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Smart Framework: Application under the Conditions of Modern Economy

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'Smart' is a term that has earned considerable scientific attention in different areas of research over the last few years. The variety of areas the term 'smart' is used nowadays calls for the development of a comprehensive and inclusive definition that would fit to all the contexts and situations. Many researchers focus on the fragmentary aspects of the concept 'smart', but systematic research in this area is hard to find. In response to the increasing use of the concept 'smart', the main aim of this paper is to provide an accurate definition of 'smart' which would be applicable in different areas of modern economy. A standardized definition could be used as an 'umbrella' for the development of other relevant topics. This conceptual paper also introduces the 'smart' framework, which incorporates all the components of the definition: challenges, environment, orchestration and sustainable welfare. The 'smart' framework was built by integrating different concepts and principles, such as technology reference models (TRM), open systems interconnection principles (OSI), etc. It reveals the peculiarities of 'smart' performance and application under the conditions and challenges of modern economy.

Keywords: *Smart Framework, Environment, Infrastructure, Innovation, Sustainable Welfare.*

Introduction

Literature review and the keyword analysis showed that the general meaning of 'smart' has not been strictly defined, although the term has been widely used in different areas of academic research from technological to social sciences (Albino *et al*., 2015; Anttiroiko *et al.*, 2013; Lombardi, 2011; Zygiaris, 2013; Jucevicius *et al.*, 2014; Bruneckiene & Sinkiene, 2014). In the area of social sciences, the concept 'smart' is rather complex and quite different from the concept found in the area of technological sciences. As a term, 'smart' is really popular; it is used in different ways and under different circumstances. Currently, the term 'smart' is flooding all the areas of our life; everybody uses the concepts of smart cities, smart businesses, smart systems, smart technologies, smart products, etc., but often without understanding what 'smart' really means. Moreover, there is a danger to use the term 'smart' so widely that it can become a marketing jargon without any appropriate conceptual grounding. In essence, a substantial difference between actually being smart and simply lauding a smart label can be observed. This determines the need to conduct an in-depth scientific analysis which could help to develop a comprehensive and inclusive definition of 'smart'. While analysing the works of different authors, who searched for a general definition of 'smart', it is difficult to find any objective sense following which a single definition could be considered the most accurate one. In many cases, if different definitions are properly interpreted, they have the same meaning but expressed in different words. This means that a general and encompassing definition can be developed. The concept 'smart' could be better perceived if a number of relevant theories and conceptual approaches were employed. Apart from provision of an accurate definition of 'smart', it is also important to provide a discussion on how the concept was interpreted in previous studies. **The main aim** of this paper is to provide an accurate definition of 'smart', which would reflect the peculiarities of current living conditions and would be applicable in different areas of modern economy.

The paper is organized as follows. Firstly, we define the term 'smart' and identify its key dimensions. Secondly, in order to support the components of the definition, we build the 'smart' framework which focuses on the peculiarities of 'smart' performance and application. Finally, we provide the detailed analysis of the components of a smart environment and explain interrelation among them.

Definition of 'Smart'

Although scientific literature does not contain any single standard and commonly accepted definition of 'smart', different definitions are strongly related to each other and share many common features. There is a range of conceptual variations generated by replacing the term 'smart' with other alternative adjectives, such as 'intelligent', 'clever' or 'wise'. In most cases, the concept 'smart' is used in parallel with the concept 'intelligent', when both of the concepts refer to cognitive and informational processes, i.e. information processing, creative learning and problem solving capability. For comparison, the recent definitions of 'intelligence', provided by Legg and Hutter (2007) who have collected different definitions from different authors and areas of research, have been presented in Table 1.

