

Using Persuasive Systems to Incentivize Sustainable Smart Cities

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Abstract

The smart city projects have been more and more popular and widespread all over the world. The continuous increasing of city's population and the complexity of city management drive local governments towards the strong use of technologies to support a higher quality of urban spaces and a better offering of public services.

The concept of smart cities different from one person to other around the globe. For several experience in the ground show that many cities define themselves as smart but the meaning attributed to this word is different each time.

This paper aims to clarify the meaning of many scientific definitions such as "smart cities", "internet of things (IOT)", "big data" and "persuasive technologies" It also identifies the main dimensions and elements characterizing a smart city and introduce a new architecture where part of the smart city where a middleware based on persuasive technologies has been added in order to change actions of citizens toward their cities using the big amount of data generated by their daily activities. This work is a first step for a future study that aim to predict factors and building predictive models for persuasive technologies that change the attitude of citizens in the field of transportation within a smart cities.

Keywords: Smart Cities · Big data · Internet of Things · Gamification · Persuasive Systems

I. INTRODUCTION

In order to understand the challenges that urban areas are facing at this time, the context must be contextualized. The ever-increasing concentration of individuals in cities

inevitably leads them to preserve and optimize their resources and organization. To fully understand, here is two findings: Currently, 50% of the world's population lives in cities[1], in the figure reaches 77% in Morocco the rate of urbanization in Morocco exceeds 60% in the last 50 years; in 2050, this percentage will rise to 70%. This population is considered to be a primary consumer of resources; in fact, cities consume 75% of the world's resources and energy. More than that they generate 80% of greenhouse gases, occupying only 2% of the world's territory.

This evolution or urban explosion gives birth to new vital needs are imposed in terms of food, health, climate, mobility... ETC. And it has to face many challenges: population increase, energy needs, and economic precariousness, social spreads, reduction of budgets at a time of crisis, rising energy costs, depletion of fossil resources, pressure Media... ETC, which requires a very significant change in the deployment and management of all types of infrastructure in cities. Therefore, this fact must be taken into account by the public policies developed locally in the years to come. Given the scenario that shows an urban environment with a growing demand for efficiency and resources, public administrations need to consider an evolution in city management models. At the same time, we live in the 21st century in the era of the digital revolution ubiquitous: the world has exceeded the figure of 5 billion of connected devices and, in 2020, this figure should have tripled. The idea, therefore, does not use this digital revolution in order to accompany cities around the world in their transition to face the demographic and environmental challenges of the future in order to build so-called Smart Cities which uses new information and communication

technologies (ICT) as well as the development of digital infrastructure and services to improve quality and reduce the costs of urban services.

The objective is to have a smart city whose architecture is based on a technology that can be seen as a revolution in the fields of computer research and directly affects the main actor in the architecture of Smart cities which is the inhabitant, we talk here about persuasive technologies, one is made the change of the human mind to behave positively in situations has always been the target of many researchers. It is a technology that is designed to persuade humans by changing their attitude and influencing their behavior positively regarding different fields (economic, medical or personal) based on using digital resources (big Data) collected by different types of sensors.

II. SMART CITY AND TECHNOLOGY WAVES

A. *Smart City*

As we discuss before More than half of the World's population now lives in urban areas [2], [3]. This shift from a primarily rural to a primarily urban population is projected to continue for the next couple of decades [4]; which generate surely new kinds of problems and difficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestions and inadequate, deteriorating and aging infrastructures are among the more basic technical, physical, and material problems. In order to solve those problems and overcome the limitations of traditional urban development that tends to manage urban infrastructure systems in silos[5]–[8], a deeper understanding of the smart city concept that introduces new practices and services that highly impacts policymaking and planning.

A smart city is a community that is efficient, sustainable and liveable. Recently that term became very famous and popular in the urban planning field. Here there are various Definitions of Smart City.

- A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens. [1]

- A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens. [2]
- A city striving to make itself “smarter” (more efficient, sustainable, equitable, and livable) [3]
- A city “combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and livability.” [4]
- “The use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient” [5]

The goal of building a smart city is to improve the quality of life by using technology to improve the efficiency of services and meet residents' needs, Building a city adapted to the needs of the present but preserving resources for the future has given rise to the concept of smart city. Its objective can be summarized in 3 points: to improve the comfort of the inhabitants while having more efficient transport and respecting the environment.

