

FROM TRADITIONAL CITIES TO SMART CITIES.

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Abstract. The transformation of traditional cities to smart cities becomes increasingly important for the actors that interact with it; government, public and private organizations, and citizens in general, in addition to making easier its implementation thanks to the development of ICTs (Information and Communications Technologies). Each project deals with specific needs according to the city's characteristics (technological development, educational level, quality of provision of public services, number of inhabitants, climatic and environmental conditions, etc.), however, it is possible to establish a general methodology for developing this transformation. The present article develops a methodological proposal for the implementation of a smart city which includes five stages; analysis of current situation, preparation of a work plan, strategic formulation, action plan and management plan. Each stage is developed by integrating components such as infrastructure, technologies, processes and human capital in order to satisfy established strategic objectives and, overall, to create a better quality of life of its inhabitants and a sustainable environment.

Keywords: Smart city, methodology, ICTs., integration, sustainable.

1 Introduction.

The concept of smart city began to be utilized at the end of the 20th century with the aim of providing solutions for the problems of sustainability in cities around the world [1] and it was even more promoted by the urban growth trends which predict that in 2050 about 70% of the world population will live in cities [2]. In recent years, the word has been linked to the use of ICTs (Information and communications technology) as a way to promote economic growth and improve the quality of life of the different cities' inhabitants in harmony with the environment [1], [2]. A smart City is attractive for citizens, businessmen and workers because it offers a safer space, better services, creation of jobs and reduction of inequalities through creative solutions [3].

2 Smart cities.

2.1 Concept of smart city.

According to the International Telecommunications Union "A smart and sustainable city is an innovative city that takes advantage of information and communication technologies (ICT) and other ways to improve the quality of life, efficiency of operation and urban services and competitiveness, responding at the same time to the needs of present and future generations with regard to economic, social and environmental aspects " [4].

2.2 Architecture of the smart city.

Although each smart city project looks for specific solutions associated with problems that affect the greatest number of people, they agree on the need to integrate people, technologies and processes [3]. From the technological point of view, a smart city can be considered as an integral system that includes different levels associated with providing intelligent services in different categories [5].

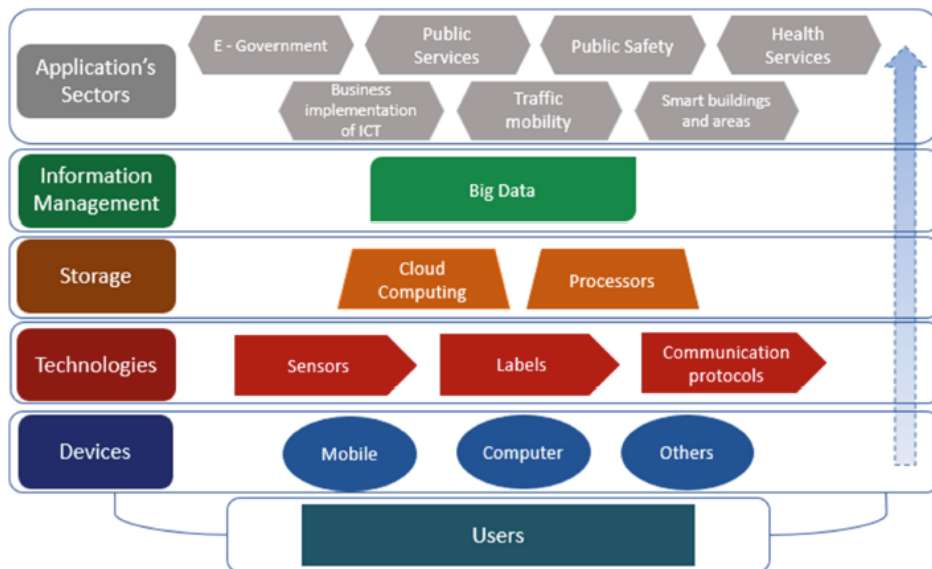


Fig. 1. IoT proposal architecture for smart cities [6].