Table 1

Definitions of 'Intelligence'

No.	Definition	Author
1.	The power to rapidly find an adequate solution in what appears a priori to be an immense search space.	Lenat and Feigenbaum, 1991
2.	The ability to use optimally limited resources – including time – to achieve goals.	Kurzweil, 2000
3.	The capacity to acquire capacity.	Lanz, 2000
4.	Achievement of complex goals in complex environments.	Goertzel, 2006
5.	The ability to adapt effectively to the environment, either by changing the environment or finding a new one.	Anderson, 2006
6.	Intelligence measures an agent's ability to achieve goals in a wide range of environments.	Legg and Veness, 2013
7.	Intelligence is to relate two independent systems: the knowledge and the goals. The intelligence uses whole knowledge available to find the solution to the problem.	Moreno-Cano *et al.*, 2015

Even though the concepts 'smart' and 'intelligent' are closely related and both possess references to cognitive capabilities, 'smart' involves more than the ability of quick thinking and capability to come up with the best solution for a situation. In fact, 'smart' is more about application of ideas and thinking in a practical way to find solutions to particular problems. Hence, 'intelligent' may refer to the capacity of understanding, while 'smart' refers to the ability of applying intelligence in practice.

Other interpretations recommend that 'intelligent' is a part of the term 'smart' because 'smartness' is realized only when an intelligent system adapts itself to a user's needs. In general, smart systems diverge from regular systems by their orientation towards problem solving rather than towards automation of traditional processes. They are defined as adaptive rather than preprogramed, and treated as creative rather than computational. Doom (2001) and Gabrys (2005) highlight five attributes of 'smart' systems:

1. Adaptable, i.e. able to modify their behaviour to fit the environment.

The ability to adapt to users needs and the environment (i.e. to recognize the context) is one of the basic characteristics of smart systems. More adaptive systems (e.g. applied for people, location, networks or system condition) provide more opportunities to ensure convenient performance in the long run.

2. Sensing, i.e. bringing awareness concerning the status information on particular objects or spaces.

Sensing systems can acquire data from the surrounding of the different scale around them and respond to this world. This ability to interpret external signals and communicate back is what makes these systems smart. The creative combination of new types of sensors, microprocessors and tiny actuators are main enablers of radically new kind of sensing systems creation, which can work for the environment, people or be built in state-of-the-art devices.

3. Inferring, i.e. able to draw conclusions from rules and observations.

Smart systems should be able to solve problems by following rules and observations; what is more, they should be able to draw the conclusions that can help them accomplish particular tasks. This capacity, known as inferring, is principal for any intelligent entity; it is the core of 'intelligence' in artificial intelligence systems, e.g. it is similar to a human ability from seeing the smoke to recognise that a fire has sparked nearby. More importantly, the inferring systems continues to develop in the variety and powerfulness. The systems that go beyond problem solutions and are able to learn from experience and training have already been developed.

4. Learning, i.e. able to lean on past experience to improve the performance in the future.

The capacity of learning is a vital characteristic of intelligence. Smart systems must be able to improve through interaction with external world; they must also lean on their internal states and processes. To complete the learning process, a system must be able to evaluate its current behaviour, create a common concept of how to identify a problem and transform its internal knowledge. There are many methods that can enable a computer to learn, but the most promising of them are case-based reasoning neural networks and genetic algorithms.

5. Anticipating, i.e. able to think and reason about what to do next.

An anticipating system can reason about itself, its users and its environment; it can also predict particular actions and needs, and offer the solutions to current and/or arising problems. In general, an anticipating system is able to think ahead. These systems are not limited to one specific field but can apply their knowledge and reasoning across various fields.

Literature review made by Nam and Pardo (2011), shows that the term 'smart' can be seen from different perspectives: academic, industrial and governmental. In academic literature, with an interest in knowledge and information development, the meaning of 'smart' covers a range of technological characteristics, such as self-configuring, self-healing, self-protective and self-optimizing. In industrial literature, with a hint to business and industrial instruments, the term 'smart' refers to intelligent-acting products and services, artificial intelligence, and autonomously thinking machines and tools. Finally, governmental documents interpret the term 'smart' with regard to 'smart growth', which refers to a compact and reasonable exploitation of resources and the aims to make development decisions predictable, fair and cost effective. In this context, 'smartness' is treated as a normative claim and an ideological dimension (Nam & Pardo, 2011; Sarkiunaite *et al.*, 2012; Herrschel, 2013; Mosannenzadeh & Vettorato, 2014; Albino *et al.*, 2015).

