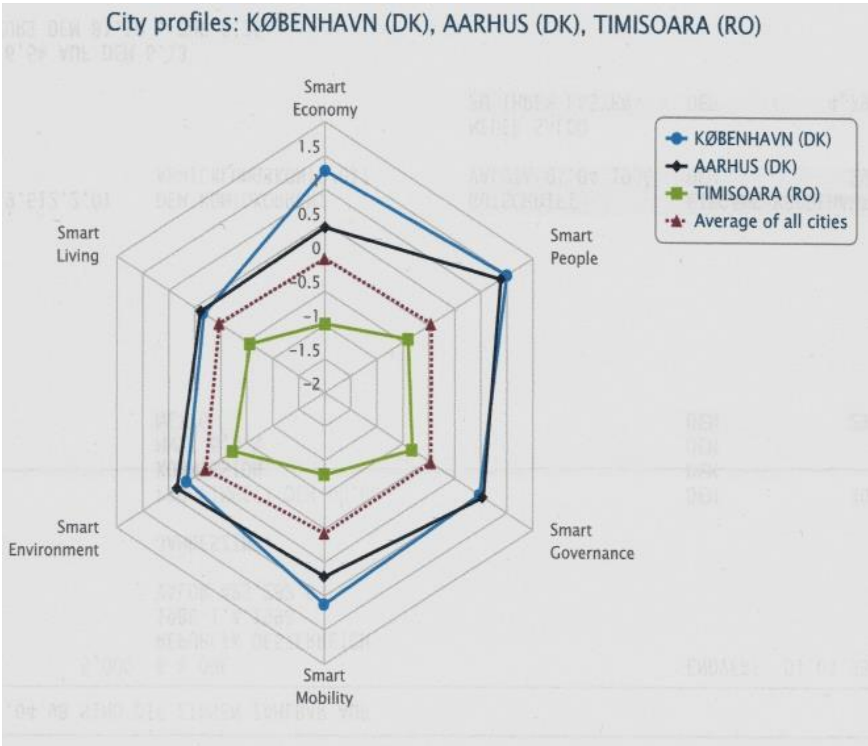

Figure 10. Comparison of three European cities (Copenhagen, Aarhus and Timişoara), based on the elements in figure 9 describing a smart city [11].

Conclusions

Numerous smart city projects have begun, but have never been completed. For example, when the city of Mascar (Abu Dhabi) was created, it was presented as the first intelligent city in the world; would have had to have no CO2 emissions, be wasteful, and have many intelligent boosters installed all over the place. This year, the competent authorities said the works would be completed only in 2030.

Likewise, Songdo (South Korea) has announced it will be the smartest city in the world, with boaters installed anywhere, with waste management systems on the streets, roads and highways, with detailed statistics on citizens' consumption, and other intelligent economic activities. However, the promised technology city has remained unfinished and under-populated.

Mankind does not yet realize that by not respecting the promises made, it cuts its own branch under its feet.

References

1. http://www.link-labs.com/m2m-to-iot-to-ioe/
Vermesan, O., et al., "Internet of Things Strategic Research Roadmap," *Internet of Things-Global Technological and Societal Trends,* no. 9, 2011
2. Ruoklainen, T., and Kutvonen, L., "Interoperability in Service-Based Communities," *Business Process Management Workshops: BPM 2005*, Bussler, C., and Haller, A., (Eds.), vol. 3812 of Lecture Notes in Computer Science, Springer-Verlag, pp. 317–328, Nancy, France, 2005.
3. International Data Corporation (IDC), "Worldwide Smart Connected Device Shipments," *March* 2012. http://www.idc.com/getdoc.jsp?containerId=prUS23398412.
4. Guillemin, P., Friess, P., "Internet of Things Strategic Research Roadmap," *The Cluster of European Research Projects, Tech. Rep*., September 2009. http://www.internet-of-things-research.eu/pdf/IoT_ Cluster_Strategic_ Research_Agenda_ 2009.pdf
5. Su, K., Li, J., Fu, H., "Smart City and the Applications," *In Electronics, Communications and Control (ICECC), 2011 International Conference on*, Ningbo, China, September 2011, 1028–1031.
6. Giffinger R.,et al., "Smart Cities Ranking of European Medium-Sized Cities," Research Project Report, Centre of Regional Science, *Vienna UT, October 2007*. http://www.smart-cities.eu/ download/smart_cities_ final_ report.pdf
7. http://www.panoptinet.com/cybersecurite-decryptee/cest-quoi-linternet-of-everything-ioe/
http://theinstitute.ieee.org/static/special-report-the-internet-of-things
8. http://www.fahim-kawsar.net/papers/Kortuem. IEEE Internet 2010.Camera.pdf
Kortuem, G., et al., "Smart Objects as Building Blocks for the Internet of Things," *IEEE Internet Computing* pp. 30–37, January/February 2010.
9. Bandyopadhyay, D., and J. Sen, "Internet of Things - Applications and Challenges in Technology and Standardization," *Wireless Personal Communications*, vol. 58(2011), Issue 1, pp. 49/69.
Băjenescu, T.-M., "Internetul obiectelor," *Meridian inginerесс,* nr. 3(2014), pp. 24-29.
10. https://www.ptc.com/~/media/Files/PDFs/IoT /PTC_ Smart _Connected_Products_eBook. pdf?la=en
11.http://www.smart-cities.eu/download/ smart_cities_final_ report.pdf12. Dustdar, S., et al., (Eds.), *Smart Cities – The Internet of Things, People and Systems,* Springer International Publishing AG, 2017
13. Kumar Vinod T. M. (Ed.), *Smart Economy in Smart Cities,* Springer Nature Singapore Pte Ltd, 2017
14. Hadzic Tobias, *Smart Cities – Eine Bestandsaufnahme von Smart Ciyt-Konzepten in der Praxis,* Masterthesis, Fachhochschule Dortmund, 2016
15. Hua Bee Gogh (Ed.), *Smart Cities as a Solution for Reduction Urban Waste and Pollution,* Information Science Reference, 2016
16. Pol Goetzinger, P., „Une approche différente du concept de „smart city", http://ebl.lu/wp-content/uploads/2014/10/Vortrag-Pol-Goetzinger-Smart-City.pdf
17. * * * What is a Smart City? https://www.wien.gv.at/stadtentwicklung/studien/pdf/b008403j.pdf
18. * * * Smart cities Ranking of European medium-sized cities, http://www.smart-cities.eu/ download/smart_cities_final_report.pdf
19. IEC, Smart Cities, www.iec.ch/about/brochures/ pdf /technology/smartcities.pdf
20. Wu, Dong, „Smart Cities and Infrastructure," http://unctad.org/meetings/en/Presentation/ecn162016p01_Wu_en.pdf 2016
21. Batty, M., et al., „Smart Cities of the Future," *Eur. Phys. J.* Special Topics 214, 481–518 (2012)