The Fig. 1. presents an IoT (Internet of things) proposal architecture for smart cities[6] in which the general characteristics of different IoT's architectures examined has been identified. In this the information flow goes from user to the interested sectors, being users the main source of data. The flow levels can be classified into:

Devices. It corresponds to mobiles, computers and other intelligent devices that are equipped with microprocessors and allow machine-machine connections [3].

Technologies. They allow the capture of different stimuli from the physical world and intelligence to monitor and communicate this information of the city [5].

Storage. It is about the provision of the necessary information to provide the services by the smart city [7].

Information management. It refers to the intelligent understanding and analysis of stored data in order to structure it and make it available through different means such as applications [7].

Application sectors. Constructed from the smart city solution, they comprise the client interface and the integration with the customer's systems [7].

The proposal architecture establishes the necessary links to develop apps with a standard that can allow integrations of software and reduce the gap of compatibility [6].

2.3 Benefits of becoming a smart city.

Unquestionably, smart cities are destined to become one of the most powerful tools in public policies in the field of cities in the coming years [8]. By integrating the use of information and communication technologies (ICTs) in the construction of an intelligent city, as well as significantly improving the provision of services, it will also allow us to build a sustainable path for economic and social development in the future years of this and your country.

In practice, the benefits will be much broader, studies on technical reports carried out in Spain on smart cities, allow the identification of benefits and risks of the implementation of smart cities [9]. Among the benefits are: the improvement of the effectiveness and efficiency of public administrations, the obtaining and analysis of the information generated in real time, the reduction of expenses in the maintenance of buildings and infrastructures, the reduction in the congestion of the systems of transport, increase of the citizen security, increase of the competitiveness of the cities and of the quality of life of the citizens. Smart cities also allows the latter, companies and third parties in general to help solve the problems presented by cities, by democratizing access to information and services in a transparent manner [8][9].

The following table summarizes the benefits obtained by becoming a smart city.

Table 1. Benefits of the smart city [3], [8]

Good management of current and future problems.	It generates integration, which in turn provides the public administration with necessary and transparent information for better decision making and budgetary management.
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Promotes innovation.	It presents an ideal platform to create an environment of innovation and generation of new business and ideas, favoring economic and social growth.
Optimizes resource allocation.	It optimizes the allocation of resources and helps reduce unnecessary public expenditures.
Greater satisfaction of citizens.	It allows providing a better service to users of services and improves the image of public bodies and, in this way, increases the level of satisfaction of the inhabitants.
Greater participation of civil society in administration.	Through the use of technological tools that help monitor public services, identifying problems, reporting and interacting with the municipal administration to solve them.
Minimization of environmental impact.	Optimization of operations to minimize environmental impact and improve the results of the use of resources, maximizing performance.

2.4 Major smart cities in the world.

In 2017 the IESE cities in motion index revealed the most outstanding cities in 10 key dimensions: economy, human capital, technology, environment, international projection, social cohesion, mobility and transport, governance, urban planning and public management, meeting in the first three places the cities of London, New York and Paris respectively, cities that, according to the study, have a higher level of sustainability and quality of life for its inhabitants [10].

New York, United States. New York has been concerned to offer access to internet on a large scale [11], also the transit department receives real-time images generated by cameras installed on the most important routes and junctions, and together with the meteorological information they have improved the signaling, change the times of the traffic lights according to the needs and generate traffic alerts by applications, Comp Stat was developed, a data collection service for the visualization of the criminal record of suspects involved in different crimes and has been implemented the use of cameras in police uniforms [3].

London, England. Since 2013, it has installed sensors to regulate car parks through a Smartphone application. It has also carried out initiatives such as "Source London", a network of charging points for electric vehicles in the city [12].