Although some scientists consider 'smart' to be an instrumental rather than a normative term, this interpretation is not agreed upon. From an instrumental perspective, 'smart' indicates a category of entities and systems in which ICT and sensors play essential role. For some researchers, the word 'smart' means a desired outcome, which makes it normative (Al-Nasrawi et al., 2015). Giffinger et al. (2007)

describe 'smart' as operating in a forward-looking manner, and focus on such issues as awareness, flexibility, transformability, synergy, individuality and self-decisiveness. According to Vermesan & Friess (2013), 'smart' is the environment in which digital and real-world objects cooperate in a cognitive and autonomic manner to fulfil specific goals in a more efficient way than application of the basic systems grounded on static rules and logic.

The definition of 'smart' also depends on the viewpoint followed. 'Smart' could be defined by considering not only techno-centric, but also human-centric approach as the idea of smartness goes beyond application of state-of-the-art technologies and is believed to include more important social dimensions, such as social welfare, living standards, sustainable development, etc. Considering the techno-centric point of view, modern smart systems already have the capacities that are similar to the capacities of humans, for example, learning, memory and decision making. In most cases, smartness of a system can be treated as an autonomous performance based on self-regulation, i.e. requiring minimum human monitoring or supervision. Ultimately, intelligence of a system is dependent on the innovative packaging of existing and emerging technologies (Doom, 2001). For example, in terms of computational power costs, the performance of computers has shown a remarkable and steady growth, doubling every year and a half since the 1970s. According to Kurzweil (2012), computer performance will be able to simulate and exceed the performance of human brains, just in a few decades from now. As it was stated by Moreno-Cano et al. (2015), in a near future, the human role could be reduced to provision of services to smart systems; what is more, huge amounts of human personal memory could be stored outside human beings the same as the ability to make decisions. Following this approach, 'smartness' can get so disseminated that people can become only foolish creatures, living in a reality where smart entities are in charge of taking all decisions for them. But considering the other perspective, both intelligent systems and smart entities are dependent on human intelligence and interaction with humans. Human knowledge and skills still remain essential and create the basis for the development of smartness in future systems.

The term 'smart' is quite controversial because what is called smart today can be considered common tomorrow. Therefore, 'smart' is a relative rather than an absolute term. The term 'smart' represents an evolutionary improvement (i.e. a continuous innovation process), which is promoted with the aim to create certain benefit or welfare by combining economic, ecological and social domains. These multi-dimensional sustainability transitions could be seen as a technical challenge for the development and implementation of smart technologies, or as a broad process of social transformation that entails particular lifestyles and social behaviours. In both cases, the evolutionary transition requires a considerably high degree of flexibility and adaptability to the changes and highly dynamic conditions. In short, it could be concluded that 'smart' is an evolutionary transition, which is promoted with the aim to achieve sustainable development and ensure sustainable welfare of a particular socio-technical system (STS). A STS describes three interrelated dimensions: created artefacts (by agents), technological systems and policies that mutually shape the scope of actions. According to Smith and Stirling (2014), a socio-technical system is understood as a system that displays complex, dynamic, multiscale, and adaptive properties. The shape of a new STS is at its beginnings unclear, uncoordinated and uncertain. Therefore, a STS learns, adapts and ejects new values, technologies, processes, actors or rules. Different attitudes towards the term 'smart' lead to various definitions. For instance, considering different fields of its application, the term 'smart' could be defined as follows:

- A system: 'smart' is a sustainable and efficient outcome of a dynamic and evolutionary transition to sustainable welfare in a STS.
- A process: 'smart' is a sustainability and efficiency-oriented dynamic and evolutionary process geared for a STS for sustainable welfare.
- An implementation: 'smart' is a sustainable and efficient implementation of particular transition drivers so that they would meet the challenges/visions of sustainable welfare.
- An orchestration: 'smart' is a sustainable and efficient orchestration of the dynamic and evolutionary transition of a STS to sustainable welfare.