The 4P vision [6] is a model of smart city that has proved its excellence in several countries and will be implemented in Morocco: Casablanca nominated to become an exemplary smart city in Africa.[7].

The 4P is a model where the partnership between the different stakeholders (public, private, citizen) is at the heart of the Cluster's activities. This model takes into account the importance of connected communities within the city and the role of inhabitants as users, consumers, producers of information and data.

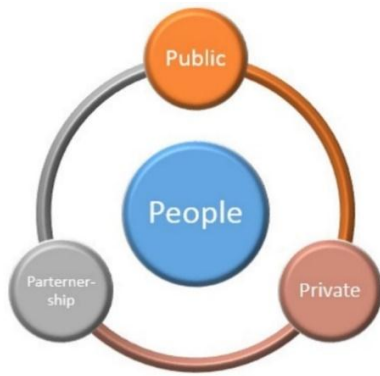


Figure 1: 4P shema

Various models of intelligent cities are presented in the literature. The six characteristics are shown in Figure 1 according to Rudolf Giffinger[8] and Colldah [9]

Six levels are defined in a comprehensive way by beams of factors: a typology of the intelligent functions of the city.[8, p. 16].

SMART ECONOMY (Competitiveness) <ul style="list-style-type: none"> ▪ Innovative spirit ▪ Entrepreneurship ▪ Economic image & trademarks ▪ Productivity ▪ Flexibility of labour market ▪ International embeddedness ▪ Ability to transform 	SMART PEOPLE (Social and Human Capital) <ul style="list-style-type: none"> ▪ Level of qualification ▪ Affinity to life long learning ▪ Social and ethnic plurality ▪ Flexibility ▪ Creativity ▪ Cosmopolitanism/Open-mindedness ▪ Participation in public life
SMART GOVERNANCE (Participation) <ul style="list-style-type: none"> ▪ Participation in decision-making ▪ Public and social services ▪ Transparent governance ▪ Political strategies & perspectives 	SMART MOBILITY (Transport and ICT) <ul style="list-style-type: none"> ▪ Local accessibility ▪ (Inter-)national accessibility ▪ Availability of ICT-infrastructure ▪ Sustainable, innovative and safe transport systems
SMART ENVIRONMENT (Natural resources) <ul style="list-style-type: none"> ▪ Attractivity of natural conditions ▪ Pollution ▪ Environmental protection ▪ Sustainable resource management 	SMART LIVING (Quality of life) <ul style="list-style-type: none"> ▪ Cultural facilities ▪ Health conditions ▪ Individual safety ▪ Housing quality ▪ Education facilities ▪ Touristic attractiveness ▪ Social cohesion

Figure 2: A typology of the city's smart functions.

The concept of smart cities can be considered as a purpose that offers a way to achieve many objectives in favor of the citizens, such as maintenance or improvement of the inhabitant's life quality, sustainable development, the economy of resources or even sustainable mobility. For an integrated understanding of the smart city concept, we must know that smart cities projects are a very important part of a general concept of city modernization where we Incorporating new information and communications technologies into the various sectors and services of the city to achieve of those objectives. In general, the objective of this concept is to offer the most virtuous development possible.

B. Internet of Things

In 1999, a member of the Radio Frequency Identification (RFID) development community coined the concept of for the first time but in the last years it becomes more relevant to the practical world largely this is due to the great development witnessed in the technical field, which contributed to facilitate the connection to the Internet in almost any place, the development and the growth of mobile devices, and also the emergence of the so-called cloud computing and data analytics.

It's a network where billions of objects are able to communicate, sense and also share information, using public or private Internet Protocol (IP) networks. The internet of things (IOT) common definition is a network of physical objects that able to collect and analyze data from different sources also offer a wealth of intelligence for planning, management, and decision making. The internet is not only a network of computers, but it has evolved into a network of devices of all type and sizes the most important thing is the ability to communicate & share information based on stipulated protocols in order to achieve smart reorganizations, positioning, tracing, safe & control & even personal real-time online monitoring, online upgrade, process control, and administration.[1], [10].

There are three categories of IOT:

- People to people,
- People to machine/things,

- Things/machine to things/machine, Interacting through the internet.

C. Big Data

Big data presents a solution that makes everyone able to access giant databases in real time. [11] It's a massive volume of both structured and unstructured data that is so large that it is difficult to process using traditional database and software techniques[12].