Paris, France. In Paris, the use of shared bicycles has been implemented, with approximately 2,000 parking spots and 20,000 bicycles at present [13]. It is also proposed to use different techniques of energy production in buildings, the construction of automated metro lines, and the use of electric buses and shared vehicles, increase the length of bicycle lanes in Paris and the installation of Wi-Fi in each metro station [14].

3 Methodology proposed for the construction of a smart city.

To make a smart city there is no single approach, each one represents an independent system with different actors and organisms interacting at different scales and using different platforms and infrastructures [5]. However, the main intelligent services that intelligent cities are expected to provide are the following:

Table 2. Intelligent services of the smart city.

Service.	Description.	Applications.
Urban mobility.	The aim is to build a sustainable, integrated, safe and interconnected system with real-time information [15], reducing pollution, congestion and increasing the level of accessibility to it [16].	Traffic management in real time. Management of means of transport. Parking management. Payment of tolls. Shared vehicles. Electric vehicles [8].
Energy efficiency and environmental management.	It seeks the environmental sustainability of the city, reduction of water consumption, energy and raw materials, reduction of operation and maintenance costs, as well as the times of action in cases of incidents [15], [16].	Smart energies Smart meters. Management of public parks and gardens. Waste treatment Measurement of environmental parameters [8].
Intelligent management of infrastructure and public services.	The optimization of four basic elements is sought: structure, systems, services and administration [17].	Management of public and inmotoc buildings. Management of public infrastructures and urban equipment. Urban incident report [8].
Government and citizenship	It seeks to have greater transparency in the processing of data in real time and that these are required by everyone, in addition to helping in citizenship education [15].	E-Administration E-Participation. Smart economy Open Government and Open Data. Analytical applications [8],[15].
Public security.	The promotion of a safe lifestyle is sought, increasing capacities and response time of the different emergency systems [8].	Management of public emergency services and civil protection. Video surveillance. Prevention of fire detection [8].
Health.	The aim is to reduce healthcare costs and contribute to maintaining the expected levels of quality of service [8].	Telemonitoring and telemedicine. Telecare and social services. Public health [8].
Education, human capital and culture.	It seeks to support the administration, management and monitoring of the bodies responsible for offering them [8].	E-learning and teleworking. E-tourism and cultural information services [8].

E-commerce.	It seeks to offer multi-service payment platforms [8], in order to streamline transactions, avoid unnecessary costs and reduce waiting times [18] .	Payment platforms [8].
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After carrying out a bibliographic review, the methodological proposal for the elaboration of a smart city was established (figure 2), which consists of 5 stages.