Although the term 'smart' is usually used as an adjective, which describes an object or a system, it is purposeful to provide its general definition that could fit any context and would be applicable regardless of the type of a system or an object addressed (e.g. home, city, environment, etc.). By combining all the above-analysed components and key attributes of the concept 'smart', our research group propose to define ***'smart' as meeting challenges to improve sustainable welfare.***

In the following sections of this article, the proposed definition of 'smart' and its key components will be explained in detail. We will focus on the main elements of the definition and will explain it in terms of the interconnection among the structural elements under the conditions of modern economy.

SMART Framework

With reference to the theoretical interpretations of the concept 'smart', introduced in previous sections of this article, the framework that would cover all the components of the definition and would illustrate the applicability of this definition was developed. For the initial explanation of the 'smart' framework, some fundamental questions have to be answered: (Why?) – this question helps to identify the reasons and essential drivers of 'smart'; (Where?) – it helps to define the areas in which a 'smart' object can be implemented; (How?) – it helps to explain the way following which 'smartness' could be achieved; (What for?) – it helps to define the main results and outcomes of 'smartness'.

The 'smart' framework was built by integrating different concepts and principles, such as technology reference models (TRM), open systems interconnection principles (OSI), etc. It revealed the peculiarities of 'smart' performance and application. The framework characterizes and puts in order all the components of 'smart': challenges, environment, orchestration and sustainable welfare. Figure 1 shows the conceptual schema of the 'smart' framework.

Challenges

The dynamism, complexity and multi-dimensional nature of technological transformation, as well as the contemporary challenges of sustainability in terms of modern economy, lead socio-technical systems towards more convenient solutions and new forms of reflexive governance capable to initiate and implement innovations at longer time-scales and wider aggregation levels. The increasing number of intelligent components and the dynamism introduced by STS reconfiguration requires the development of the systematic measures that would allow to explore, understand, model and possibly control the systems in which smart technologies are entangled with social structures. In particular, there is a need to focus on the behavioural patterns, dynamics and driving mechanisms of the social structures, interactions of which are integrated from the level of individuals to the level of groups, communities and large-scale socio-technical systems.

Why?	Where?	How?	What for?
To meet Challenges of social-technical system (dynamics, complexity, scarcity, equity, etc.)	In Smart environment (technologies, spaces, services, society)	By Orchestration of all layers of Smart environment	For development of Sustainable welfare (ecology, safety, quality, happiness, etc.)