Despite the “Big Data” became a new buzz-word, there is no consistent definition of Big Data, no detailed analysis of this new emerging technology. Most discussions until now have been going in blogosphere where active contributors have generally converged on the most important features and incentives of the Big Data.[13], [12], [14].

Most scientists and data experts define BIG data according to the following three main characteristics (called 3Vs) [15] which define the need for reliable, relevant and meaningful data to give meaning and economic interest to the analysis and thus a thoughtful and comprehensive decision support.

The volume will reach 40 by 2020 [22] and a few years later we are going to talk about brontobytes (1027 bytes) it refers to the large amounts of data generated every second. Just think of all emails, twitter messages, photos, video clips, sensor data, and more. That we produce and share every second. Variety of information (From various sources, unstructured, organized, Open...), Velocity refers to the speed at which new data is generated and the speed at which data moves around. Veracity refers to the messiness, or trustworthiness of the data, refers to the disorder or reliability of the data. (just think of Twitter posts with hash, abbreviations, typos and familiar words.)But Big Data and Analytics technology allow us to work with this type of data. Value: having access to big data and turn it into a value.

However, other major V data which draw attention to the top are: validity is like the veracity of large data is the question of validity, the data are correct and accurate for the intended purpose and volatility: large data refers to the validity period of the data and their shelf life. In this world of real-time data, you need to determine when the data is no longer relevant for the current analysis.[16].

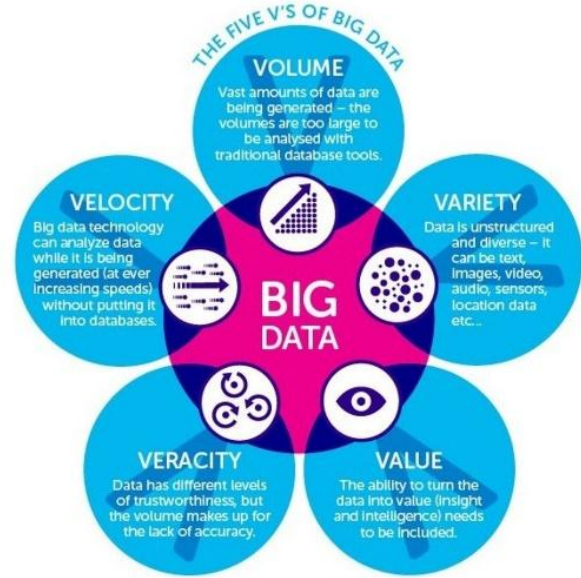


Figure 3: 5v of Big Data

D. Persuasive Systems

Persuasive technology is widely defined as a technology designed to change the attitudes or behavior of users through persuasion and social influence, but not through coercion or deception [17].

The persuasive systems used to change behavior in urban personal mobility context is an active field of research - Figure 4-, there are many examples of systems and implementations that exist and their main objective is motivating users and make them more aware about environmentally friendly choices.

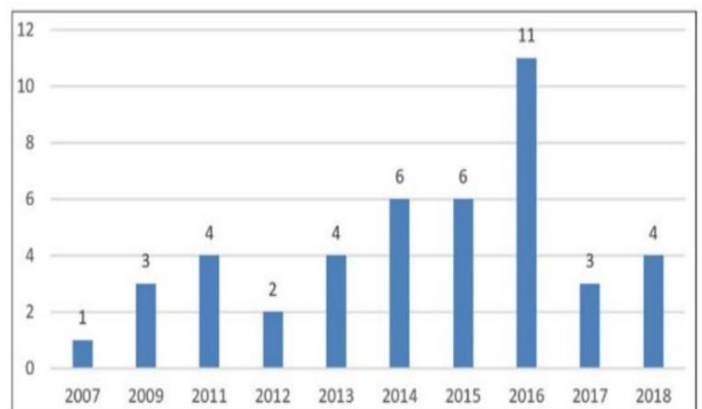


Figure 4: Published papers related to persuasive technologies for sustainable mobility by year.

After introduction of the study of the persuasive technology by Fogg, Ever since Fogg's popularization of persuasive technologies, persuasion has been utilized in different application domains such as health, environmental awareness and education [18], [19] In all these domains, users of persuasive technology are guided towards the adoption of desired attitudes or actions. Such systems typically employ a number of persuasive strategies, such as those suggested by Fogg and others [20], to motivate users to choose a more environmentally behavior. Theories of behavior change agree that any voluntary change of behavior is not an event, but a process.