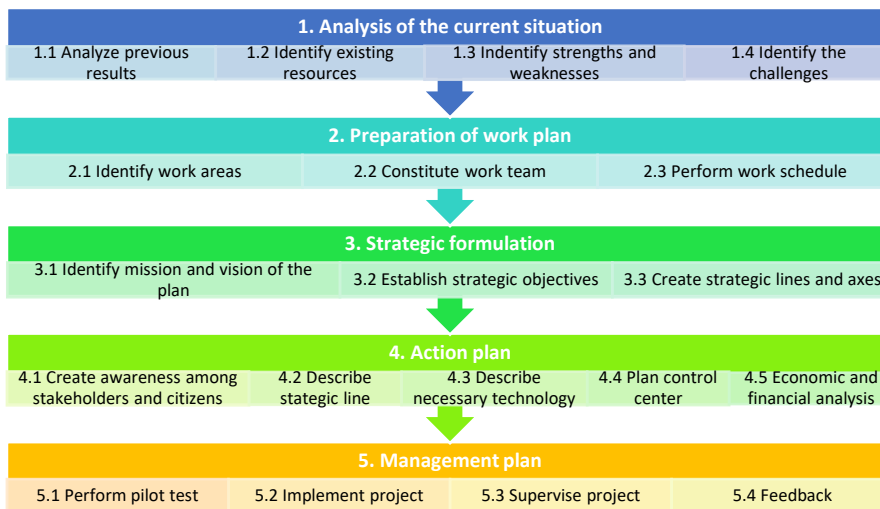


Fig. 2. Methodological proposal for the implementation of smart cities

These stages contemplate the key aspects to consider in the transformation towards smart cities: the analysis of the current situation, which is of vital importance to know the progress made, the weaknesses, as well as the available resources and establish feasible objectives; the preparation of work plan, which establishes the team and work schedule and specifies the areas or services in which you want to work -it is recommended to take into account the intelligent services described above-; the strategic formulation, which is the basis for measuring progress and the results obtained in the transformation process; the action plan that specifies the resources and strategies that will be carried out; and finally the management plan where the action plan is implemented and the process is fed back through the results obtained. Without a competent team, proper planning, implementation and a continuous review process, it is not possible to guarantee the achievement of the expected results.

The proposed methodology highlights the importance of strategic planning, the establishment of the necessary technologies and economic resources, as well as a process of feedback and measurement through some proposed indicators.

Once the analysis of the current situation is carried out, the city in the process of transformation identifies what service or intelligent services it wishes to implement,

and following the steps of the methodology focused on these, guarantees that the transformation process adjusts to its particular needs.

This is applicable both for new cities and those that face changes. For new cities it is recommended to work from the beginning in all areas or proposed intelligent services, while for cities that must face changes, it is proposed to start with the areas of highest priority for the proper functioning of the city [8].

3.1 Analysis of the current situation

It consists in identifying which issues merit attention, and deciding to what type of programs and services to allocate the available resources [19], ensuring the relevance of a program and defining the best way to proceed.

Carry out an analysis of the needs and results of previous plans. Identify the starting situation by analyzing the needs and results of plans or actions previously carried out in the scope of action of each topic [7].

Identify existing resources. Identify existing or available resources (natural, infrastructure, technology, human and economic resources) for their implementation in each area of action, being important to define the proposals according to the plan [7].

Identify strengths and weaknesses. Perform the SWOT diagnosis (Strengths, Opportunities, Weaknesses and Threats), making it possible to know and evaluate the actual operating conditions of the city based on the analysis of these four variables for each area, in order to propose actions and strategies for their benefit [20].

Identify the challenges. To manage and improve cities, it is necessary to know what happens in them, bearing in mind the challenges that must be faced, in order to set clear, realistic and concrete goals.

3.2 Preparation of a work plan.

In this stage the guidelines and artifacts that guarantee the realization and fulfillment of the objectives of the plan that will be carried out are established [7], this serves as an instrument of planning and management that allows carrying out the ends efficiently.

Identify the work areas. Identify the areas or topics of work that will be contemplated [7], for example: area of mobility, infrastructure, culture, security, trade, environment, among others.

Constitute the work team. The work team should be set up to coordinate the process of preparing the plan, according to the areas that need to be worked on, involving all those people and organizations that may be involved or affected by the plan, making known the objectives and the work context [7].

Perform the work schedule. Write the work program and the timetable for its development, taking into account the resources and their availability. The process of developing the schedule must be: complete, it must represent all the work to be done; realistically, with respect to time expectations and availability and accepted; you must have the support of team members and those interested in the project [21].

3.3 Strategic formulation.

For strategic formulation, it is necessary to take into account the degree of development, viability in terms of economic, geographic and environmental factors, as well as the priority of development [22]. The importance of the integration of intermediaries in the process to achieve the objectives must also be taken into account.

Identify the mission and vision of the plan. The mission seeks to synthesize the main purposes of the city that should be known by all intermediaries [7]. The vision should reflect the long-term goals of the city in terms of efficiency, sustainability and competitiveness [23].

Establish strategic objectives. They are established based on the observed weaknesses and after establishing the priorities for the management of the smart city. They represent the future points to be reached and serve as a guide to the tactical and operational behavior of the plan [7].

Create strategic axes and lines. The strategic axes to be discussed are established based on the strategic objectives and refer to the smart services offered by the smart city. The strategic lines refer to the lines of action necessary to achieve them and are related to the applications of intelligent services [7].