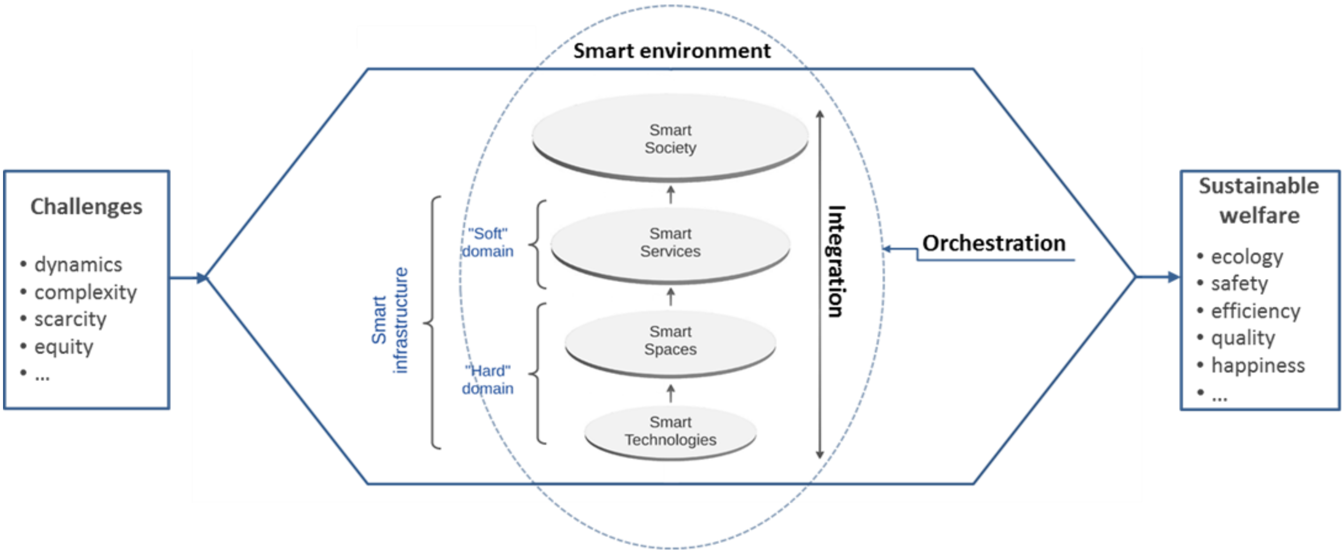

Figure 1. Conceptual Schema of the 'Smart' Framework

Smart Environment

Smart environment, described in this framework, integrates ubiquitous systems, including smart technologies, spaces, services and society - the main domains that are employed for illustration of 'smart' application. It could also be defined as a 'system of systems' that uses smart technologies to transform its core systems and make them instrumented, interconnected and able to create system intelligence. In a technology-centric smart environment, the primary focus falls on the technological systems, which serve a background for smart infrastructure development and design. Application of smart technologies and smart infrastructure provides prospects for resource mobilization; this way, it allows to enhance coordination of sustainable solutions and empowers creation/formation of smart communities that connect people and services in an efficient and seamless manner. Smart environment is explained by 4 interrelated conceptual layers (Figure 2.).

Smart technologies (sensors, information and communication technologies (SICT), software and actuators) are treated as an essential part of 'hard' domain; they act as the main basis that integrates all the interactions between the core components of the 'smart' infrastructure. The main goal is to create smart platforms and networks for interconnection, integration and monitoring of the infrastructure of the upper layers. The latter is an essential component of the 'smart' infrastructure that acts like a glue to connect different spaces and services. In addition to the technical implementation of SICT, the questions regarding innovative services and public interest-oriented concepts also arise, and they involve the issues of increased integration of infrastructures (Teufel & Teufel, 2015).

Smart spaces are also attributable to 'hard' domain, a tangible part of the 'smart' infrastructure (buildings, industry infrastructure, energy and transport systems, leisure facilities, etc.). 'Hard' domains are the settings in which the vision of a smart environment can be implemented. Supported with distributive mechanisms, smart technologies may provide efficient and flexible solutions for facilitation of the active interaction between smart spaces (e.g. acquisition of information, definition of meanings and provision of an appropriate reaction). In general, smart spaces help to create and foster the development of smart platforms, which connect smart objects and integrate future generation devices, network technologies, software technologies, interfaces and other evolving ICT innovations for the promotion of social well-being.

Smart services are attributable to 'soft' domain, an intangible part of the 'smart' infrastructure (governance, education, healthcare, tourism, waste management, mobility, etc.). Services are provided in a well-structured smart manner, and can be managed and orchestrated for a multitude of applications running in parallel. This means that tomorrow's services and applications do not need to be defined in an intertwined manner or strictly linked to a physical system; they simply run as services in a shared physical world.