Recently many researchers focus on the usage of persuasive technologies as a tool in order to motivate and change individuals' behavior positively this idea has been expanding quickly. Faludi concluded that persuasion was a science, newborn and inexact, but a science nonetheless [28].

These systems incorporate one or more persuasive strategies in order to motivate change.[21] During the review of related systems, we identified a set of five strategies that are commonly used.

Table 1: Five persuasives strategies

Strategies	Description (Adopted from [22])	Related Papers
Challenges & Goal Setting	Offering challenges and setting goals that incentivize the user to show an intended behavior in a self-competitive context through a comparison of the present and a desirable future situation.	[23]–[27]
Self-monitoring and Feedback	Using tracking technologies to supervise the status of the users and their performance toward a behavior can help people to achieve predetermined goals or outcomes.	[26], [28]–[30]
Personalized messages	In order to be more persuasive Information provided by computing technology must be tailored to the individual's needs, interests, personality, sage context, or other factors relevant to the individual	[31], [32]
Social comparison	Making a comparison between system users performance toward a target behavior can be a great and powerful way to motivate them to Adopt this behavior.	[23], [26], [28], [33]–[42]
Gamification	One of the most effective ways to influences people to perform the target behavior is offering a virtual reward on such a target behavior	[25], [26], [33], [35], [36], [42]–[50]

For the last one (Gamification) we notice during the research review that it has a large audience of fans in the ranks of researchers and it prove itself as a successful strategy. It consists in transposing the mechanics of the game into a non-digital world [59] The process of game-thinking and game mechanics to engage users and solve problems.[60]

Regardless of the type of game, whether it is classical (On board, with cards, with dice...) or a video game, we always have four criteria: Clear objectives, Rules, A feedback, and a voluntary participation of players [61].

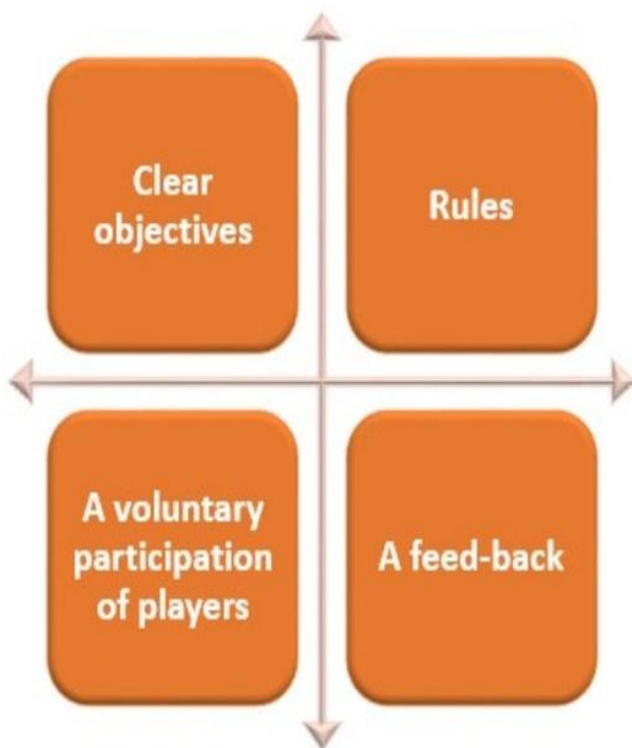


Figure 5: Criteria of Gamification

- Clear objectives: In the real world, where goals are fuzzy and rule selectively applied, gamification provides clear goals and well-defined rules of play to ensure players feel empowered to achieve goals.[62]

- Rules: the rules can be considered as a norm for guiding players to achieve specific objectives the superfluous obstacles that can be faced.
- A voluntary participation of players: no one can force you to play the game. Admittedly, there some situations where we can play under threatening or terrorize but in this case, it can't be named as a game anymore because we will not feel or touch the magic of the mechanics of this one, even with an extremely immersive game.
- A feedback: is anything that gives a user some understanding of progress and achievement. This can be something as simple as a message that says, "You have completed the mission" to a virtual integrated economic system where we can find points, badges, levels, leaderboards, trading, prizes...Etc.; the main objective is keeping the user always in touch.