3.4 Action plan.

It is the detail of the initiatives to be developed with respect to the strategic axes and the lines of action proposed, as well as the instruments for their implementation [7].

Create awareness among stakeholders and citizens. It includes providing greater support to entrepreneurial initiatives, teaching the use of new technologies, the services available and engaging citizens in the communication of information [24].

Perform strategic line description. It is necessary to make a description of the characteristics, objectives and main advantages of each strategic line according to the needs of the city [7].

Describe the necessary technology. It includes information about infrastructure providers, service providers, and necessary applications [8]. In addition to this, the most appropriate technologies must be considered to fulfill the established purposes.

Table 3. Technologies for the smart city [5], [8].

Function.	Specification.	Type.
Data recollection.	Sensors and actuators.	Resources (Water, gas, light), security, lighting, presence, weather conditions, transportation infrastructure, movement, position.
	Identification technologies	RFID
Data transmission.	Communication networks.	Fiber optic (FTTB, FTTA, FTTH), (Integrated, aerial, down, indoor cable)
	Wireless technology	LTE-A, 4G
	Communication protocols	Wi-Fi, Bluetooth, ZigBee
Data storage and analysis.	Data warehouse	
	Data mining	
Data access.	Technological devices	Computers, cell phones, tablets
	Communication interface	Applications, platforms.

Integration plan through the control center. It requires the provision of computers and software applications that receive process and analyze data, as well as communication interfaces that send and receive information from the population and encourage collaborative participation [3].

Economic and financial study. The financial aspects are associated with the need to make the smart city tangible and, based on this, the business plan that supports the implementation of the new solutions, products and services is developed [25]. It is necessary to carry out adequate financing, studying the possibilities of public-private collaboration or with other institutions worldwide. A clear objective of return on investment from the economic, environmental and social point of view is established. Since this is a long-term investment, project cost control must be followed so that any specific deviation does not jeopardize its development [26].

3.5 Management plan.

The Management Plan should include the instruments and mechanisms that allow coordinating the actions of the plan, promote them and ensure adequate compliance with the objectives set [7].

Perform pilot test. The general plan should start with one or more pilot projects, and move forward with firm steps and in accordance with the city's institutional and financial capacities [3]. The pilot tests should be designed in such a way that if they are successful they can be expanded, so that the key factors that will be needed for an extension decision are already explored during this phase [27].

Implement project. To implement the project, the technology required to start up an efficient collection, transmission, storage and analysis of data is acquired, allowing an adequate management of the information when it is stored in the cloud. This large volume of information exists in a great variety of data, which can be represented in different ways around the world, which can measure and communicate, in such a way that the applications that analyze These data require that the speed of response is very fast in order to obtain the correct information at the right time, promoting greater interaction with citizens, raising their level of satisfaction [5]. For this, it is necessary to have the execution capacity to concretize that vision; an intelligent government that has trained professionals endowed with this multisectoral perspective is the key to start this process [3].

Supervise the project. The results must be recorded, measured and analyzed to identify the improvements achieved by the different initiatives in contrast to the initial situation. The degree of success of the smart city project will be given by long-term economic, social and environmental results [26], for this it is necessary to have a set of objective indicators to measure intelligence, establish comparisons and rankings of cities, quantify objectives, establish actions and detect deviations or effects not sought [25]. Table 4 shows a description of some indicators based on the smart cities services mentioned in table 2.