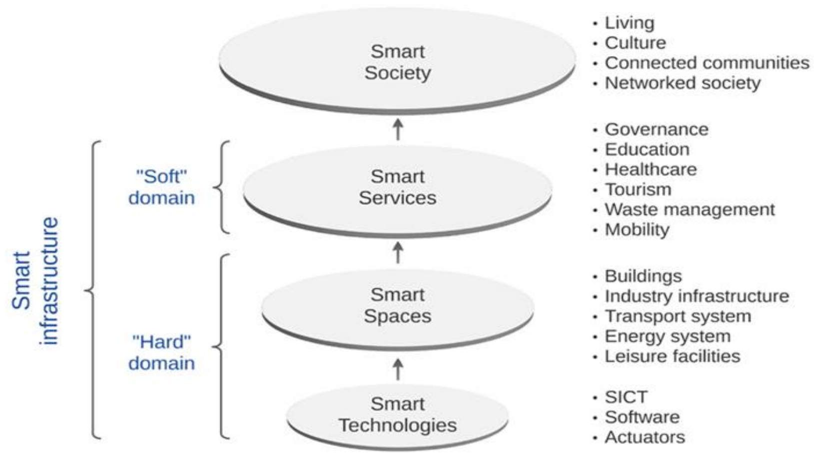

Figure 2. The Concept of Smart Environment

In *smart society* (incorporating living/lifestyle, culture, connected communities, networked society, etc.), which is a top layer in the 'smart' framework, people are not passively affected by technologies, but actively shape their use and influence. Smart living is a conceptual extension of smart infrastructure from the personal context to the area of larger communities and society as a whole. Smart living refers to availability of supportive infrastructure and the quality of life in liveable and safe settings. As highlighted by Teufel and Teufel (2015), digitizing and communication, i.e. the seamless connection of ubiquitous technologies employed to enhance liveability, make the basis of smart living. Smart living embodies the vision of a comfortable, economical and technically sound as well as socially safe and satisfactory habitat, characterized by a high degree of self-responsibility of the actors, dynamic structures and constant reorganization based on the measured data and interpolation.

Orchestration

Orchestration refers to coordinative, sequenced and synchronized execution of processes and management of information flows across smart environment layers to ensure efficient/convenient performance of all the components. The most distinctive features of different implementations are sequence of the interaction and conversational skills required to execute an associated process. One of the biggest challenges envisaged while orchestrating a smart environment is a rapid seamless integration of heterogeneous elements pursued without any losses in functionality and efficiency.

Sustainable Welfare

This component of the 'smart' framework represents the outcome of 'smart' in which sustainable welfare is defined through reference to ecology, safety, quality, happiness, etc. Creation of sustainable welfare calls for a multi-dimensional approach and is associated with sustainable development, involving economic, social and environmental concerns. Development and improvement of sustainability relies on the thorough arrangement of smart systems, along with introduction of appropriate strategic and policy interventions while moving towards sustainable welfare. It is expected that the development of smart entities will be addressed for the emerging needs of the present without consideration of any compromising abilities for future generations to meet their needs.

The 'smart' framework, introduced in this section of the article, provides the overall vision of 'smart' application. The main goal of the framework is to explain extensive 'smart' performance and application. The framework may also be employed for explanation of smaller-scale 'smart' concepts, e.g. a smart city, smart home, etc.

Conclusions

Considering various conceptual definitions, explained from different theoretical perspectives, we have developed the definition of 'smart', which is used in different areas of modern economy. Our research has revealed that 'smart' is a multidimensional concept, which can be defined through the different components and features of smart environment by extending the traditional separate issues of smart technology, infrastructure, society and living. Having combined all the components and key attributes, we propose to define *'smart' as meeting challenges to improve sustainable welfare.*

Leaning on the exploration of a wide and extensive array of literature from various disciplinary areas, we have developed the 'smart' framework, which supports and structures the proposed definition of 'smart' by integrating and explaining the relationships between all the components of the definition: challenges, environment, orchestration and sustainable welfare. The 'smart' framework can be employed not only for characterization of a STS as a whole, but also for explanation of a STS's conceptual layers. It can also help to develop initiatives and strategies that would allow to orchestrate the layers while addressing the emerging challenges of modern economy.

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