III. PROPOSED ARCHITECTURE

Unlike classical architecture of smart cities, we offer an advanced architecture where we add a middleware component between the amount of space-timing information - generated by the activities performed by humans, for example, Increased pollution in the air which can be collected using various sensors- and the final actors (citizens), these data will be used to build a dataset that feeds our persuasive system.

The middleware must be able to adapt and evolve – using Data profiling in order to examine available data and collects information about it, also it gives overall idea about the database which obliging for data cleaning[63]; the last one is essential to maintain the data warehouse; it deals with detecting and removing errors and inconsistencies from it in order to improve its quality techniques and also able to estimate the susceptibility of a person to different persuasive strategies - this is also called "Persuasion Profiling" – and that will be used as an action dedicated to changing the behavior of citizens in smart cities.

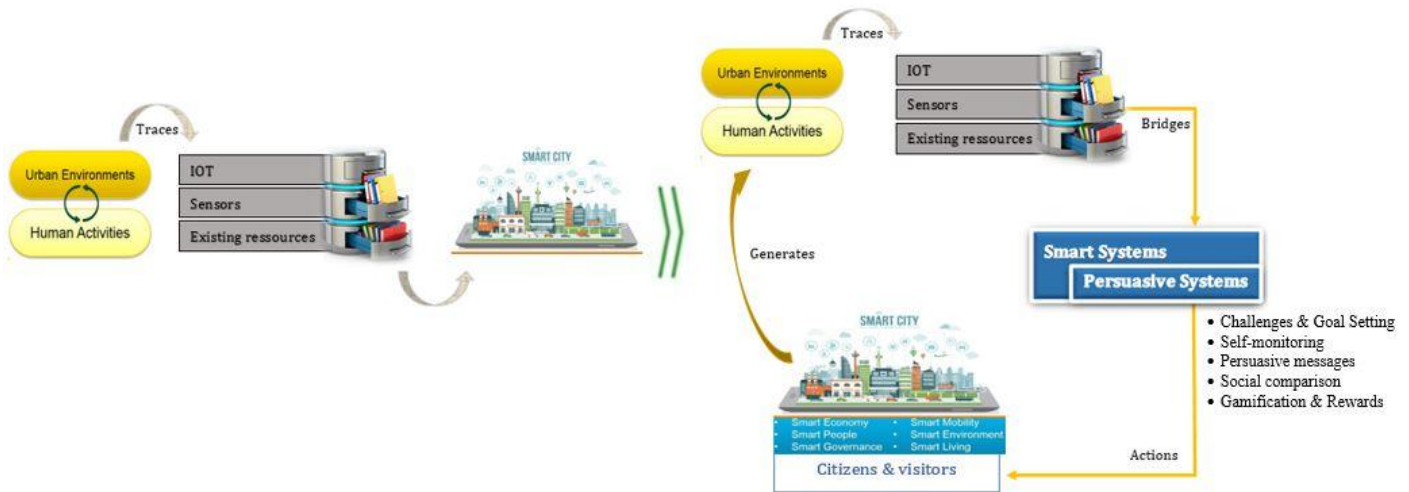


Figure 6: Architectures existing / proposed

IV. CONCLUSION

The concept of smart city is not an extension of the concept of sustainable development, but rather a tool for the realization and implementation of a sustainability-oriented community. The factors of success of such an approach based in particular on a specific transparent and collaborative governance in which the importance of citizen's participation is central. In this article, we have detailed the state of the art of technological and social components and proposed a new architecture that includes persuasive technologies in order to encourage citizens to participate directly or indirectly in the rational consumption of resources, whether energy or natural. Indeed, a smart city is above all made by and for citizens.

Persuasive technologies, through their ability to act on the behavior and attitudes of individuals, are a promising avenue for dealing with the major societal challenges that arise. They are based on results obtained in cognitive and social psychology during the last decades. In our future works involves the identification of different principles and persuasion strategies, research has attempted to model the behavior of technology users to better understand how we can influence them. We also present the main behavioral models developed in the field of persuasive technologies and a comparative study between existing systems. This is a first study aimed at predicting factors and developing predictive models of persuasive technologies that change the attitude of citizens in the field of transportation. And we aim to propose a model of prediction for persuasive technologies that change the attitude of citizens by applying techniques of predictions in order to describe and distinguish concepts for future predictions on new users of persuasive technology.

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