Table 4. Smart cities assessment indicators [28]

Service.	Indicator.
Urban mobility.	<p><i>Local accessibility.</i> Efficient local communication channels that allow reducing the time and cost of transportation, as well as reducing polluting emissions, providing ample travel satisfaction.</p> <p><i>Local internationality.</i> External communication channels, which allow a correct connection with other local cities, airports, railway terminals, ports, etc.</p> <p><i>Availability of ICT infrastructure.</i> Infrastructure fiber optic network, satellite network, telephone network, computer equipment, video surveillance, etc., available to be used by the inhabitants of the city.</p> <p><i>Sustainable, innovative and safe transport system.</i> Shared electric vehicle system, free of traffic and green transport.</p>
Energy efficiency and environmental management.	<p><i>Pollution.</i> Level of particles suspended in the air, damage to the ozone layer, population with respiratory diseases caused by pollution.</p>

	<p><i>Sustainable management of resource.</i> Efficient use of water, efficient use of electricity, rescue of contaminated land.</p> <p><i>Waste generation.</i> Waste generated by city.</p> <p><i>Energy.</i> Percentage of use of clean energy on the total use of energy, legislation to improve energy efficiency.</p>
Smart management of infrastructure and public services.	<i>Infrastructure connection to public services.</i> Water piped, sewage, electricity services, waste management services, knowledge infrastructure services.
Government and citizenship	<p><i>Participation in decision-making.</i> Representatives in the city by local residents, national inhabitants in political activity, participation of female representatives.</p> <p><i>Public and social services.</i> Satisfaction for the operation of drainage, cleaning services, day care, procedures through ICT solutions, etc.</p> <p><i>Transparent government.</i> Institutions of transparency and information established and efficient.</p>
Public security.	<p><i>Individual security.</i> Local crime, number of deaths per assault, police units per capita.</p> <p><i>Emergency care.</i> Number of ambulances and firefighters per inhabitants, average time of response to emergencies.</p>
Health.	<p><i>Health conditions and services.</i> Life expectancy, hospitals per inhabitant, doctors per inhabitant.</p> <p><i>Quality housing.</i> Minimum satisfaction of the occupied dwelling, good general conditions of the dwelling, compliance with minimum standards in housing.</p>
Education, human capital and culture.	<p><i>Cultural facilities.</i> Number of theaters, cinemas, museums per inhabitant.</p> <p><i>Educational centers.</i> Students per inhabitant, educational level of schools, satisfaction with the education system, access to the education system.</p> <p><i>Tourist activity.</i> Importance of tourist sites, visit days per year per inhabitant.</p> <p><i>The social cohesion.</i> Poverty rate, perception of aid to the poverty rate</p>
E-commerce.	<i>Universal accessibility to the internet.</i> Percentage of households that have access to the internet, active population in social networks, free Wi-Fi points, population with smartphones.

To select or create the correct indicators, it is useful to ask these questions: What do you want to measure? Why? Do you monitor the results of one of the objectives? Is it a key factor? Who is responsible for supervising it? With what frequency should it be supervised?

Feedback. This plan must be in permanent construction, so it is necessary to ensure its continuous adaptation to new elements or changes in the environment, whether changes

in regulations, technology, budgets or the same result of projects involve that technical decisions and situations are changed in which it is necessary [7] , so it must always be in a continuous improvement process, using the results to provide feedback and make the necessary modifications.

4 Conclusions.

The implementation of smart cities is not easy, it is a complex task that requires analysis, planning, supervision and permanent feedback, however it brings many benefits for both the government and the population in general.

The implementation of each initiative seeks the solution of specific needs of the city in which the project will be carried out, however, the methodology proposed in this article provides a general idea of how this transformation can be carried out, in such a way that it is applicable both for new cities and for those that are going to carry out a process of change with a view to becoming smart cities.

The transformation and modernization of cities generates concrete and positive effects, since it improves efficiency by integrating different areas of action (mobility, energy efficiency and environmental management, infrastructure and public services, government and citizenship, safety, health, education, culture, electronic commerce, among others), so it is necessary to highlight the importance of carrying out this project in a comprehensive manner, where both objectives, actors, means and strategies to carry them out are done collaboratively and in this same way to share the benefits of its implementation , because if each one of these initiatives is developed individually, the obtaining of favorable results is not guaranteed.

It is hoped that this methodology will be used, serve as a reference for different cities of the world and at the same time be complemented thanks to new technological and scientific advances.

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